COMPUTER-GUIDED WORKFLOW

Using a Digital Dentistry Integrated Planning and Manufacturing Service in Completely Edentulous Treatment

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Abstract: The use of an integrated digital planning and manufacturing modular service and a time-tested dental implant system to treat a completely edentulous patient, as shown in this case report, offers numerous clinical benefits. Computer-guided surgery and digital dentistry have gained in popularity and demonstrated great clinical success; however, clinicians and dental laboratory technicians can further maximize the benefit gained from these technologies through additional training and resource investment. By using the streamlining solution (Smile in a Box®, Straumann) described in a clinical step-by-step manner in this case report, dental professionals can provide effective digital solutions for improved patient treatment acceptance, experience, and satisfaction.

Treatment of partially or fully edentulous patients with dental implants has garnered popularity in recent years. A common treatment option for edentulous patients is a complete fixed dental prosthesis, also known as a "hybrid prosthesis." Typically, a hybrid prosthesis used to restore the patient's occlusal function and esthetic appearance comprises a zirconia, metal-ceramic, or metal-acrylic full-arch fixed dental prosthesis supported by four to eight dental implants.[1,2] Various studies have shown a high success rate of the hybrid prosthesis.[3,4] Besides a fixed dental prosthesis, the implants can be used with a removable partial denture to eliminate metal clasps, provide additional support and stability, and improve patient satisfaction.[5] Regardless of the type of prosthesis, the fundamental success of dental implant treatment is based on prosthetically driven implant planning, accurate intraoral implant positioning, and effective communication among treatment team members (clinicians and laboratory technicians) and patients.

Ideal implant positioning not only helps clinicians avoid damaging vital anatomic structures but also provides a stable peri-implant hard- and soft-tissue environment for favorable prosthesis design.[6] Static computer-aided implant surgery (or computer-guided surgery) has been widely used in preoperative planning to reduce surgical time and improve patient safety during the surgery. Most importantly, CAD/CAM surgical templates can guide the implant placement according to the preoperative plan.[7,8]

The workflow of guided surgery for a completely edentulous patient typically includes fabrication of an interim prosthesis or diagnostic tooth arrangement with desired final prosthesis design, followed by a dual scan. Two cone-beam computed tomography (CBCT) scans are used in a dual-scan with six to eight fiducial markers attached to the interim prosthesis or diagnostic tooth arrangement during CBCT imaging. One scan is taken with the patient wearing the prosthesis, and another scan is taken with the prosthesis alone. The clinician can then merge two sets of CBCT volumetric data in an implant planning software program for subsequent implant planning.[9]

Inspection of the digital data quality and accuracy, registration of multiple digital datasets, implant selection and position planning, surgical template design/manufacturing, and immediate loading prosthesis design/manufacturing are all critical elements to ensure a successful computer-guided surgery. However, without thorough training, practical experience, and investment in resources, the clinician's and dental technician's ability to sustain an effective in-house workflow for computer-guided surgery planning and associated surgical template design/manufacturing could be hindered.

An integrated digital planning and manufacturing modular service (Smile in a Box®, Straumann, straumann.com) can be used that provides streamlining solutions to help clinicians gain confidence, ensure predictability, and improve patient acceptance through utilization of emerging technologies such as computer-guided surgery and CAD/CAM prostheses. For use in daily practice, the modular service also provides the freedom for clinicians and dental technicians to choose which steps in the process they wish to outsource and which steps to keep in-house. This case report, therefore, presents an efficient computer-guided surgery workflow utilizing Smile in a Box service for treating a completely edentulous patient.

Clinical Treatment

A 56-year-old Caucasian man presented to the Center for Implant, Esthetic, and Innovative Dentistry (Indiana University School of Dentistry, Indianapolis, IN) with a chief complaint of wanting to replace his "upper missing teeth with a bridge." His medical history revealed controlled hypertension with medication (enalapril). The patient had no other pertinent medical conditions or allergies. Clinical and radiographic examination showed a completely edentulous maxilla and partially edentulous mandible. The remaining mandibular teeth were periodontally stable, and the patient was being seen every 3 months for regular periodontal maintenance. The existing interim maxillary complete denture and mandibular removable partial denture were clinically satisfactory.

Treatment Planning

Multiple treatment options were discussed with the patient, and he consented to a maxillary metal-acrylic hybrid prosthesis supported by four dental implants and a mandibular implant-assisted removable partial denture with one dental implant. CBCT imaging was completed with a dual-scan protocol with the patient's existing interim prostheses. An intraoral scan was done to capture digital information of the remaining mandibular dentition.

Digital imaging and communications in medicine (DICOM) files from CBCT imaging and a standard tessellation language (STL) file from the intraoral scan were transmitted to the Smile in a Box service via a secure cloud server. The digital dental technician merged all datasets in an implant planning software program (coDiagnostiX®, Straumann) and designed a maxillary diagnostic tooth arrangement in a CAD/CAM software program (CARES Visual®, Straumann). Implant selection and positioning were completed in the implant planning software program (coDiagnostiX).

A remote online meeting was held for the clinicians to discuss the case with the digital technicians in real-time to finalize the surgical plan (Figure 1). After the surgical plan was confirmed, a maxillary CAD/CAM fixation pin

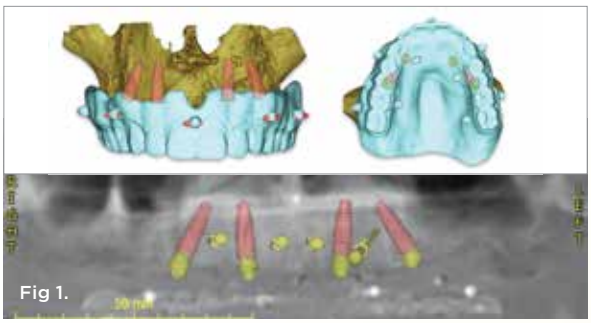
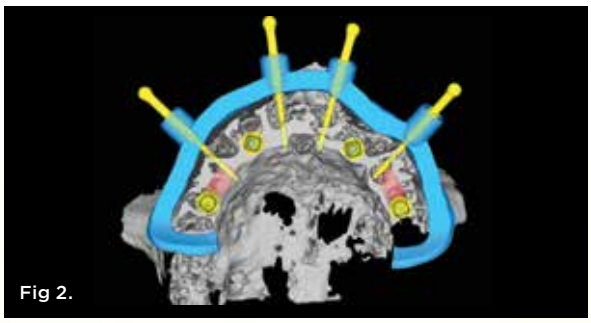


Fig 1.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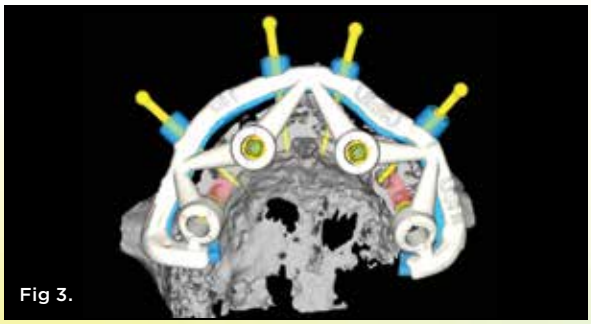
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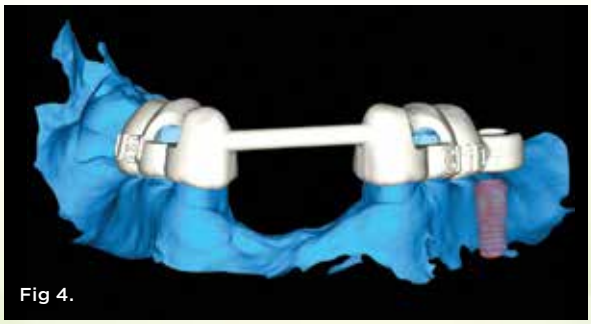
Fig 4.

Fig 1. Surgical planning for computer-guided surgery was completed with a live discussion between clinicians and digital dental technicians. **Fig 2.** After the surgical plan was confirmed, a bone reduction template was digitally designed and manufactured. **Fig 3.** Subsequently, the implant placement template was digitally designed and manufactured. **Fig 4.** After the surgical plan was confirmed, the mandibular implant placement template was digitally designed and manufactured.

placement template, bone reduction template (Figure 2), and implant placement template (Figure 3) were designed in the implant planning software program. The mandibular implant placement template was also digitally designed (Figure 4). After confirming template designs, the maxillary fixation pin placement template and bone reduction template were 3D-printed; maxillary and mandibular implant placement templates were milled.

Implant Placement

On the day of surgery, the patient was informed of the anticipated outcomes and side effects of the procedure, and a consent form was obtained. Topical anesthesia of lidocaine 2% with epinephrine 1:100,000 was used as buccal and palatal local infiltrations on the maxilla. The fixation pin placement template was positioned over the gingival mucosa, and a size-specific drill (Drill for Template Fixation Pin - ∅ 1.3 mm, stainless steel, Straumann) was used to complete the osteotomy for fixation pins. A crestal incision was then performed from the bilateral first molar area to reflect a full-thickness flap both palatally and buccally. The reflected palatal tissue was then stabilized by sutures.

The bone reduction template was then placed on the bone and supported by fixation pins (Template Fixation Pin - ∅ 1.3 mm, Ti, Straumann). The alveolar bone reduction was then completed following the guidance of the bone reduction template using piezo devices. The implant placement template was seated over the bone reduction template. Osteotomies were made using the sequence of drills (BLT Drill – guided, Straumann) and drill handles (Drill handle, Straumann) based on the preoperative guided implant surgical plan.

Four bone-level 4.1 mm x 12 mm implants (Bone Level Tapered Roxolid® SLActive®, Straumann) were placed under the guidance of the implant placement template. All templates were removed, and cover screws (RC Closure Cap, Straumann) were placed on the implants with primary closure of the surgical site (Figure 5). The patient presented on another day for implant placement in the mandibular left molar area (Tapered Effect Tissue Level, Roxolid SLActive, 4.1 mm x 8 mm, Straumann) for the purpose of supporting the implant-assisted removable partial denture.

Two months after the surgical procedures, the maxillary implants were then exposed with the placement of healing abutments (RC Healing abutments, ∅ 5 mm x 6 mm conical) to start subsequent prosthodontic procedures.

Interim Screw-Retained Prostheses

Prefabricated abutments (RC Screw-retained abutment angled, angulation 30°, ∅ 4.6 mm, gingiva height 4 mm, type A and straight, angulation 0°, ∅ 4.6 mm, gingiva height 2.5 mm, Straumann) were secured to the implants under 35 Ncm torque. Scannable impression copings (Mono

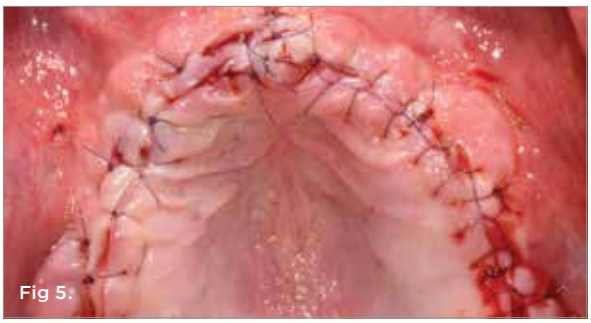
Fig 5.


Fig 6.


Fig 7.


Fig 8.

Fig 5. All templates were removed, and cover screws were placed on the implants with primary closure of the surgical site. **Fig 6.** Scannable impression copings were secured to the prefabricated abutments, and intraoral scans were completed for the maxillary impression. **Fig 7.** After the confirmation of functional and esthetic outcomes of the maxillary interim hybrid prosthesis, a titanium substructure was designed and manufactured using the interim prosthesis as a reference. **Fig 8.** Delivery of maxillary metal-acrylic screw-retained (hybrid) prosthesis and mandibular implant-assisted removable partial denture.

Scanbody for screw-retained abutment, Straumann) were secured to the abutments under 15 Ncm torque. The maxillary and mandibular intraoral scans were completed using an intraoral scanner (Virtuo Vivo™, Straumann) (Figure 6).[10] The intraoral scans and virtual interocclusal records were exported in the polygon file format (PLY) and transferred to the dental laboratory for the design and fabrication of an interim implant-supported prosthesis.

The interim screw-retained prosthesis was designed in a CAD/CAM software program (CARES Visual 13.0, Straumann AG) and milled with a tooth-colored polymethyl methacrylate (PMMA) disc (Vericore Gradient Temp, A3, Whipmix, whipmix.com) on a five-axis milling unit (DWX-51D, Roland DGA, rolanddga.com). Tissue-colored light-polymerizing composite resin (Gradia® Gingival Shade System, GC America, gcamerica.com) was layered at the cervical portion to mimic soft tissue. Temporary cylinders (Temporary Coping for Screw-retained Abutments, ∅ 4.6 mm, for bridges, Straumann) were secured on the abutments under 15 Ncm torque and connected to the milled prosthesis intraorally with autopolymerizing resin (Jet Tooth Shade, Lang Dental Manufacturing, langdental.com). The interim screw-retained prosthesis was delivered and tested for 1 month.[11]

The mandibular definitive impression for the removable partial denture was made with polyether impression material (Impregum™ Soft, 3M Oral Care, 3m.com) and a custom tray. The impression was poured with type 4 dental stone (Silky-Rock, Whipmix). The maxillary intraoral scan was also sent to a centralized production center for a 3D-printed cast.

Definitive Prostheses

After 1 month of intraoral service, the patient provided confirmation of esthetic and functional outcomes on the interim implant-supported prosthesis. A diagnostic impression was taken over the maxillary interim implant-supported prosthesis with irreversible hydrocolloid impression material (Jeltrate®, Dentsply Sirona, dentsplysirona.com) and poured with type 4 dental stone (Silky-Rock). The maxillary 3D-printed definitive cast, maxillary diagnostic stone cast, and mandibular definitive stone cast were articulated on a semiadjustable articulator (Model 2240 Articulator, Whipmix). The maxillary diagnostic stone cast and mandibular definitive stone cast were digitized with a laboratory scanner (CARES 7 series, Straumann). The maxillary intraoral scan was used to design a titanium substructure (AccuFrame®, Cagenix, cagenix.com) using a scanned diagnostic stone cast as a reference (Figure 7). The digitized mandibular cast was used to design a metal framework for a removable partial denture in CAD/CAM software (3Shape Dental System, 3Shape, 3shape.com). The removable partial denture metal framework was 3D-printed with cobalt-chrome metal alloy (Bertram Dental Lab, bertramdental.com). Diagnostic tooth arrangement was completed on both the maxillary titanium substructure and the mandibular metal framework. The patient returned to the clinic for a final trial insertion to confirm the desired clinical outcomes.

Injection-molding denture base resin (SR Ivocap® High Impact, Ivoclar Vivadent, ivoclarvivadent.com) was used to process both the maxillary and mandibular prostheses. An attachment abutment (Locator®, Zest Dental Solutions, zestdent.com) was torqued on the mandibular implant under 35 Ncm. After trial insertion, the attachment housing and insert were luted on the mandibular removable partial denture with autopolymerizing resin (Quick Up®, VOCO, voco.dental). The maxillary definitive metal-acrylic screw-retained (hybrid) prosthesis was torqued under 15 Ncm onto the prefabricated abutments (RC Screw-retained abutment). All screw-access holes were sealed with dental isolation tape (IsoTape, TDV Dental, tdv.com.br) and single-component resin sealing material (Fermit®, Ivoclar Vivadent). The patient was then instructed in a home care regimen and scheduled for follow-up appointments (Figure 8).

Conclusion

With an extensive history of research in the field of implant dentistry, Straumann offers a variety of different biomaterials and CAD/CAM products and services. The Roxolid implants with SLActive surface used in this report are made of 15% zirconium and 85% titanium with a hydrophilic surface, providing high mechanical strength, reduced healing time, and excellent osseointegration.[12] The integrated digital planning and manufacturing modular service, Smile in a Box, aids clinicians and dental laboratory technicians in utilizing—and benefiting from—digital dentistry without significant financial investment. As demonstrated in this report, it provides users a flexible solution to adapt digital dentistry to their current practice. By incorporating digital dentistry and Smile in a Box service in the practice, practitioners gain an opportunity for better communication with the clinical treatment team and the patient, along with improved patient treatment acceptance, experience, and satisfaction.

DISCLOSURE

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