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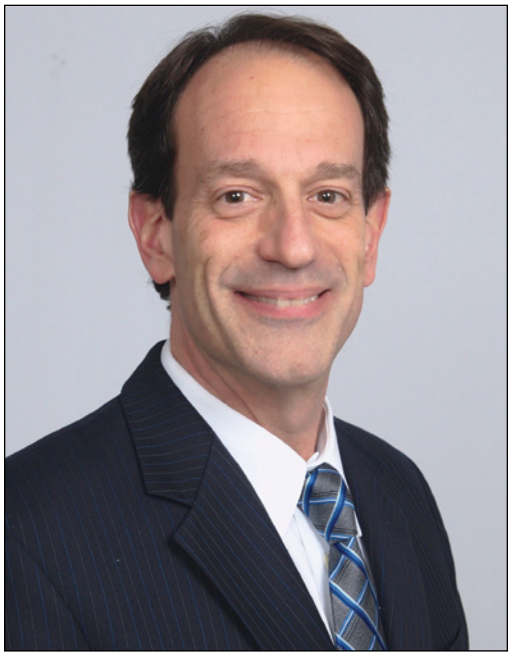

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Disclosure: Dr. Silverman is a consultant for Carestream Dental and BioHorizons.

The Complete Digital Workflow in Implant Dentistry

This article discusses the complete digital workflow in implant dentistry that streamlines the process for achieving the correct prosthetic restorative position prior to implant placement in order to ensure long-term implant success.

Digital technology can reshape businesses' and society's ways of thinking. Initially, there can be a short-term disruption of learning while a new technology and workflow are implemented into a business, but, overall, the long-term gains should be the goal to be focused upon. When dentists first started placing implants, it was protocol to place the implant where adequate bone was located, which often created prosthetic problems. Clinicians quickly shifted to being prosthetically driven with implant placement, whereby the end result is planned first.[1,2] It was first determined where the crown or prostheses needed to be located, followed by what series of steps was necessary to achieve an optimal final result. The correct prosthetic restorative position allowed for proper occlusion, function, and long-term dental implant success.[2]

The complete digital workflow allows clinicians to digitally streamline this process and predictably place an implant where it needs to be prosthetically placed.[3] This digital workflow creates greater ease of prosthetic restorability. It provides clinicians the means to plan, arrange treatment, place implants, and complete cases more predictably and as efficiently as possible.

Envision a Rubik's Cube with one side having unique colors and words on each box. One says CBCT; one says intraoral scanner; and others say 3-D printer, guided surgery, immediate milled provisional, surgical guide, CAD/CAM software, implant planning software, digital radiography, temporary abutment, customized gingival former, milled zirconia restoration, etc. It looks like a rainbow of colors and words without any meaning, but as we turn each piece and learn more about these techniques, the colors become one and the words start making sense. The digital workflow becomes clear.

When looking at the complete digital workflow for implant dentistry, there are several options available to the clinician. The most important part of this process is the armamentarium. The center of the digital wheel is an intraoral scanner. With many scanners available on the market, clinicians should focus on one that is an open platform, provides HD-quality images, does not require spray-on powder to scan,[4] has no pay-per-click fees, provides a degree of accuracy greater than conventional techniques,[4,5] and is portable. Next, using or having access to an in-office cone beam computed tomography (CBCT) scanner is also paramount to digital workflow. The CBCT scan, with its primary and secondary 3-D reconstructions, allows the viewing of a patient's bony anatomy before the patient is taken to surgery. It is crucial in planning implant placements.[6] The machines available today have high resolution and several different views available, so the amount of radiation given to patients is limited.[7]

Digital software is the next component of digital workflow. There are several types of digital planning software on the market. The software will typically take the DICOM (digital imaging and communications in medicine) files from the CBCT scanner and merge them with the stereolithography (STL) files from the intraoral scanners and allow surgical guide planning,[2] as well as abutment and crown design and milling.[8] Last on the list of equipment is a 3-D printer. Whether one chooses to use the services of an outside third party or have a 3-D printer in the office, the 3-D printers now available allow for surgical guide and crown fabrication, as well as the ability to mill abutments, bars, and zirconia crowns with degrees of accuracy that surpass those of analog techniques.

There are many options for integrating digital workflow into implant dentistry. The first option is guided surgery. As mentioned previously, implant placement is prosthetically driven in terms of planning. The proper position of crowns must be planned in order to allow patients to function in a

Figure 1. A patient presents with a horizontal fracture of his maxillary left lateral incisor.

Figure 2. The DICOM files of the CBCT scanner are merged with the STL files of the intraoral scanner, and a guided surgical guide is fabricated, along with a temporary PEEK abutment and a temporary acrylic crown.

Figures 3 and 4. After the extraction with periotomes, the surgical guide is placed, and then the implant is placed.

Figure 5. After stability is confirmed with an ISQ reading of 68, the temporary abutment and crown are placed at the time of implant placement.

Figure 6. The sculpting of the gingiva in the aesthetic zone is started right away. The patient is seen here at a 2-day postoperative check of occlusion.

Figure 7. An intraoral view of a custom-milled gingival former, planned and fabricated with the guided surgical guide preoperatively. It is inserted at the time of implant placement. This allows the developing of the emergence profile of the final restoration to begin at the time the implant is placed.

biocompatible and optimal physiologic state, and then implant placement is planned accordingly. A CBCT scan and an intraoral scan are taken and merged into implant planning software, and virtual crowns are placed where the patient's teeth need to be. The exact angulation and position of the virtual implants are inserted into the software, and a guide is planned and printed. This process can be performed by a third party or in-office. The patient presents for surgery, and, using the guide, the implants are placed where they prosthetically need to be placed.[9] Several options exist within this process. The guide can be fabricated alone and the implant placed, or a temporary abutment and temporary crown can be prefabricated with the guide. If the implant is sufficiently stable, the clinician can place the temporary abutment and temporary crown and start sculpting the gingival tissues and emergence profiles at the time of implant placement (Figures 1 to 6). This could be important in an aesthetic area of the mouth.

Whether we place implants and perform a 2-stage approach or perform a one-stage surgery and place a gingival former or healing abutment at the time of placement, using a surgical guide can minimize tissue reflection. If the decision is not to immediately load the implants but to start sculpting the gingival tissues, the laboratory can prefabricate a customizable gingival former. This customizable gingival former can be placed at the time of implant placement and would allow the clinician to start contouring the gingival tissues during the osseointegration process (Figure 7).

Once the implants integrate, the options are using a standard abutment or fabricating a custom abutment. If the choice is to fabricate a custom abutment, the clinician would normally take a fixture level impression using a fixture level impression coping in the analog method. However, the digital option would allow the placement of a scan body, which is the digital counterpart of the fixture level impression coping. Here the gingival former is removed, the scan body is placed into the implant, and a digital intraoral scan is performed. The digital scan is sent to a digital lab, and a custom abutment and crown are planned and milled. Using this technology, screw or cementable restorations, or individual or bridge restorations, can be used.

CASE REPORT

A 69-year-old male presented for the extraction of his mandibular right second premolar, mandibular right first molar, mandibular right second molar, and mandibular right third molar (Figure 8). Upon presentation, his past medical history was significant for glaucoma. He had no known allergies and was taking Tamsulosin and Lumigan medications and 81 mg of aspirin. The patient complained of occasional pain and swelling from his carious and non-restorable dentition previously noted. An oral examination was performed along with a panoramic radiograph.

After consultation with his restorative dentist, the plan was for the replacement of his mandibular right second premolar and mandibular right first and second molars with an implant-supported restoration. The surgical and prosthetic plan was to extract the above noted teeth and bone graft sites for teeth Nos. 29, 30, and 31. After 4 months of healing, a guided surgical implant placement would be performed. Following integration of the endosseous implants, digital intraoral impressions and the fabrication of abutments and crowns were planned.

The patient was taken to the surgical suite, where intravenous anesthesia was induced and maintained in a balanced technique. Local anesthesia was obtained with 144 mg 4% Articaine 1:100,000 epinephrine, placed in an infiltrative fashion. An intrasulcular incision was performed, minimal flaps were reflected, and teeth were sectioned and removed in an atraumatic fashion. Any residual granulation tissue was curetted from the sockets. MinerOss (BioHorizons) 50/50 cortical/cancellous bone was placed in the involved sockets, and a non-resorbable membrane (Cytoplast [Osteogenics]) was placed and tucked under the minimal flaps both buccally and lingually. Next, 3-0 polytetrafluoroethylene (PTFE) sutures were placed in an interrupted fashion, affording non-primary closure of the wounds. This author prefers the use of non-restorable membranes in this situation to help develop a greater amount of attached or keratinized gingiva for second-stage tissue development (Figure 9). The sutures were removed in 2 weeks, and the membranes were removed one month after the surgery.

The areas were allowed to heal for approximately 4 months, and then a CS 3600 intraoral scanner (Carestream Dental) was used to perform a digital intraoral scan, and CBCT images were obtained (CS 9300 [Carestream Dental]) (Figures 10 and 11). The DICOM file of the CBCT scan and the STL file of the intraoral scan were sent to Implant Concierge (San Antonio, Texas), and implant placement in the mandibular right second premolar and the first and second molar sites was planned using coDiagnostiX Implant Planning Software (Dental Wings) (Figure 12). The STL file was sent to the author's office, and the in-office 3-D printer (Form 2 [Formlabs]) was used to print the

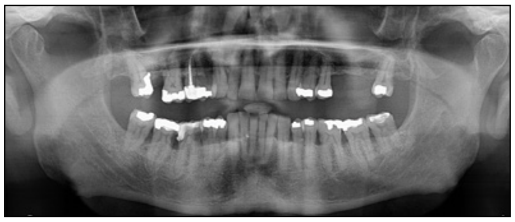

Figure 8. The pre-op panoramic radiographic view prior to the extraction of the mandibular right involved teeth.

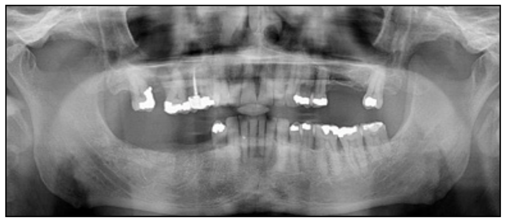

Figure 9. A panoramic radiograph of the mandibular right area following the healing of bone grafts in the areas of teeth Nos. 29, 30, and 31.

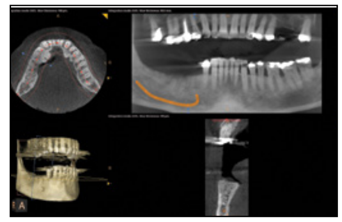

Figure 10. A cone beam scan prior to exporting and merging it with an intraoral scan and using software for implant planning.

Figure 11. An intraoral scan of the partially edentulous planned implant area.

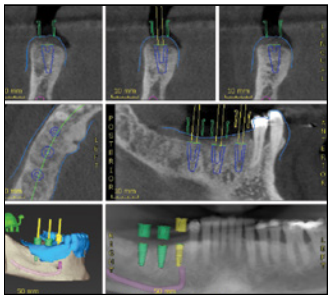

Figure 12. The CBCT image is merged with the STL of the intraoral scan. Using the implant planning software, the virtual crowns are planned where they need to be, and the implants are placed to allow for proper crown positioning.

Figure 13. The surgical guide in place prior to flapless implant placement.

Figure 14. The initial placement of 3 BioHorizons Tapered Internal Implant Systems, with 3.0-mm gingival formers in place.

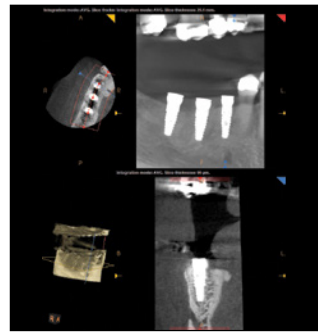

Figure 15. A CBCT scan of the mandibular right area immediately following implant placement, confirming good positioning of implants well within bone and above the mental foramen.

Figure 16. The placement of Snap scan bodies (BioHorizons) after seating was confirmed by intraoral radiographs and prior to intraoral scanning.

Figure 17. An intraoral scan of the mandibular right area using the CS 3600 (Carestream Dental).

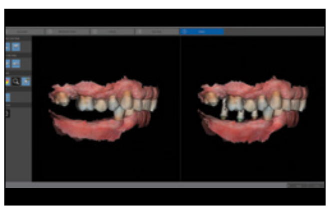

Figure 18. Intraoral tissue and bite scans from the intraoral scanner, which will be exported to the dental lab to plan and mill the restorations.

Figure 19. The printed 3-D model, with implant analogues placed inside. Milled custom titanium abutments are under milled zirconia crowns.

Figure 20. The intraoral view of the final zirconia restoration in the mouth after titanium abutments were inserted and torqued to place and the bite and contacts were adjusted.

Figure 21. A panoramic radiograph of the completed case.

guide. BioHorizons-manufactured tubes were placed inside the guide. The guide was processed according to the 3-D printer protocol and sterilized using an autoclave at 134°C for 3 minutes.

The patient was taken to surgery, and since adequate attached gingiva was present, a flapless approach was used for the implant placements (Figure 13). A 3.8- x 10.5-mm implant (Tapered Internal Implant System [BioHorizons]) was placed in the mandibular right second premolar area, and 4.6- x 10.5-mm implants were placed in both the mandibular first and second molar sites. All implants were placed with greater than 35 Ncm of insertional torque values, and 3-mm gingival formers were placed (Figures 14 and 15). The implants were allowed to fully integrate over the following 3 months.

The patient presented back to the office. First, a periapical radiograph was obtained, confirming the maintenance of good crestal bone and no periapical radiolucencies. The healing abutments were removed, and an implant stability quotient (ISQ) reading greater than 70 ISQ on each implant was obtained, confirming good implant stability. Implant-type- and size-specific scanning bodies were placed in each implant (Figure 16). Periapical radiographs were taken to confirm proper placement. The CS 3600 was used to obtain maxillary and mandibular soft-tissue, implant, and bite scans (Figures 17 and 18). The STL files were sent to Vulcan Labs (Birmingham, Ala). Custom abutments and crowns were planned using Implant Studio software (3Shape). A model was printed, implant analogs were placed, and custom titanium abutments and Zirconia crowns were milled (Figure 19). The custom titanium abutments were placed, the positions were confirmed radiographically, and the abutment screws were torqued to 30 Ncm. The zirconia crowns were inserted and cemented with Temp-Bond (Kerr) after the contacts and bite were minimally adjusted (Figures 20 and 21).

CONCLUSION

In the case presented, a complete digital workflow was performed from start to finish. There are several options available when using the digital implant workflow; this case demonstrated several of them. Once digital dentistry is integrated into a practice, it can be more predictable than analog, require less chair time and remakes, and reduce costs. Hopefully, this workflow will provide more optimal care for patients and, ultimately, increase implant referrals.✦

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TEST 230 Expiration date of this CE article is February 1, 2022

To submit Continuing Education (CE) answers, use the answer sheet below. Or, use our easy online option at dentalcetoday.com. This article is available for 2 hours of CE credit. The following 10 questions were derived from "The Complete Digital Workflow in Implant Dentistry" by Bart Silverman, DMD, on pages 86 to 88.

Learning Objectives: After reading this article, the individual will learn: (1) the armamentarium needed for complete digital workflow in implant dentistry, and (2) an example of the step-by-step process for using a complete digital workflow in implant dentistry. **Subject Code:** 690.

1. Which is *not* part of the digital workflow armamentarium?
- **a.** A CBCT scanner.
- **b.** An intraoral scanner.
- **c.** An analog impression coping.
- **d.** Implant planning software.

2. When placing an implant, the clinician:
- **a.** Would like to place the implant where the bone is.
- **b.** Goes to the end result first, and then places the implant where the implant needs to be so the crown can be in a proper biomechanical position.
- **c.** Places the longest and largest implant that will fit into the space.
- **d.** All of the above.

3. An implant surgical guide can be fabricated alone, and the implant can be placed. Or, a temporary abutment and temporary crown can be prefabricated with the guide.
- **a.** The first statement is true; the second is false.
- **b.** The first statement is false; the second is true.
- **c.** Both statements are true.
- **d.** Both statements are false.

4. When fabricating a guided surgical guide, one must merge the DICOM file of the CBCT scan with the STL file of the intraoral scan in the implant planning software.
- **a.** True.
- **b.** False.

5. When discussing options available within a digital workflow, which is *not* a viable option?
- **a.** The fabrication of a surgical guide.
- **b.** The fabrication of a surgical guide with a custom healing abutment.
- **c.** The fabrication of a surgical guide with a temporary abutment and a provisional crown.
- **d.** None of the above.

6. After the implant integrates, a digital impression can be obtained by placing and scanning:
- **a.** A ti-base abutment.
- **b.** A scanning body.
- **c.** A final crown.
- **d.** None of the above.

7. In the fabrication of a guided surgical guide, once the case has been planned:
- **a.** The surgical guide can be printed by a third party.
- **b.** The STL of the planned guide can be sent to an in-office 3-D printer, and the guide can be printed in-office.
- **c.** The guide can be both planned and printed in-office.
- **d.** All of the above.

8. A benefit of fabricating a temporary abutment and provisional crown that is placed at the time of implant placement is that it allows the sculpting of the gingival tissues and contouring of the emergence profile to begin at the time the implant is placed.
- **a.** True.
- **b.** False.

9. The complete digital workflow in implant dentistry allows for:
- **a.** Predictable and more exact final crown fabrication.
- **b.** Decreased costs associated with implant dentistry.
- **c.** Less chair time.
- **d.** All of the above.

10. In-office CBCT:
- **a.** Is necessary for guided surgical guide fabrication.
- **b.** Has a smaller footprint and fits in more offices.
- **c.** Provides more options in scan sizes, with less radiation.
- **d.** All of the above.

ANSWER SHEET Test 230, beginning on page 86

Complete the paper answer sheet and submit your answers for this issue's CE examination. Answer at least 7 of the 10 questions correctly to earn 2 CE credits.

Please check the correct box for each question below.

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7. ❑ a ❑ b ❑ c ❑ d
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