Understanding the Potential of Digital Intraoral and Benchtop Scanning Workflows

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Abstract: Although the overwhelming majority of dental offices now use digital radiography and patient records, relatively few yet use either stand-alone intraoral scanning systems (6%) or complete systems that combine intraoral scanning with computer-aided design and computer-aided manufacturing (12%). This should change as dentists become more aware of the numerous advantages scanning systems offer in terms of patient care and communication of patient information, particularly with the dental laboratory. This article reviews the various types of scanner architecture as well as potential workflow models.

Any dental offices have implemented digital processes, including the creation of digital patient records. For many restorative and surgical practices the transfer and sharing of some parts of patients’ digital records—including health history, financial/insurance information, and digital radiographs—are well understood and routine. In fact, an estimated 90% of dental offices use some type of digital software for patient records, with 71% using digital radiographs. The often-overlooked component of the patient record—laboratory information (eg, impressions, models, restoration fabrication data)—is also becoming increasingly digital; however, incorporation of digital methods for creating and transferring this intraoral data is far less prevalent than for the aforementioned data. For example, despite the benefits offered by digital impression scanners, such as greater accuracy, enhanced patient comfort, and savings of time and materials, stand-alone intraoral scanner (IOS) systems are used in just 6% of dental offices. Complete systems combining IOS and in-office restoration milling (computer-aided design/computer-aided manufacturing [CAD/CAM]) (eg, PlanScan™, Planmeca, www.planmeca.com; CEREC®, Sirona Dental, www.cereconline.com; CS 3000™, Carestream Dental, www.carestreamdental.com) are found in only 12% of dental offices.
data of analog impressions and/or models. Both types of scanners convert the acquired images and data into a digital format.

Once in a digital format, these records can potentially be electronically transferred between restorative, surgical, and laboratory teams, presenting opportunities to change current dental workflow models.\(^2,9\) However, this capability is dependent upon whether the scanner’s architecture is open, closed, or semi-open (as described below).

This article reviews various digital workflows that could be incorporated into restorative, surgical, and laboratory offices when the laboratory portion of patient records is acquired using IOS or benchtop scanning systems.

**Scanner Architecture**

Not all digital data are the same, and some cannot be shared easily. Like different dialects, there are different types of system architecture. Because their architectures—ie, the ability to send and receive digital data in a usable format—may differ, not all of the various IOS systems or manufacturers’ scanned data are interchangeable. As a result, data collected from an IOS system from one manufacturer may not be able to be exported to fabricate a milled restoration from another manufacturer.

Today there are three types of architectures: open, closed, and semi-open. Open architecture enables a scanner (eg, Trios\(^\text{TM}\), 3Shape, www.3shape.com; PlanScan\(^\text{TM}\), Planmeca, www.planmeca.com; 3M\(^\text{TM}\) True Definition, 3M ESPE, www.3m.com; iTero\(^\text{TM}\), Align Technology, Inc., www.itero.com) or digital system from one manufacturer to send and receive data from various other manufacturers. In such a case, IOS data from system A can be exported and used to mill a restoration on system B. These scanners typically produce stereolithography files that can be used with multiple design software systems, thereby enabling dentists to work with a variety of referring specialists and laboratories.\(^{10,11}\) The ideal situation is to have a digital scanning system with an open architecture and thereby have the ability to use all manufacturer data interchangeably and among a variety of partners (eg, dental colleagues, specialists, laboratories).

With closed-architecture systems, such as CEREC, only data from a given manufacturer’s system can be used. Typically, the IOS and milling units for CAD/CAM systems are combined by the manufacturer. In this scenario, scan data from system A can be used to mill a restoration on the system A mill, but scan data from system B or C cannot be exported to the system A mill for milling a restoration. The individual manufacturers determine how IOS images and data can be transmitted.\(^8\)

Semi-open architecture enables a system to accept some type of third-party data to enhance its own data or add value to its data. For example, cone-beam computed tomography (CBCT) data from system C will accept some third-party software from system D to enhance viewing of the system C scan data.

Therefore, when dental practitioners are contemplating different workflows based on digital data transfer, architecture is an important consideration. Just as there are language barriers that impede communication among individuals, scanning system architecture barriers among different equipment and software companies can limit the use of data by dental professionals using different scanning and/or CAD/CAM systems. The type of workflow model desired by dental professionals—including restorative dentists, specialists, laboratories, and production centers—should be considered when purchasing any type of digital system. Just because a dental practice has and uses an IOS does not mean its collaborative or referral partners will be able to use the acquired data.

**Potential Workflow Models**

Any dental practitioner today could benefit from using an IOS system. Depending on whether the system is a stand-alone unit or part of a complete CAD/CAM milling system, different workflows could be implemented to capture tooth and soft-tissue morphology, topography, and preparation data to ultimately produce restorations (eg, inlays, onlays, crowns, veneers, fixed partial dentures), models, master casts, surgical guides, or orthodontic appliances. Workflows that are possible by incorporating IOS systems are described below.

**IOS for In-Office Fabrication**

IOS systems can be used in conjunction with CAD/CAM and milling technology in the dental practice for fabricating many different types of restorations. A variety of same-day restorations offer patients significant convenience and practitioners more control over the restorative process yet with the same accuracy demonstrated by restorations fabricated by a professional dental laboratory.\(^3,5,12\)

![Image](Fig 2)  
**Fig 2.** Whether in the dental office or the laboratory, CAD enables efficient and accurate design and evaluation of proposed restorations based on IOS data: multiple restorations can be done with CAD at one time (Fig 1), and individual cusps (Fig 2) can be manipulated and put in occlusion, as can contacts and restoration profiles (Fig 3).
Scanning the intraoral landscape, designing restorations chairside, and milling them in the dental practice reduces the time required to deliver restorations from several weeks to just a few hours in the same day.

In this workflow model, intraoral images are captured using the IOS, after which computer software evaluates and manipulates the images into 3-D renderings, such as digital images of the impression and digital models. The dentist then uses this information to design the proposed restoration—a computer-aided design, or CAD, process (Figure 1 through Figure 3). Once the restoration is designed, the information is transferred to the in-office milling unit for fabrication.

While there is a learning curve, advances in intuitive software for both capturing intraoral data and designing and milling restorations are making this workflow increasingly popular in restorative dental practices. Overall, complete in-office CAD/CAM systems enable dental practices to perform all aspects of the restorative process digitally: impression making, model making, and restoration design and fabrication.13

What clinicians must understand is that a complete system can offer different workflows in their practice, including same-day and/or next-day dentistry, which many patients are now desiring. Additionally, complete systems offer more control of the restoration. Scan data can be used to mill multiple restorations or anterior restorations, which the clinician may feel more comfortable completing with the help of a laboratory professional. In such cases, restorations can be milled in the dental office and then sent to the dental laboratory for completion. This can both reduce the clinician’s laboratory bill and save the laboratory time.

**IOS for Transfer to a Business Partner (eg, Dental Laboratory for Restoration Fabrication)**

Many restorative dentists choose not to fabricate restorations in their offices yet appreciate the convenience, accuracy, and real-time collaborative potential that can be achieved with digital impressions. Moreover, even if a dentist has a complete IOS and CAD/CAM system, there may be cases for which higher-strength materials (eg, zirconia) are needed, but the dentist’s in-office capabilities cannot accommodate such restorations. For example, cases that require a zirconia restoration that must be baked or those requiring cutback techniques for esthetic layering can be digitally scanned and the data files sent to the laboratory for fabrication. Additionally, a dentist with a complete IOS and CAD/CAM system could switch from a chairside workflow to this collaborative model by sending optical impressions to the laboratory when treatment challenges arise.14

In this workflow model, dentists acquire data about the patient’s preoperative condition and tooth preparations using an IOS stand-alone system or the IOS of the complete system (keeping in mind the necessary architecture), and then transfer the digital files to their laboratory, regardless of geographic location. In such a scenario, the IOS and digital file transfer represent an advancement over sending impressions and/or models via traditional methods of mailing or shipping. Currently, orthodontists frequently use stand-alone IOS systems and this type of workflow model, particularly those practitioners who prescribe removable clear aligners for their patients’ treatment. Furthermore, in the author’s experience, when an IOS system is used to send patient intraoral data to the dental laboratory, cases can be completed and returned in as few as 3 days.

**IOS for Information Sharing Among Referring Dental Professionals and Laboratories**

The availability of IOS systems is enabling patient referrals among multidisciplinary dental practices (eg, oral surgeons, periodontists, restorative dentists), as well as collaboration with dental laboratories. In this workflow model, an oral surgeon, for example, may consult with a patient, acquire IOS images and CBCTs (see section...
below) both pre- and postoperatively, and transfer them to the restorative dentist and/or laboratory as a means to generate and maintain referrals, as well as facilitate treatment planning (Figure 4 through Figure 6). This type of virtual treatment diagnosis and planning using IOS and CBCT systems fits naturally into the routine flow of treatments.

Alternatively, when the restorative dentist uses an IOS, preoperative data can be acquired and transferred to the oral surgeon as part of the collaborative process to better plan surgical procedures (eg, implant placement). This saves the patient time and offers convenience, because referral consultations are generally performed virtually, without the need for a separate patient appointment with the surgeon or specialist.

Furthermore, consider that after placing implants, oral surgeons and/or periodontists perform a surgical release to verify healing—usually 3 to 4 months post-treatment—to ensure the patient can proceed with restorative therapy. During this appointment, the specialist can use an IOS system and scan the now integrated implant with a corresponding scanbody in place to provide relevant impression and opposing-arch/occlusion data to the restorative dentist and laboratory, thereby relieving the patient of the need for an impression appointment with the restorative dentist.

This workflow would involve the surgeon using a scan-ready healing abutment or removing the healing abutment, placing a scanbody on the implant, and scanning it using an IOS. This significantly streamlines the process for all parties involved. Previously, impressing for dental implant restorations required the use of conventional impression materials and impression copings, a time-consuming effort fraught with the potential for errors.

**IOS and CBCT for Partnering With Referring Professionals and Laboratories**

With a digital patient record system and IOS, software can be used to incorporate CBCT images and data to facilitate implant and other dental surgical treatment planning. If a restorative dentist has both an IOS system and a CBCT, the two data files could be merged and forwarded to the dental laboratory and oral surgeon/periodontist for treatment planning (Figure 7) to determine ideal implant placement based on proposed restorative needs and for fabrication of an implant surgical guide.
In this type of workflow model, a CBCT scan is made showing the area of concern, along with an IOS or a benchtop scan of a model or impression. This enables thorough evaluation of the patient’s condition, as well as planning of ideal restorations from esthetic and functional perspectives. The intraoral information can be merged with the CBCT scan to further evaluate whether the proposed treatment is appropriate or whether additional procedures (eg, bone grafting) should be considered (Figure 8 through Figure 10). These images can then be used for collaboration with the laboratory and referral specialists, either via cloud-based file sharing or electronic transmission, to ensure that a restoratively driven approach is undertaken for ideal implant placement.34,39

Benchtop Scanner for Transferring Digital Data Based on Analog Impressions/Models to Laboratories or Production Centers
A variety of benchtop scanners (Figure 11) have become available, enabling scanning and digitizing of conventional analog impressions and models by dentists who do not have or want an IOS system but who still desire the convenience of digital data.20 One concern is that most benchtop scanners are only able to scan 65% to 70% of impressions (personal communication with Mike Girard, RDT, Managing Consultant, Modern Dental Lab USA, August 2015). Due to the negative dynamic topography (ie, undercuts), the scanners have difficulty obtaining all of the analog impression data.

Benchtop scanners still need to evolve in order to serve as a viable and reliable alternative for obtaining digital data regarding tooth and soft-tissue morphology, topography, and preparations.

Conclusion
Acquiring and processing information digitally—with IOS, milling units in the dental office, or transferring digital files of analog impressions and models to the laboratory—offers tremendous advantages to dental professionals and completes the patient’s digital record. These advantages are maximized when IOS and benchtop scanning are incorporated into new digital workflows, any one of which can enhance communication of patient information among restorative, laboratory, and surgical/specialist partners.

DISCLOSURE
The author had no disclosures to report.

Fig 9 and Fig 10. By merging CBCT files with IOS files and using implant planning software, dental professionals can plan all components of the implant/restoration procedure in advance for a restoratively driven approach: CBCT, IOS, and CAD merged and overlaid as one (Fig 9); implant placement and implant guide CAD (Fig 10). Fig 11. Example of a box scanner for acquiring digital images of analog models or impressions.
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Queries to the author regarding this course may be submitted to authorqueries@aegiscomm.com.

REFERENCES

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1. Digital dental scanners record information by acquiring what via a scanning device?
   A. radiographs
   B. images
   C. workflows
   D. computer-aided designs

2. What type of scanner captures image data of analog impressions and/or models?
   A. intraoral
   B. benchtop
   C. IOS
   D. none of the above

3. What type of architecture enables a scanner or digital system from one manufacturer to send and receive data from various other manufacturers without limitations?
   A. open
   B. closed
   C. semi-open
   D. all of the above

4. What type of architecture allows only data from a given manufacturer's system to be used?
   A. open
   B. closed
   C. semi-open
   D. none of the above

5. Intraoral scanning (IOS) systems can be used in conjunction with CAD/CAM and what in the dental practice for fabricating different types of restorations?
   A. DICOM files
   B. cutback techniques
   C. same-day shipping
   D. milling technology

6. While there is a learning curve for in-office restoration fabrication with CAD/CAM, advances in what are making this workflow increasingly popular?
   A. intuitive software
   B. model-making technology
   C. esthetic layering techniques
   D. surgical guide quality

7. Even with a complete IOS and CAD/CAM system, there may be cases that the dentist’s in-office capabilities cannot accommodate, such as those involving:
   A. same-day restorations.
   B. scanning of the intraoral landscape.
   C. higher-strength materials (eg, zirconia).
   D. 3-D images.

8. When an IOS system is used to send patient intraoral data to a dental laboratory, the case can be completed and returned in as few as:
   A. 30 minutes.
   B. 1 hour.
   C. 3 days.
   D. 2 weeks.

9. In the “IOS for Information Sharing Among Referring Dental Professionals and Laboratories” workflow, a surgeon uses what to streamline the process?
   A. conventional impression materials
   B. impression copings
   C. a laser scanner
   D. a scan-ready healing abutment

10. With a digital patient record system and IOS, software can be used to incorporate what to facilitate surgical treatment planning?
    A. a light-emitting diode
    B. CBCT images and data
    C. overnight delivery
    D. insurance information

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