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Intraoral Digital Impression Technique: A Review

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Abstract

There are various technique for impression making in field of prosthodontics and with time techniques of computer-aided design and computer-aided manufacturing (CAD/CAM) being applied in the field of prosthodontics, a concept of intraoral digital impressions was put forward in the early 1980s. It has drawn comprehensive attention and has been used for dental prosthesis fabrication in a number of cases. This new digital impression technique is expected to bring about absolute digitization to the mode of prosthodontics. A few published articles have indicated that dental prostheses fabricated from intraoral digital impressions have exhibited remarkable advantages over those from conventional impressions in several respects. The present review discusses intraoral digital impression techniques in terms of the following aspects: (1) categories and principles of intraoral digital impression devices currently available; (2) operating characteristics of the devices; and (3) comparison of the manipulation, accuracy, and repeatability between intraoral digital impression and conventional impression.

INTRODUCTION

Technological advancement is playing pivotal role in many fields and with electronic technology, digital technology, and advanced manufacturing technology being applied in the field of dentistry, digitization in diagnosis and treatment has become a major trend in prosthodontics. Computer-aided design and computer aided manufacturing (CAD/CAM) have been employed in the fabrication of restorations, especially ceramic crowns and fixed dental prostheses (FDPs), since the 1980s.1 A few published articles have indicated that dental prostheses fabricated from intraoral digital impressions have exhibited remarkable advantages over those from conventional impressions in several respects.[2-4] Many CAD/CAM systems are now available for design and production of restorations based on conventional silicone impressions.[5] In these cases, a plaster cast is made from the silicone impression and is sent for extraoral scanning, where the plaster cast is fixed on the extraoral scanner platform. Although the accuracy of extraoral scanning is adequate, the intraoral outline depictive process of a conventional impression is hard to perfectly reproduce due to the deformation of impression materials and plaster. Therefore, the inadequate precision of plaster casts is not optimal for completing CAD/CAM procedures. In contrast, direct intraoral digital impressions can avoid errors more than a conventional impression can. Additionally, this saves time for making conventional impressions and plaster models and lowers the cost of materials. Recent developments in the field of intraoral digital impression offer great progress. An increasing number of fixed prostheses are now manufactured with intraoral digital impressions, which have become a pivotal part of the digitization of prosthodontics.[6]

CAD/CAM systems are composed of three major parts: (1) a data acquisition unit, which collects the data from the region of the preparation teeth and neighboring structures and then converts them to virtual impressions (an optical impression is created at this moment directly or indirectly); (2) software for designing virtual restorations anchored in virtual impressions and setting up all the milling parameters; and (3) a computerized milling device for manufacturing the restoration with solid blocks of the chosen restorative material.[6] The first two parts of the system play roles in the CAD phase, while the third is responsible for the CAM phase

CAD/CAM systems can be divided into two types based on digital data sharing capacity: open and closed.[7] Closed systems offer all CAD/CAM procedures, including data acquisition, virtual design, and restoration manufacturing. All the steps are integrated in the unique system. There is no interchangeability between different systems. Open systems allow the adoption of original digital data by other CAD software and CAM devices. There are still several obstacles and deficiencies to address in intraoral digital impressions. Some systems need a layer of powder spray on the tooth surface, and the inhomogeneous powder thickness may slightly transfigure the tooth outline. Another major problem is scanner displacement during the scanning process, which may affect scanning accuracy. This article reviews the characteristics of some major intraoral digital impression devices currently available, and focuses on categories, principles, and operation. We also discuss the differences between intraoral digital and conventional impressions.

Categories, principles, and operating characteristics

The main intraoral digital impression systems currently available on the market include CEREC, Lava C.O.S. system, and TRIOS. They vary from each other in terms of key features such as working principle, light source, the necessity of powder coat spraying, operative process, and output file format.

CEREC system

The CEREC 1 system (Sirona, Bensheim, Germany) was brought to market in 1987 together with the Duret system as the first intraoral digital impression and CAD/CAM device.[8] This system is designed with the concept of "triangulation of light," in which the intersection of three linear light beams is focused on a certain point in 3D space.[1] Surfaces with uneven light dispersion adversely reduce the accuracy of scans. Therefore, adoption of an opaque powder coating of titanium dioxide is required for producing uniform light dispersion and increasing scan accuracy.[9] Currently, the most prevalent CEREC system is its fourth generation product, known as CEREC AC Bluecam. It captures images using a kind of visible blue light emitted from an LED blue diode as its light source. The CEREC AC Bluecam can capture one quadrant of the digital impression within 1 minute and the antagonist in a few seconds. The newest CEREC system, CEREC AC Omnicam, was brought to market in 2012. The Omnicam imaging technique is a style of continuous imaging, where consecutive data acquisition generates a 3D model, whereas Bluecam imaging is a single image acquisition. Omnicam can be used for a single tooth, quadrant, or full arch, but Bluecam can only be applied for a single tooth or quadrant. Powder-free scanning and precise 3D images with natural color are the most prominent features of Omnicam. The powder-free feature has particular benefits for a larger scanning area.[10] Tooth surfaces with uneven light dispersion adversely reduce the accuracy of scans. Accordingly, it is wise to make an opaque powder coating of titanium dioxide before scanning to induce uniform light dispersion and improve scan efficacy.[11] When digitally scanning, the dentist holds the scanner and aims the camera towards the scanned area. The camera tip should be a few millimeters away from the tooth surface or should just slightly touch the surface.[6] The dentist is asked to slide the camera head over the teeth in a single direction gently so as to generate the successive data into a 3D model. This seamless scanning process can express a notable depth of field. In addition, the scan can be interrupted and resumed at any time by the operator. A new technology of shake detection system can ensure the 3D images are only captured when the camera is stable and still, so it can avoid any possible inaccurate data due to shaking or trembling of the operator's hand.6 When scanning is complete, the preparation can be shown on the monitor and looked over from any angle. The virtual die is cut on the effective model, and the finish line is outlined by the dentist directly on the die image. Then, a CAD system "biogeneric" proposes an idealized restoration design to let the dentist makes adjustments using a number of on-screen tools. Once satisfied with the restoration, the dentist can mount a block of ceramic or composite material with the desired shade in the milling unit and start to produce the physical restoration. During the design stage, color-coded tools determine the degree of interproximal contact and ensure the finished restorations require minimal adjustments, if any, before cementation. The dentist can either capture the teeth digitally and fabricate a restoration in a single visit, or can transfer the data to the dental laboratory by CEREC ConnectR, which can in turn select the restoration design virtually and mill it in the laboratory.[10] This type of intraoral scanner can be used for single crowns, veneers, inlays, onlays, and implant-supported FDPs. For crowns over implants, the prepared abutment can be directly scanned,[6] or a scan body seated on the implant can be scanned by the dentist. A scan body is a plastic coping with markers that provide 3D registration of the implant location.[12] The CEREC system is a closed system, exporting the digital impression data as a proprietary format file that works on Sirona's supporting CAM devices such as CEREC MC and CEREC In-Lab. The CEREC MC is a chairside milling unit that can provide single-appointment treatments. Earlier, the CEREC chairside milling unit was not capable of milling FPDs and some high-strength ceramic materials. Therefore, these types of cases had to be milled through CEREC In-Lab. With recent developments in CEREC devices, the CEREC MC X and CEREC MC XL combined with CEREC AC Omnicam can be used for a majority of indications and materials, including FPDs and zirconium oxide.

Lava C.O.S. system

LavaTM C.O.S. (Lava Chairside Oral Scanner; 3M ESPE, Seefeld, Germany) is an intraoral digital impression device invented in 2006 and brought to market in 2008. It works under the principle of active wavefront sampling.[13] This principle refers to obtaining 3D data from a single-lens imaging system. Three sensors can capture clinical images from diverse angles simultaneously and generate surface patches with infocus and out-of-focus data by proprietary image-processing algorithms.[14] Twenty 3D datasets can be captured per second, embodying over 10,000 data points in each scan.[2] This allows the system to produce a precise scan out of 2400 more datasets (or 24 million data points). The manufacturer states that the high data redundancy ascribed to many overlapping pictures ensures the highly accurate image quality.[2] The Lava C.O.S. has the smallest scanner tip—only [13].2- mm wide. The scanner sends out pulsating visible blue light as light source and works with a mobile host computer and a touch-screen display.[6] Similar to CEREC AC Bluecam, the Lava C.O.S. also requires a powder coating spray on the tooth surface before scanning. After the mouth is rinsed and air dried, the particular powder (LavaTM powder for chairside oral scanner; 3M ESPE) is sprayed on the tooth surface to form a homogeneous layer. In the progress of scanning, the dentist should start with the posterior tooth area and move the camera forward, ensuring both buccal and lingual sides are captured.[10] The Lava C.O.S. can display the images seized in the mouth on the touch screen at the same time. With real-time visibility, dentists can immediately see if they are receiving enough information from the preparation. Once it is confirmed that all necessary details were captured on the preparation scan, a quick scan of the rest of the arch is required. If the display shows a critical missing or blurry area in the scan, the dentist simply needs to rescan this specific area, and the software will be amended automatically.[10] The dentist then scans the opposite arch in the same manner. Finally, a scan from the buccal side with the patient in occlusion is taken, and the system will articulate the maxillary and mandibular teeth automatically to create a bite record.[15] After reviewing all the scans, the dentist can fill out an onscreen laboratory prescription. The data are wirelessly transferred to the laboratory, where a technician cuts the die accordingly and digitally marks the margin with customized software. The digital data are virtually ditched after being transferred to 3M ESPE. Afterward, the data is normatively articulated with the opposing and bite scans.10 A stereolithography (SLA) model is created by the manufacturer and delivered to the laboratory. Despite the different system name, it is not dedicated solely to the creation of Lava crowns and FDPs. All types of finish lines may be reproduced on the SLA dies, which allows any type of crown to be manufactured by the dental laboratory.[10] In most cases, the Lava C.O.S. also exports data files in a proprietary formatted manner, which can be designed and manufactured only by its supporting CAD software and CAM device. Scanning of implant cases is accomplished by Biomet 3i (Palm Beach Gardens, FL). It uses a healing cap (Encode; Biomet 3i) attached to the implant before taking an optical impression. After data acquisition, Biomet 3i can mill the abutment. The alternative option is to deliver the data to Dental Wings software (DWOS). The compatibility with other software makes Lava C.O.S. a semi-open system.[6]

TRIOS system

In 2010, 3Shape (Copenhagen, Denmark) launched a new type of intraoral digital impression system, TRIOS, which was presented to market in 2011. This system works under the principles of ultrafast optical sectioning and confocal microscopy. The system recognizes variations in the focus plane of the pattern over a range of focus plane positions while maintaining a fixed spatial relation of the scanner and the object being scanned. Furthermore, a quick scanning speed of up to 3000 images per second reduces the influence of relative movement between scanner probe and teeth.[21] By analyzing a large number of pictures obtained, the system can create a final digital 3D model instantly to reflect the real configuration of teeth and gingival color. Similar to the iTero and E4D systems, the TRIOS intraoral scanner is a powder-free device in the scanning process. The TRIOS system boasts an essential trait, "the variation of the focal plane without moving the scanner in relation to the object being scanned."[21] According to Logozzo et al,[21] "The focal plane should be continuously varied in a periodic fashion with a predefined frequency, while the pattern generation means the camera, the optical system, and the object being scanned are fixed in relation to each other. Further, the 3D surface acquisition time should be small enough to reduce the impact of relative movement between probe and teeth. The scanning system has the property of telecentricity in the space of the object being scanned and it is possible to shift the focal plane while maintaining telecentricity and magnification."[21] The operation of TRIOS is relatively simple. The dentist can hold the scanner at a range of distances to the tooth. Either closely over the tooth or 2 to 3 cm away will not affect the focus and the capturing of images.[21] The 3D profiles of teeth and gingiva are generated simultaneously, while the dentist moves the scanner gradually above them. After scanning the upper and lower teeth, a buccal scan can be taken when the patient closes into an intercuspal position. The system of the host computer will implement a digital registration to create a 3D occlusion relationship. TRIOS includes two parts: TRIOSR Cart and TRIOSR Pod. The TRIOSR Pod offers better mobility and flexibility due to its simple construction with a handheld scanner only and its compatibility with other computers or iPad.[21] For both the TRIOSR Cart and the TRIOSR Pod scanner, clinics can choose either a TRIOSR Standard or a TRIOSR Color solution program. The latter is capable of capturing and demonstrating the teeth and soft-tissue images in real color. The TRIOS system can provide service in a broad range of indications including crowns, FPDs, veneers, inlays, onlays, implants, and orthodontic cases. With the development of TRIOSR Color, it is expected that the patients with a removable partial denture or complete denture will be intraorally scanned directly in the future.[21] The TRIOS system is an open system that can export 3D data as an STL file or a proprietary file. The STL file can work together with other CAD/CAM systems. The proprietary encrypted file can only be designed by 3Shape's specific CAD software and 3Shape Dental SystemTM. Additionally, TRIOS is a professional digital impression acquisition and CAD system, and does not include a CAM milling device.[21]

Accuracy and repeatability of intraoral digital impression

Accuracy between digital and conventional impression Marginal and internal fitness are important criteria for the success of FDPs like ceramic restorations. A high level of impression accuracy is important to assist the fabrication of a precise restoration. Syrek et al2 conducted an in vivo experiment to compare the fitness of zirconia single crowns produced from an intraoral digital impression with that from a conventional silicone impression. Four surfaces (mesial, distal, buccal, and lingual) per tooth were measured. The median marginal gaps in the digital impression group were 50 µm for mesial, 55 µm for distal, 53 µm for buccal, and 51 µm for lingual. In the conventional impression group the gaps were 69 µm for mesial, 70 µm for distal, 74 µm for buccal, and 67 µm for lingual. The overall marginal gaps of digital and conventional impression groups were 49 µm and 71 µm, respectively. The study concluded that ceramic crowns fabricated from a digital impression had a better fit than conventional impressions did. It also revealed better interproximal contact for the digital group than the conventional group. The all-ceramic crowns manufactured from digital impressions demonstrated narrower marginal gaps than the ones from conventional impressions. This outcome was mainly explained by the working procedure difference: in the conventional group, silicone impressions and plaster models were made, whereas in the digital group, the crowns were designed and manufactured directly from the scanning data without needing to fabricate an intermediate model. Additionally, making silicone impressions and plaster models could engender inevitable errors from deformation.[25] Therefore, the crowns produced from the digital impression could achieve a higher accuracy level. Ender and Mehl26 conducted an in vitro experiment on fullarch scanning to evaluate the precision of conventional and digital impressions, and determined the values to be 30.9 µm for CEREC Bluecam, 60.1 µm for Lava C.O.S., and 61.3 µm for a conventional impression. The authors concluded that the accuracy of digital impressions was similar to that of conventional impressions, potentially due to a powder coat spraying, which was applied before both Lava C.O.S. and CEREC scanning. Even if the programs inside the scanners were capable of taking the powder spraying into account in the algorithm, the powder thickness still varied due to different dentists, reducing scan accuracy.[27]

Repeatability between digital and conventional impressions

The quality of repeatability reflects the stability and authenticity of a scanning device to some extent. Intraoral digital scanning is performed in a process where the scanner is held by a clinician and not fixed on a platform. The digital impression repeatability should meet a satisfactory level to improve the impression quality. Several publications reported the investigation of digital impression repeatability by repeated scans. An in vitro study by Stimmelmayr et al28 evaluated the reproducibility of implant scan bodies under both direct intraoral scanning on an original polymer model and indirect extraoral scanning on a stone cast model. The results showed that the mean discrepancies of scan bodies among repeated scans were 39 µm for the intraoral group (original model) and 11 µm for the extraoral group (cast model). The systematic error of scanning models was 13µm for the original polymer and 5 µm for the stone cast model. The authors concluded that the reproducibility of extraoral scanning was better than that of intraoral scanning. In an in vitro experiment Del Corso et al29 found that the bias error value of the intraoral optical capturing system was 14 to 21 µm. Mehl et al30 reported a 20 µm or less systematic error in extraoral scanning on plaster casts. These data indicated that both intra- and extraoral optical scanning could provide decent precision. The manipulative operation might be the major cause of the larger discrepancy from intraoral scanning than that from extraoral scanning. An unpredictable spatial movement of the scanner by operator would initiate a change of coordinate system and affect the digital fit of images, consequently reducing the scan accuracy. On the contrary, an extraoral scan could maintain a high consistency in multiple scans with a plaster model fixed on a scanner platform. Additionally, the powder spray might be a factor in the intraoral scan becoming less precise. Therefore, scanning devices dispensing with powder spraying are desirable to improve the performance of intraoral digital impression devices.

Conclusion

The intraoral digital impression technique has been used in prosthodontics to aid the CAD/CAM process. As a relatively new technique, the deficits in repeatability of the intraoral digital impression need to be solved, but dental products fabricated

with intraoral digital impressions have presented accuracy on par with conventional impressions. Although conventional impression materials like poly(vinyl siloxane) 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.[31] The further improvement of the intraoral digital impression technique will lead to its wide use in dentistry

References

1. Mormann WH: The evolution of the CEREC system. J Am Dent Assoc 2006;137:7S-13S

2. Syrek A, Reich G, Ranftl D, et al: Clinical evaluation of all-ceramic crowns fabricated from intraoral digital impressions based on the principle of active wavefront sampling. J Dent 2010;38:553-559

3. Almeida e Silva JS, Erdelt K, Edelhoff D, et al: Marginal and internal fit of four-unit zirconia fixed dental prostheses based on digital and conventional impression techniques. Clin Oral Investig 2014;18:515-523

4. Seelbach P, Brueckel C, Wostmann B: Accuracy of digital and ¨ conventional impression techniques and workflow. Clin Oral Investig 2013;17:1759-1764

5. Luthardt R, Weber A, Rudolph H, et al: Design and production of dental prosthetic restorations: basic research on dental CAD/CAM technology. Int J Comput Dent 2002;5: 165-176

6. Galhano GA, Pellizzer EP, Mazaro JV: Optical impression ´ systems for CAD-CAM restorations. J Craniofac Surg 2012;23:e575-e579

7. Correia ARM, Sampaio Fernandes JCA, Cardoso JAP, et al: CAD-CAM: informatics applied to fixed prosthodontics. Rev Odontol UNESP 2006;35:183-189

8. Rekov ED: Dental CAD/CAM systems: a 20-year success story. J Am Dent Assoc 2006;137(Suppl):5S-6S

9. CEREC 3: Operating instructions for the acquisition unit. Sirona The Dental Company, Bensheim, Germany, 2004

10. Birnbaum NS, Aaronson HB, Stevens C, et al: 3D digital scanners: a high-tech approach to more accurate dental impressions. Inside Dent 2009;5:70-74

11. Poticny DJ, Klim J: CAD/CAM in-office technology: innovations after 25 years for predictable, esthetic outcomes. J Am Dent Assoc 2010;141:5S-9S

12. Patel N: Technologies for comprehensive implant integrating three-dimensional digital. J Am Dent Assoc 2010;141:20S-24S

13. Rohaly J: Three-channel camera systems with non-collinear apertures. United States Patent 2006;7:372-642

14. Lava Chairside Oral Scanner C.O.S: 3M ESPE Technical Datasheet, St. Paul, MN, 2009

15. Birnbaum NS, Aaronson HB: Dental impressions using 3D digital scanners: virtual becomes reality. Compend Contin Educ Dent 2008;29:494, 496, 498-505

16. Garg AK: Cadent iTero's digital system for dental impressions: the end of trays and putty? Dent Implantol Update 2008;19:1-4

17. Kachalia PR, Geissberger MJ: Dentistry a la carte: in-office CAD/CAM technology. J Calif Dent Assoc 2010;38:323-330

18. Glassman S: Digital impressions for the fabrication of aesthetic ceramic restorations: a case report. Pract Proced Aesthet Dent 2009;21:60-64

19. Jacobson B: Taking the headache out of impressions. Dentistry Today 2007;26:74-76

20. Cadent debuts "next generation" iTero digital impression system. Implant Tribune, US edition, 2007;1(12):14

21. Logozzo S, Franceschini G, Kilpela A, et al: A comparative analysis of intraoral 3D digital scanners for restorative dentistry. Int J Med Tech 2011;5. http://ispub.com/IJMT/5/1/10082#

22. Tsitrou EA, Helvatjoglu-Antoniades M, van Noort R: A preliminary evaluation of the structural integrity and fracture mode of minimally prepared resin bonded CAD/CAM crowns. J Dent 2010;38:16-22

23. Lee SJ, Gallucci GO: Digital vs conventional implant impressions: efficiency outcomes. Clin Oral Implants Res 2013;24:111-115

24. Persson AS, Oden A, Andersson M, et al: Digitization of simulated clinical dental impressions: virtual three-dimensional analysis of exactness. Dent Mater 2009;25:929-936

25. Quaas S, Rudolph H, Luthardt RG: Direct mechanical data acquisition of dental impressions for the manufacturing of CAD/CAM restorations. J Dent 2007;35:903-908

26. Ender A, Mehl A: Full arch scans: conventional versus digital impressions-an in-vitro study. Int J Comput Dent 2011;14:11-21

27. da Costa JB, Pelogia F, Hagedorn B, et al: Evaluation of different methods of optical impression making on the marginal gap of onlay created with CEREC 3D. Oper Dent 2010;35:324-329

28. Stimmelmayr M, Guth JF, Erdelt K, et al: Digital evaluation of ¨ the reproducibility of implant scanbody fit-an in vitro study. Clin Oral Investig 2012;16:851-856

29. Del Corso M, Aba G, Vazquez L, et al: Optical three-dimensional scanning acquisition of the position osseointegrated implants: an in vitro study to determine method accuracy and operational feasibility. Clin Implant Dent Relat Res 2009;11: 214-221

30. Mehl A, Ender A, Mormann W, et al: Accuracy testing of a new intraoral 3D camera. Int J Comput Dent 2009;12:11-28

31. Christensen GJ: Will digital impressions eliminate the current problems with conventional impressions? J Am Dent Assoc 2008;139:761-763