An Update on Digital Impressions

The field of digital impressions in dentistry has expanded and evolved rapidly. Next-generation systems have been introduced with more capabilities than before, and scanning is increasingly being performed for restorative care and other disciplines. The accuracy of current systems is excellent, and digital impressions offer some distinct advantages over traditional impressions. An understanding of the capabilities of different systems is helpful with respect to open/closed systems and considerations in selection. It can be anticipated that developments in this field will continue.

Introduction

Digital technologies have changed the world we live in, and have also resulted in significant changes in dentistry. One of these was digital impressioning, together with CAD/CAM. Digital dental impressions were first introduced in the 1980s, with two available options: scanning and chairside milling of inlays and onlays; and digital scanning of stone models that had been poured from traditional impressions. Much has changed since then. The evolution of digital impressioning has resulted in it now being utilized for restorative care, implant components, splints, orthodontics and dentures. Digital impressioning is now mainstream. In the case of restorative care, not only the availability of accurate CAD/CAM systems but also esthetic and durable CAM restorative materials and advanced adhesive technologies have promoted the adoption of digital impression techniques.

About the Author

Robert W. Berg, DMD

Dr. Robert W. Berg received his DMD degree from Tufts University School of Dental Medicine and a Certificate in Prosthodontics from Albert Einstein College of Medicine/Montefiore Medical Center. He currently maintains a full-time private practice limited to prosthodontics in Manhattan, NY. He is a clinical instructor in Surgery (Dentistry, Oral & Maxillofacial Surgery) at New York Presbyterian Hospital – Weill Cornell Medical College. He is an active member of the American College of Prosthodontics, Academy of Osseointegration, the International and American Associations for Dental Research, and a fellow of the Greater New York Academy of Prosthodontics.

LEARNING OBJECTIVES

The overall goal of this article is to provide the reader with information on digital impressions. After completing this article, the reader will be able to:

1. Describe the changes that have occurred in digital impression technologies
2. List and describe differences between digital and traditional impression techniques
3. Review the differences between open and closed architecture, scanning options and restorative options with different systems.

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Digital Impressions in Restorative Care

Depending on whether a stand-alone scanner system or a scanner and chairside milling unit is used, restorations can immediately be fabricated or scanned images securely transferred digitally to a laboratory or manufacturing center. Digital scans are used to create virtual models for CAD/CAM fabrication of milled restorations, or a model can be created from the images and a restoration fabricated traditionally. Another method involves digital impressioning of a traditional impression. However, a traditional impression must still be taken first and the digital impression/scan can only be as good as the original impression plus or minus a poured model. Any inaccuracies or distortions in the model are replicated in the digital scan of the model.

Restorative Requirements and Accuracy

A final restoration can only be as accurate as the original digital scan or final traditional impression, regardless of the technique subsequently used to create the restoration. Key aspects of a restoration's architecture include the marginal fit, proximal contacts, contours, and occlusion. Adequate interocclusal and proximal space must be created to match the physical properties and requirements of the restorative material being used, and appropriate space must be present at the tooth-restorative interface for the adhesive material/cement.

Numerous studies support the accuracy of digital scanning for single-unit crowns, veneers, inlays, onlays, and multi-unit restorations. In one review and meta-analysis, a comparison of marginal gaps showed no significant differences between restorations fabricated from digital and traditional impressions in laboratory studies (mean marginal fit 63.3 µm vs. 58.9 µm) or in vivo (56.1 µm vs. 79.2 µm). The upper range for conventional impressions was 98.9 µm and for digital impressions 65.8 µm, well within the maximum marginal gap of 120 microns that is generally considered acceptable.

Comparing Digital and Traditional Impressions

Digital impressions are more pleasant for patients. Trays and messy impression materials are not required, and the risk of a patient gagging is reduced. Digital impressions offer less opportunity for errors, provided the instructions for use are followed since, unlike with impression materials, there is no possibility of voids, tears or distorted impressions, or errors associated with models or dies. The clinician is able to evaluate the virtual model immediately and rescanning if needed; whereas, minor issues with physical impressions may not be apparent until the lab pours the model. In addition, if models are produced by CAD/CAM systems these are significantly harder and more durable than stone models and do not abrade or chip during handling. (Table 1)

Obtaining Accurate Digital Impressions

The basic requirements for accuracy are the same regardless of which system is used. Soft tissue management and isolation are essential for accurate and complete scanning of the margins, the area 0.5 mm apical to the margins, and the whole preparation and adjacent teeth. If the margins are supragingival, soft tissue retraction should not be necessary (isolation still is), but is required if margins are equi- or subgingival. Digital scanners cannot scan through or displace fluid or soft tissue, so as with physical impressions, tissue retraction becomes necessary to capture the margins subgingivally.

Options for soft tissue management include retraction cord, retraction pastes, and surgical management. Single-cord or double-cord retraction can be used, depending on the clinical presentation. For supra- or equigingival preparation, single-cord

<table>
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<tr>
<th>Table 1. Attributes of Digital Impressions</th>
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<tbody>
<tr>
<td>No requirement for trays or impression material</td>
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<tr>
<td>Less risk of patients gagging</td>
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<tr>
<td>More pleasant experience for the patient</td>
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<tr>
<td>Save time at impression appointment</td>
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<tr>
<td>Alert the user to errors/areas requiring attention or adjustment</td>
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<tr>
<td>Save time at seat appointment</td>
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<tr>
<td>Suitable for all types of restorations</td>
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<tr>
<td>Allow for same-day restorations if coupled with a milling system</td>
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<tr>
<td>Flexibility</td>
</tr>
<tr>
<td>Can be used with CAD/CAM milling or for traditional fabrication of crowns</td>
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retraction suffices and helps to avoid tissue trauma. The double-cord technique is more effective for subgingival preparations, whereby a thin cord is first placed followed by a slightly thicker second cord on top of it. This outer cord is removed prior to scanning the preparation, and the thinner, deeper cord after scanning is completed. Care must be taken to avoid tissue damage. Cord can be soaked in a hemostatic agent before placement to control bleeding (e.g., ferric sulfate or aluminum chloride).

Retraction paste is a second option, sets and retracts the tissue, and contains a hemostatic agent to help control oozing/bleeding. The last option is surgical management. A diode laser creates troughing around the preparation and provides for hemostasis. It may also be used in combination with retraction cord. Electrosurgery is not recommended as tissue reactions are unpredictable, potentially with gingival sloughing and recession.

**Digital Impression Systems**

The field of digital impressions has changed rapidly. System capabilities have increased, with more systems now offering the ability to use them for multiple disciplines. Designs have evolved with smaller footprints, improved scanner/wand designs and lighter-weight desktop/portable options, and there is greater focus on connectivity and open-system designs. The section below addresses digital impression systems with the ability to connect and transfer data for laboratory/manufacturing center fabrication of restorations.

**Open- and Closed-system Architecture**

Systems with an open-system architecture utilize a standard format file, typically an STL file, which is commonly the standard file format for 3D imaging, including in CAD/CAM dentistry. This file format makes the data compatible with most software programs, and the files can then be read and used for design and downstream processes using other manufacturers’ equipment. As such, this gives dental offices more flexibility and the ability to transfer digital files either to partner labs/centers for the digital impression system or to independent third parties (laboratories).

In contrast, closed systems maintain ownership of the downstream processes, including collection and manipulation of the data in designing digital solutions for procedures, and do not allow use of the digital data with other manufacturers’ equipment.

The new-generation 3M True Definition Scanner is an open system that uses a standard STL file format. Other open systems include the Planmeca PlanScan; 3Shape TRIOS; Carestream CS3500 scanner; and the iTero system. The CEREC system is a closed system. Several scanner options are now available, and the dental office transfers the file via Sirona Connect to participating laboratories, at which point the participating lab can fabricate restorations using the proprietary InLab milling machine. However, the system now also permits participating laboratories to convert files to an STL format.

**Capturing Digital Scans**

Digital scanners vary in the technology used to capture images, whether or not powder is required, shade matching capabilities, color imaging, articulator options, and restorative indications, among others. Restorative options for the main digital scanner systems can be found in Table 2. The CEREC Bluecam requires a light dusting of titanium dioxide powder as a contrast medium on the teeth prior to scanning, while the CEREC Omnicam scanner does not. The APOLO DI Digital Impression System (Sirona) also requires use of powder. With the exception of 3M True Definition, other manufacturers’ scanners capture powder-free images. Depending on the system, image acquisition can be achieved by blue LED light or laser technology, optical scanners, continuous video image acquisition, or multiple ‘stitched’ single images. Further information is provided below on major scanner systems. (Table 3)

The 3M True Definition captures images using wavelength sampling technology (‘3D-in-Motion’) and blue light/LED video, which continuously acquires data while the operator can use the touchscreen to control the scan. (Figure 1) The scanner can capture

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<th>Table 2. Restorative Indications by Scanner</th>
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<tr>
<td>3M True Definition</td>
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<tr>
<td>3Shape TRIOS</td>
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<tr>
<td>Carestream CS3500</td>
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<tr>
<td>CEREC Bluecam</td>
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<tr>
<td>CEREC Omnicam</td>
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<td>iTero</td>
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<td>Planmeca PlanScan</td>
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20 3D data sets/second, equivalent to nearly 2,400 data sets/arch, which allows the wand to be moved while scanning without altering the scans (continuous image capture). For accuracy combined with speed of acquisition, the 3M True Definition scanner requires that a spray containing a proprietary formulation of titanium dioxide (3M High-Resolution Scanning Spray) be used on the surfaces prior to scanning to increase contrast. Instantaneous 3D model and feedback is obtained with the system, which means that any required adjustments and rescanning are quickly found.

The 3Shape TRIOS scanner uses adaptive scanning technology with multiple cameras and builds the scan sequences to create the image. The scanner can be connected to a laptop using a USB port, integrated into the dental unit, or used with a cart. (Figure 2)

Both arches are automatically aligned. The TRIOS 3 provides RealColor imaging, detailed shade mapping, and clinical photographs using the built-in intraoral camera. After image acquisition, the images and interocclusal clearance can be checked and specific areas rescanned or adjusted if required. (Figure 3) Detailed shade mapping has been shown to provide highly esthetic results.16, 17 (Figure 4)

Options for scanning images with the CEREC system include the CEREC Omnicam and the CEREC Bluecam. These differ in imaging technique, focal depth, and size. The Omnicam uses continuous imaging to generate 3D digital scans in natural color, while the Bluecam acquires single images that are then stitched together to create a 3D digital model. Omnicam is also a powder-free technique and has a focal length of up to 15 mm, while Bluecam requires that titanium dioxide powder be used as a contrast medium and the scanner can be placed on the tooth surface. The CEREC AC cart digital

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<td><strong>Image Acquisition</strong></td>
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<tr>
<td>3M True Definition</td>
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Figure 1. 3M True Definition scanner and wand
Figure 2. TRIOS scanner
Figure 3. Image showing interocclusal clearance
An Update on Digital Impressions

imaging unit integrates with the Omnicam and Bluecam scanners, and provides the design elements. A desktop version, the CEREC AF, also integrates with both scanners and CEREC AI integrates with the treatment center. (Figure 5) On-screen virtual articulation can be observed, and the interocclusal clearance digitally checked. As with other systems, any necessary adjustments can quickly and easily be made.

The Planmeca PlanScan uses blue laser technology with a wavelength of 450 nm. It scans continuously and provides real-time images of the preparations, both arches and the occlusion on a laptop with a USB connection. While scanning, missing data can be seen on the screen indicating where additional scanning is required. The system is open and data is saved in STL format files.

The scanning tip is available in standard, landscape (the smallest at 12.7 mm by 9.2 mm), and portrait sizes. The smaller tips are preferred for molar sites. The handheld portion of the scanner with the removable tip measures 1.9 x 2.1 x 10.9 inches (48 x 53 x 276 mm). (Figure 6) An optional color tip is also available. Bite registrations can be scanned, and together with the models aligned, the amount of contact can be observed as a color map. This system can also be used to scan traditional impressions.

The iTero Element Intraoral Scanner utilizes parallel confocal scanning and continuous laser scanning. This scanner takes rapid scans at 20/second and provides color scanning. The wand has side buttons and a touchpad. The system also offers connectivity to milling systems, including Planmeca. This digital impression system is available as a cart version and as a desktop version.

Productivity and Practice Building

Digital impressions are quicker to obtain than traditional impressions, and the user is quickly able to see any areas needing additional attention or adjustment rather than potentially finding there was an error at the patient’s seat appointment. This saves time, increases productivity, reduces cost, and helps to avoid having a dissatisfied patient. Together, the more pleasant experience of digital impressions, the perception of being a ‘hi-tech’ office, and the excellent esthetics that can be achieved represent a valuable practice builder.

Other Considerations

From a documentation standpoint, a pretreatment and post treatment scan can be taken to record treatment, including due to medico-legal considerations. While beyond the scope of this article, it is worth noting that the number of systems able to offer additional technologies for digital impressions in multiple disciplines has expanded. As a result, connectivity and partnering with companies in these disciplines is also increasing.

Conclusions

Digital impressions offer good accuracy for the delivery of indirect restorations, provided care is taken to follow the instructions for use and to obtain good soft tissue management and isolation. Systems offer the ability to scan both arches, the preparation, bite registrations and the occluded dentition, show interocclusal space and real-time images. The flexibility and capabilities of digital impression systems continue to increase, and more are being expanded for applicability to multiple disciplines. The digital impression experience is more pleasant for patients, and this technology has the potential to save time and increase productivity.
References


Acknowledgment

Figures 3 and 4 courtesy of Dr. G. Franklin Shull.

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1. Digital dental impressions were first introduced in the _____.
   a. 1960s  
   b. 1970s  
   c. 1980s  
   d. 1990s

2. The adoption of digital impressions for restorative care has been fostered by _____.
   a. the availability of accurate CAD/CAM systems  
   b. esthetic and durable CAM restorative materials  
   c. advanced adhesive technologies  
   d. all of the above

3. With a stand-alone scanner system, restorations can immediately be fabricated.
   a. True  
   b. False

4. Adequate interocclusal and proximal space must be created to _____.
   a. match the physical properties and requirements of the restorative material being used  
   b. leave sufficient space lingually for muscular function  
   c. leave sufficient space for adhesive  
   d. a and c

5. In one review and meta-analysis, a comparison of marginal gaps found that _____.
   a. traditional impressions were much more accurate than digital impressions  
   b. digital impressions were much more accurate than traditional impressions  
   c. there were no significant differences in the accuracy of digital and traditional impressions  
   d. neither digital nor traditional impressions fell within the generally accepted maximum gap level

6. The generally accepted maximum marginal gap for restorations is _____.
   a. 90 microns  
   b. 120 microns  
   c. 150 microns  
   d. 180 microns

7. Digital impressions offer less opportunity for errors than traditional impressions provided the instructions for use are followed.
   a. True  
   b. False

8. Soft tissue management and isolation are essential for accurate and complete scanning of the margins, the area _____ to the margins, and the whole preparation and adjacent teeth.
   a. opposite  
   b. 0.5 mm coronal  
   c. 1.5 mm apical  
   d. 0.5 mm apical

9. Options for soft tissue management include ____________.
   a. retraction cord  
   b. retraction paste  
   c. diode lasers  
   d. a and c

10. In the field of digital impressions, there is more focus on _____ and _____.
    a. complexity; open-system  
    b. connectivity; open-system  
    c. connectivity; closed-system  
    d. flexibility; closed-system

11. Single-cord or double-cord retraction may be used for soft tissue management prior to digital scanning.
    a. True  
    b. False

12. Systems with an open-system architecture utilize a standard format file, typically _____ file.
    a. a DHL  
    b. an STD  
    c. an STL  
    d. a DHT

13. Closed systems maintain ownership of the _____.
    a. equipment  
    b. downstream process  
    c. upstream process  
    d. office

14. Some scanners require that titanium dioxide powder first be sprayed on the site to function as a _____.
    a. disinfection medium  
    b. ion neutral medium  
    c. contrast medium  
    d. none of the above

15. Instantaneous 3D model and feedback means that _____.
    a. patients are always happy  
    b. any required adjustments are quickly found  
    c. patients can quickly be given an extra appointment  
    d. staff are always happy

16. Shade mapping allows for _____.
    a. detection of calculus at the margins requiring removal before the scan  
    b. caries detection  
    c. excellent esthetics  
    d. a and c

17. Digital impressions take a little more time to obtain than traditional impressions.
    a. True  
    b. False

18. One of the practice-building aspects of digital impressions is _____.
    a. the excellent esthetics that can be achieved  
    b. the more pleasant experience of digital impressions  
    c. the perception by a patient that the office is ‘hi-tech’  
    d. all of the above

19. Connectivity and partnering with companies in other disciplines is _____.
    a. increasing  
    b. decreasing  
    c. not cost-effective  
    d. problematic

20. The flexibility and capabilities of digital impression systems continue to increase, and more are being expanded for applicability to multiple disciplines.
    a. True  
    b. False

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**EDUCATIONAL OBJECTIVES**
1. Describe the changes that have occurred in digital impression technologies.
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3. Review the differences between open and closed architecture, scanning options and restorative options with different systems.

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