DIGITAL WORKFLOW

A Workflow to Design and Fabricate a Customized Healing Abutment From a Dynamic Navigation Virtual Treatment Plan

Michael J. Hartman, DMD, MD

Abstract: A customized healing abutment may be used to create a soft-tissue emergence profile that is more realistic looking compared to when a commercially available stock healing abutment is used. This article describes a workflow for the design and fabrication of a customized healing abutment based on the anticipated final restoration. Utilizing dental CAD/CAM software, a dynamic navigation virtual treatment plan, and 3D printing, this workflow can be accomplished in an all-digital, presurgical fashion.

A healing abutment or provisional restoration can be used to assist in the development of a soft-tissue contour for a final implant restoration. In cases where immediate fixed provisional restorations are contraindicated, a customized healing abutment predicated on the anticipated contours of the final restoration may be used to help in the formation of soft-tissue contours and a natural-appearing emergence profile.[1-6] When used in immediate extraction sites, customized healing abutments also offer the advantage of serving as a graft containment device and may eliminate the need for flap advancement to obtain the soft-tissue closure required when using a stock healing abutment.[7] In the esthetic zone, increased soft-tissue thickness and an optimal emergence profile may be obtained through placement of an immediate implant with either a provisional restoration or customized healing abutment versus delayed implant placement with a stock healing abutment.[8,9]

Stock healing abutments usually come in a variety of diameters and heights. Their geometry creates a circular soft-tissue emergence profile that typically does not adequately replicate the contours of the definitive restoration.[1,2,10-12] This may lead to an unesthetic final restoration with contours that are difficult for the patient to maintain hygienically.

Multiple techniques for the fabrication of customized healing abutments that have demonstrated natural emergence profiles have been previously described.[1,2,6,13-16] The purpose of this article is to demonstrate a technique in which a digital workflow that combines dental CAD/CAM software and a dynamic navigation virtual treatment plan may be used to design a customized healing abutment that is based on the anticipated final restoration and fabricated prior to the planned implant surgery.

Case Report

A healthy 61-year-old woman was referred for evaluation of a fractured maxillary left central incisor (Figure 1 and Figure 2). A hard- and soft-tissue assessment confirmed the tooth to be a candidate for an immediate implant due to surrounding keratinized tissue and adequate palatal and apical bone for primary stability.[17] The restoring doctor planned to provisionalize the site with a removable partial denture. The treatment plan was reviewed and agreed upon by the patient, who was then scheduled for a preoperative implant work-up appointment.

At said appointment, a fiducial marker clip (X-Clip, X-Nav Technologies, x-navtech.com) was molded onto the patient's maxillary right premolar/molar area. A cone-beam computed tomography (CBCT) image was acquired with the clip in place and saved in digital imaging for communication in medicine (DICOM) file format. The clip was removed, labeled, and stored for the patient's upcoming surgical appointment. Digital scans of the maxilla and mandible were acquired (Figure 3). The treatment plan was confirmed and preoperative instructions were reviewed. The patient was appointed to return in 2 weeks for extraction of the maxillary left central incisor and dental implant placement.

The patient's DICOM file was imported into the dynamic navigation virtual planning software (X-Guide™, X-Nav Technologies). The intraoral digital scans were aligned over the CBCT image for a more accurate view of the surrounding dentition. The dental implant was planned in a restoratively driven manner based on the existing maxillary left central incisor (Figure 4). Once finalized, the virtual treatment plan was exported in a stereolithography (STL) file format.

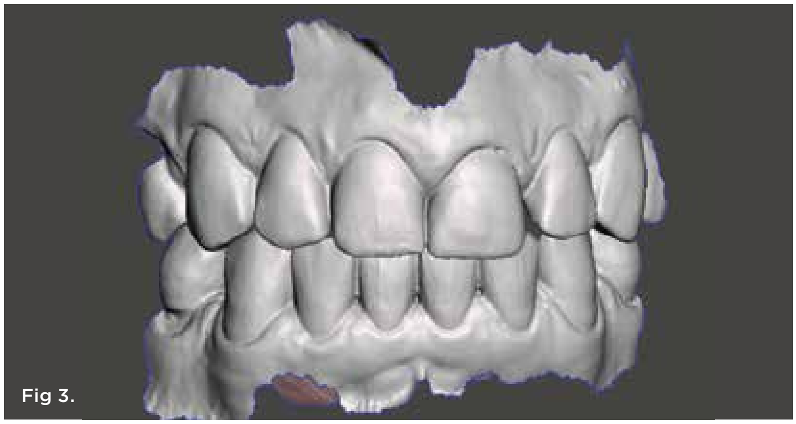
A case was created in dental CAD/CAM software (DentalCAD, exocad, exocad.com) as a screw-retained implant restoration for the maxillary left central incisor. The virtual treatment plan created from the dynamic navigation software was imported and the virtual implant was detected and converted into the selected implant system and titanium base (DESS Ti Base, DESS-USA, dess-usa.com) (Figure 5). A full-contour crown was designed onto the Ti base (Figure 6). The patient's existing maxillary left central incisor was used as a reference for the crown. Once the crown design was finalized, the cut feature was used to remove the coronal and proximal contact portions of the crown, leaving only what would be used as a customized healing abutment (Figure 7). A notch was placed onto the buccal surface to aid in orientation at the time of surgery. The customized healing abutment was exported as an STL file and printed on a 3D printer (NextDent 5100, 3D Systems, 3dsystems.com).

The printed portion was washed and cured according to the manufacturer's recommendations, luted on to the planned Ti base with light-cured resin, and polished (Figure 8 and Figure 9). The abutment was then labeled and stored for the patient's upcoming surgery.

At the time of surgery, the dynamic navigation equipment was calibrated. The maxillary left central incisor was extracted in an atraumatic fashion. The fiducial marker clip was attached to a patient tracker and seated in the same manner on the upper right dentition as when the CBCT was acquired. The standard protocol for dynamic navigation surgery was followed as per the X-Guide manufacturer's instructions. Sequential osteotomies and implant placement were performed under dynamic navigation. Upon placement, the implant was noted to have deviated only slightly from the virtual treatment plan. The internal geometry of the implant was oriented as planned on the virtual treatment plan and particulate allograft was packed in the surrounding extraction socket. The customized healing abutment was placed and verified to be in the correct position with the notch oriented toward the buccal. The abutment screw was inserted and hand-tightened. Occlusal adjustment was performed with an acrylic bur to allow passive seating of the removable partial denture.

The patient had an uneventful postoperative course. The custom healing abutment and





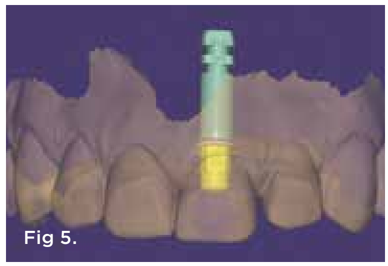
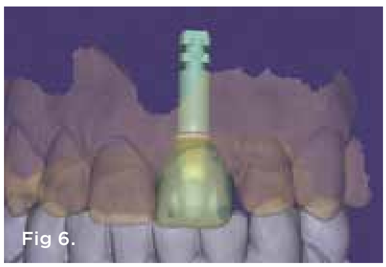





Fig 1 and Fig 2. Facial (Fig 1) and occlusal (Fig 2) views of maxillary left central incisor. **Fig 3.** Digital scans of patient's maxilla and mandible. **Fig 4.** Virtual treatment plan created in dynamic navigation software. **Fig 5.** Virtual treatment plan imported into dental CAD/CAM software with virtual Ti base placed. **Fig 6.** Full-contour crown designed onto the Ti base. **Fig 7.** Customized healing abutment completed in dental CAD/CAM software. **Fig 8 and Fig 9.** Facial (Fig 8) and occlusal (Fig 9) views of 3D-printed portion of customized healing abutment luted onto the Ti base.

contoured soft-tissue emergence profile were evaluated at 12 weeks after implant placement (Figure 10 through Figure 13). The 12-week postoperative x-ray showed acceptable healing around the implant (Figure 14). The patient was then referred back to her general dentist for the final restoration.

Discussion

This case report describes a workflow in which dynamic navigation virtual treatment planning and dental CAD/CAM software were used to design a customized healing abutment that was fabricated prior to, and inserted at, the time of dental implant surgery. The workflow was accomplished in an all-digital fashion and offers clinicians several benefits.

The main advantage of this technique is the use of surgical guidance to place the implant. Dynamic navigation is a form of surgical guidance that allows the surgeon to watch the implant site preparation and placement in real time on a navigation monitor. Dynamic navigation has been shown to be more accurate than freehand placement.[18] The dynamic navigation unit used in this case employs stereotactic cameras to detect trackers attached to the patient and dental handpiece that display information such as drill depth, angle of deviation, and lateral deviation from the virtual treatment plan. This information is synced to the patient's preoperative CBCT and displayed on the navigation monitor in multiple views to aid the surgeon during implant surgery.[19] As is typical when implementing any new technique or technology, a learning curve is needed, and once the learning curve is met, a surgeon should be able to execute a virtual treatment plan with minimal deviation.[20] When an implant is placed accurately with dynamic navigation, the virtual treatment plan can be used as a blueprint in dental CAD/CAM software to design provisional components.

A similar technique has been previously described whereby a virtual treatment plan is created and executed with the use of a static guide.[2] The virtual treatment plan was used to design a customized titanium healing abutment that was inserted at the time of implant surgery. The workflow could not be done in an all-digital format and required the use of a resin index to confirm the implant position at the time of placement. The use of a static guide requires a manufacturer-specific guided drill kit and fabrication of the guide. Implant surgeries performed with static guides can be challenging in areas of limited interocclusal distance due to the increased length of drills required with the guided kit.

Other reports have described techniques in which custom healing abutments were fabricated from impressions taken at the time of implant surgery.[1,6,10] These techniques used a variety of restorative materials for fabrication and required the use of stone casts. The abutments in these techniques were placed at the time of implant exposure, requiring an additional procedure and potentially a longer time to final restoration when compared to placing the customized healing abutment at the time of implant placement.

Commercially available third-party anatomical healing abutments come in several different shapes to mimic tooth cross-sections. Although they are not customized healing abutments based on patient-specific anticipated final restorations, they provide a more realistic emergence profile than a stock circular healing abutment and can be inserted at the time of surgery. While these abutments may be easily adjusted and smoothed chairside, clinicians should know what the healing abutment material is. For the present case report, a titanium base was chosen to provide a strong implant-to-abutment interface. In the author's experience, healing abutments made entirely of resin or medical-grade plastic may be prone to fracture at the interface. This would require a re-exposure procedure and the insertion of a new abutment, adding chairtime and expense.

While offering many benefits, the technique presented in this case report has some noted limitations. Surgeons may not have the hardware and software resources in their practice to incorporate this workflow. If this is the case, outsourcing to a dental laboratory for the design and fabrication of the customized healing abutment


Fig 10.


Fig 11.


Fig 12.


Fig 13.


Fig 14.

Fig 10 and Fig 11. 12-week postoperative facial (Fig 10) and occlusal (Fig 11) views with customized healing abutment in place. **Fig 12 and Fig 13.** 12-week postoperative facial (Fig 12) and occlusal (Fig 13) views of soft-tissue emergence profile. **Fig 14.** 12-week postoperative x-ray.

would be required. This would likely increase cost and overall fabrication time. The surgeon also needs to be proficient with dynamic navigation so that the implant placement corresponds accurately with the virtual treatment plan. Otherwise, the customized healing abutment will not fit or provide an accurate representation of the final restoration emergence profile.

The digital workflow described in this report has exciting areas for future study. One such area would be file sharing the virtual treatment plan final restoration with the restoring dental laboratory to be used as a reference to fabricate the definitive restoration, ensuring predictability and consistency throughout the entire implant treatment process. The workflow could also be used to design and fabricate provisional restorations, eliminating the need for chairside fabrication or impression taking at the time of placement for insertion at another appointment. It could also be utilized in full-arch, immediate-load cases, thereby eliminating the need for cumbersome static guides for implant placement.

Conclusion

This article describes a completely digital workflow for the design and fabrication of a customized healing abutment prior to dental implant surgery utilizing dynamic navigation and dental CAD/CAM software. Dynamic navigation in conjunction with dental CAD/CAM software facilitated the fabrication of a healing abutment placed at the time of implant surgery that replicated the soft-tissue contours of the anticipated definitive restoration. The described technique is advantageous over previous techniques because a customized healing abutment can be inserted at the time of dental implant surgery without an increase in chairtime.

ABOUT THE AUTHOR

Michael J. Hartman, DMD, MD
Private Practice limited to Oral and Maxillofacial Surgery, Mechanicsburg, Pennsylvania

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