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Are Radiographic Guides Necessary?

A paradigm shift in implant site assessment, digital planning, and surgical guide fabrication using a novel impression technique with Green-Mousse®.

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Introduction

Radiographic visualization of the alveolar ridge, tooth position, and the restorative plan are necessary steps in the treatment sequence and planning of implant restorations. Accurate implant placement is critical to the success of the surgery, prosthetics, and long-term maintenance of the implant and restoration. The position of the implant is dependent not only upon location of sufficient bone volume, but also in satisfying esthetic, biomechanical, and functional requirements.

FIG. 1: Radiographic appearance of bone volume without distinct identification of restorative plan.

Proper evaluation of three-dimensional restorative space is essential during treatment evaluation for implant restorations. This restorative space is bound by the proposed occlusal plane, denture bearing tissues of the edentulous ridge, and orofacial tissues.[1] The space is also controlled by the patient's neutral zone, which is the region balanced by the inward force of the lips and cheeks and that of the outward force of the tongue.[2] Control of this balance is largely dependent upon the bucco-lingual position of the teeth and denture base contour.[3] Inadequate attention to analyzing the restorative space may lead to problems, such as an over-contoured prosthesis, compromise in the neutral zone, fractured teeth and/or denture bases, artificially opened occlusal vertical dimension, and the need to perform additional surgical procedures.[4-7]

Cone-beam CT scanning & implantology

The use of cone-beam computerized tomography (CBCT) has gained popularity as it allows for three-dimensional evaluation as opposed to traditional two-dimensional radiographic techniques. CBCT allows visualization of critical anatomical structures and provides a superior amount of information.[8-10] CBCT software packages also allow for interpretation of digital imaging and communications (DICOM) files via volumetric or surface rendering technology. Figure 1 illustrates a typical CBCT scan of a patient wearing complete dentures without the use of a radiographic template. While the volume, width, and height of bone can be properly determined for an implant position within the bone,

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it is not possible to fully identify the correct implant position relative to the planned restorative goal. Various methods of radiographic visualization have been described in reports and techniques involving duplicating the existing or proposed restoration, and fabricating a radiographic guide.[11-14] Many of these radiographic guides contain markers, such as gutta percha[15-17], ball bearings[18-19], metal tubes[12], metal strips[20-21], and barium sulfate.[11,22-24] These markers can reliably act as tooth or restoration outline markers indicating incisal edge position, bucco-lingual position aides, and denture base contour. Additionally, these markers may potentially act as a fiducial allowing for accurate representation of the final restorative goals by ensuring adequate radiographic determination for implant placement. By using these surfaces and markers, critical anatomical features are identified and dental implants may be digitally planned.

Traditional radiographic visualization for fully edentulous patients typically involves the use of duplicating the patient's existing complete denture and fabricating a barium sulfate and acrylic resin replica of various radiodensities.[11,22-24] The method of duplication most likely calls for the use of an irreversible hydrocolloid (alginate) or a polyvinyl siloxane (PVS) impression. It requires laboratory components, and generally two clinical appointments. While visualization can be achieved with this approach, some practitioners choose not to fabricate radiographic guides because of the extra steps and costs involved. Laboratories typically charge between $50-$200 for fabrication of a radiographic guide, in addition to approximately $50 worth of impression material. Other costs involved include the use of dental gypsum for the cast and packing material needed to ship the duplicate index of the patient's denture. As mentioned prior, a second clinical appointment is necessary to fit the prosthesis before the CBCT scan. Even after guide fabrication and adjustments in the mouth, as well as taking into consideration that acrylic resin has a shrinkage of up to 21%, there is still a possibility that the radiographic guide will not adequately fit the soft tissues.[25] Figure 2 illustrates a CBCT scan of a patient wearing a barium/acrylic resin radiographic guide. Arrows depict areas of inadequate soft tissue contact and internal voids.

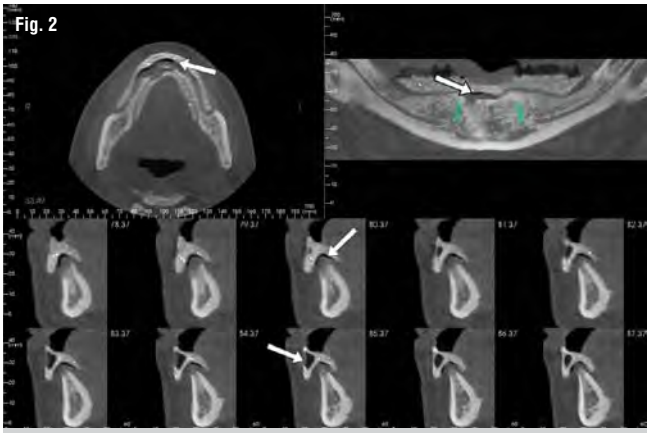

FIG. 2: Barium sulfate mixed with acrylic resin radiographic guide not adequately adapted to the soft tissues and areas of voids within the guide (as indicated by the arrows).

While some would attest that even though these areas of misfit may not impact the execution, diagnosis, and treatment of traditional dental implants using flap exposure and ridge reduction, this could limit the ability of the clinician to fabricate a soft-tissue surgical guide.

Soft tissue surgical guide simplicity.

Soft-tissue guided surgery requires a radiographic template that is fully adapted to the soft tissues in order to properly relate dental implant positions with the digital soft-tissue analogs. Many contemporary CBCT interpretation software packages allow for visualization of soft tissue replicas digitally superimposed over the rendering of DICOM files. Traditionally, superimposition involves the use of fiducial markers, such as gutta percha points, ceramic or metallic spheres, hollow tubes, and flat patterns or lines embedded into an object with an algorithm to recognize the marker. The fiducial marker contains unique features that allows the object to be reliably detected and analyzed with a computer algorithm. Once the marker has been recognized, the algorithm will allow for digital re-orientation, based upon a pair of CBCT scans that contain an identical orientation of fiducial markers.

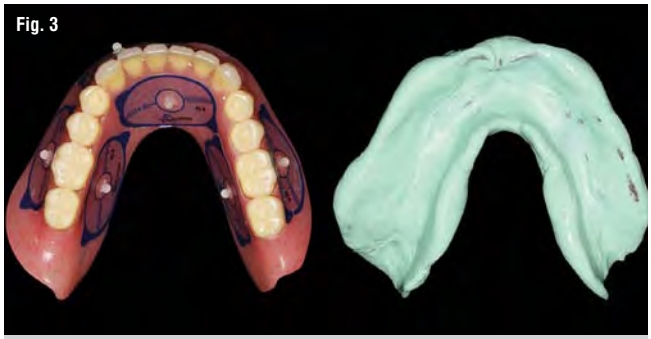

FIG. 3: Left denture illustrates 6 marker-based fiducial points, the right denture illustrates millions of surface-based fiducial points within the Green Mousse® VPS.

Studies have shown that while the marker-based methods of digital registration historically are considered more accurate, newly developed surface registration algorithms have greatly increased accuracy.[26-29] These registration algorithms allow the clinician or the laboratory to utilize readily available dental surface markers, such as cusp tips, denture borders, and soft-tissue profiles to facilitate digital registration. Figure 3 illustrates a comparison of two different registration methods based upon fiducials: the image on the left shows traditional marker based fiducials. The image on the right shows a soft-tissue impression containing a surface-based fiducial (Green-Mousse®). The method of capturing the soft tissue with Green-Mousse allows for millions of fiducial points versus only 6 with the marker-based points. Figures 4A and 4B illustrate software digital registration with marker-based fiducials in combination with a surface-based fiducial of Green-Mousse. Figures 5A and 5B illustrate software digital registration with only Green-Mousse providing surface-based fiducials.

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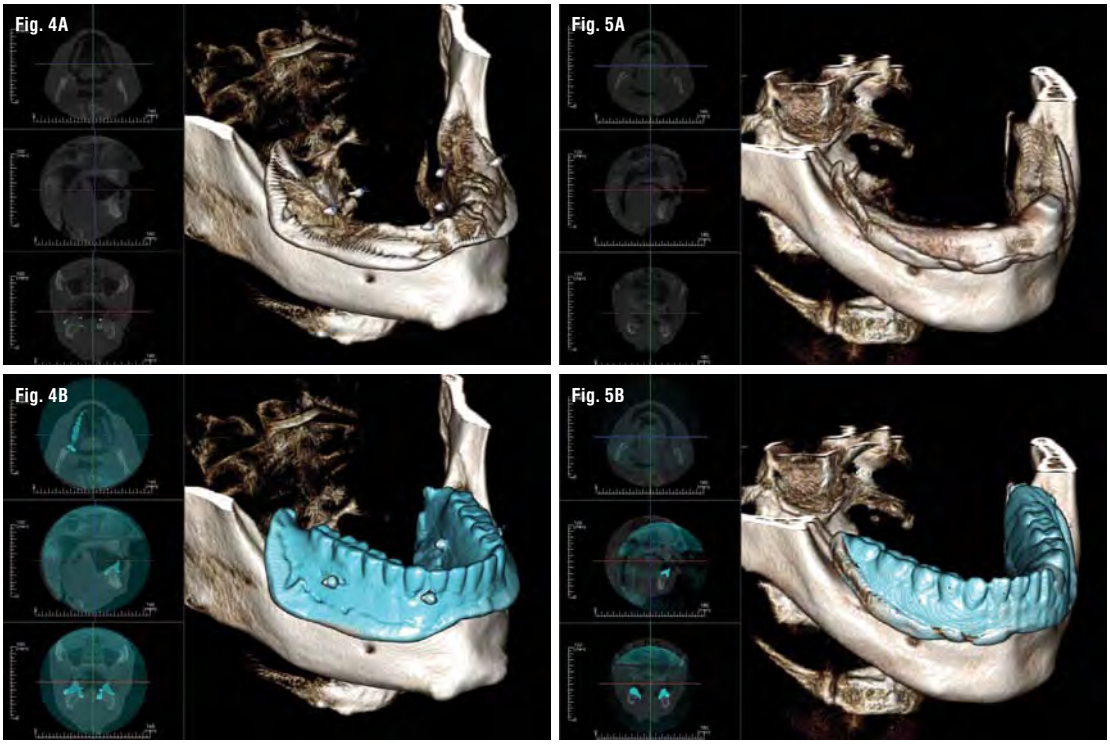

FIGS. 4A/4B: Digital registration with marker-based fiducials.

FIGS. 5A/5B: Digital registration with surface-based fiducials (Green-Mousse®).

Based upon the patient and prosthesis scan registrations, a dental laboratory technician can reliably separate a soft-tissue profile from the denture surface. In addition, the markers imparted by the soft-tissue surface-based fiducial registration allows superimposition of a soft-tissue cast or optical scan. The combination of these three parts—patient CBCT scan, denture CBCT scan, soft-tissue cast optical scan—allows the dental laboratory to fabricate a soft-tissue supported surgical guide to assist in dental implant placement.

Green-Mousse® is the preferred material to use when relating the tissue surface of dentures to CBCT scans.

Blu-Mousse® polyvinyl siloxane (PVS) bite registration material has been widely recognized and used for a variety of applications due to its effectiveness, reliability and simplicity. Parkell has added Green-Mousse to the line as a less rigid version of Blu-Mousse for use in full arch impressions as a tray material. Both Green and Blu-Mousses possess properties that make them ideal for many uses including dental radiology.

Green-Mousse is a good choice for use in CBCT radiographic interpretation of soft-tissue bearing surfaces. Specifically modified for greater flexibility (60-durometer vs. 85-durometer for Blu-Mousse), Green-Mousse has a dependable, no slump consistency that allows a clinician to fully load the intaglio surface of a denture or partial denture without risking spillage on equipment surfaces or on a patient's clothing. The increased flexibility also allows for use in situations where important soft-tissue and hard-tissue undercuts may be sensitive or painful to capture with a more rigid material. Additionally, this flexibility allows for precise capture of the soft-tissue undercut areas without tearing upon removal or displacing important soft-tissue landmarks. Finally, Green-Mousse has a radio-density similar to cortical bone (1700HU), which allows it to be discernible from tissues (50HU) and denture acrylic resin (70HU).[30]

Presented below is a clinical technique using Green-Mousse to reline a complete denture and act as a surface-based fiducial marker in the preparation of a patient for CBCT implant imaging.

Technique

1. Rinse the patient's denture to remove saliva and/or any food remnants, then dry completely. The use of a VPS adhesive is not necessary. Insert a cartridge of Green-Mousse into an auto mix gun and attach a static mixing tip. (Fig. 6)

(Continued)

FIG. 6: Completely dry denture and load Green-Mousse into auto-mix gun.

2. Inject the Green-Mousse onto the intaglio surface of the denture with a continuous motion starting from one side of the denture and ending on the other. (Fig 7) Spread the Green-Mousse with a spatula to create an even, thin layer including rolling the material over the denture borders. (Fig. 8)

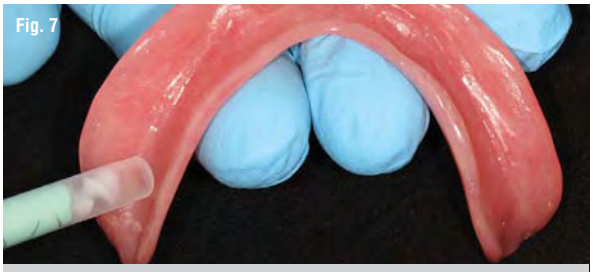

FIG. 7: Inject Green-Mousse onto intaglio surface of denture.

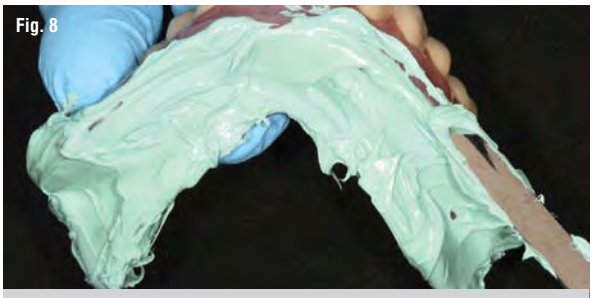

FIG. 8: Spread Green-Mousse evenly across intaglio surface and rolling it over the borders of the denture.

3. Place the denture onto the patient's edentulous ridge and have the patient lightly close while border molding the edges of the denture with the Green Mousse. (Fig. 9) Instruct the patient to move the lips, cheeks, and tongue as if performing a denture reline impression.

FIG. 9: Place denture onto edentulous ridge and have the patient bite down lightly into centric while border molding.

FIG. 10: After complete 2-minute set, remove denture.

4. After the material completes a 2-minute set, remove the denture and inspect the intaglio surface for an adequate capture of the tissue-bearing surface. (Fig. 10) Small areas of denture base showing through are acceptable. Excessive amounts of material in areas may indicate that there was an artificial opening of vertical dimension.

5. Using a scalpel blade, trim any Green-Mousse flash that may be covering the teeth. Leave material rolled over the borders as this will become an important portion of the fiducial digital registration. (Fig 11)

FIG. 11: Trim excess Green-Mousse covering teeth or peripheral areas while carefully leaving the border roll intact.

6. Place the denture back into the mouth and place 2 cotton rolls between the tongue and lingual slope of the denture. Place 3 cotton rolls between the cheek and buccal surfaces of the denture, and 2 more cotton rolls on the occlusal surfaces of the denture. Instruct the patient to close down lightly on the cotton rolls and to keep tongue tipped backward away from the denture surfaces. (Fig. 12)

FIG. 12: Place cotton rolls in the following configuration in relation to the prosthesis: 3 buccal, 2 occlusal, and 2 lingual. Instruct patient to remain still. Make a cone-beam computerized tomography scan.

7. Make a cone-beam CT scan at .3mm voxel resolution. Be certain that the patient remains perfectly motionless during the scan and evenly bites on the cotton rolls without swallowing.

8. After the scan acquisition and confirming that an accurate capture has been accomplished, remove the cotton rolls and the denture containing the radiographic impression. Place the denture onto a foam plate/block surface. (Fig. 13) Scan the denture separately using a .2 or .3mm voxel resolution with horizontal centering lines parallel to the denture occlusal plane.

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FIG. 13: Remove cotton and denture and perform a CBCT scan of the denture suspended on a foam block or plate.

FIG. 14: Mix fast setting die stone (Snap-Stone) and pour into Green-Mousse impression to form a cast and a base.

9. Place 140g Snap-Stone (Whip-Mix®, Louisville, KY) into a mixing bowl, add water, and mix with the help of a cast vibrator. Slowly pour the stone into the Green-Mousse impression and allow the material to run into undercuts in the tissue-bearing surface. (Fig. 14) When completely filled, invert the pour onto a patty of Snap-Stone to form a base. After several minutes, carefully separate the Green-Mousse denture and inspect the cast for voids or breakage. (Fig. 15) If any errors are detected in the soft-tissue cast, re-pour the impression. Remove Green-Mousse impression material by simply peeling it away from the intaglio surface of the denture with a cotton plier or by hand. (Fig. 16)

FIG. 15: After several minutes, separate denture from the tissue cast.

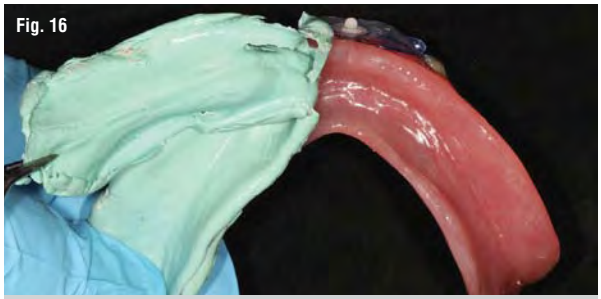
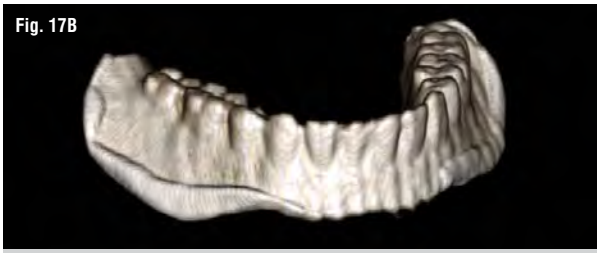


FIG. 16: Peel away Green-Mousse from intaglio surface of denture.

10. Import the patient scan and denture DICOM files into Invivo Dental software (Anatomage, San Jose, CA). Virtually section the anatomical region of interest. Then trace nerves and vital structures, and visualize bone volumes in the patient scan. Finally, save as an .inv file. In the denture scan, importing the DICOMS and saving them as an .inv file is only necessary at this point. (Figs. 17A & B) It is highly recommended to generate a tentative plan with the Invivo software by placing implants into the proposed virtual positions. These positions are dictated by bone quality and quantity, proximity to vital structures, and 2D restoration position. After the Green-Mousse digital registration is completed, 3D tooth position visualization is possible and allows the clinician to finalize the implant plan.



FIGS. 17A/B: Import DICOM files of the patient and denture scan into InVivo Dental software.

Fig. 18

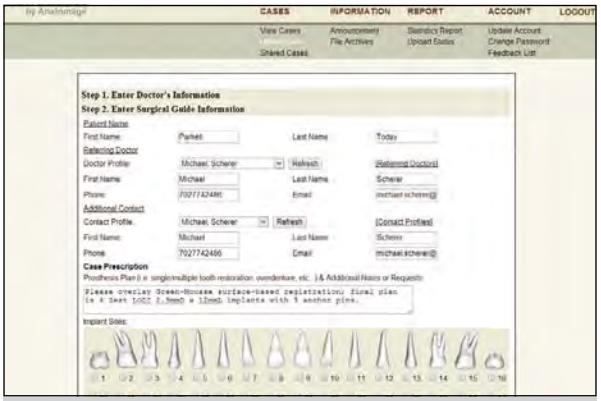


FIG. 18: Upload .inv files of the patient and denture scan to Anatomodel.com. Include information related to surgical plan.

11. Upload the .inv files of the patient and denture scan to www.anatomodel.com. If you are a first time user, registration will be required, however, repeat users will have their information stored in the database. It is necessary and recommended to write the patient's name and the tentative surgical plan into the planning text box. (Fig. 18)

(Continued)

While the Invivo software currently does not allow the user to directly superimpose two scans for the purposes of dental implant planning, Anatomage performs digital registration at no additional cost.

12. Pack and mail the Green-Mousse soft-tissue cast directly to Anatomage for optical scanning and integration into the software. Tip: If you own an optical scanner that can output as .stl files, you may upload an optical scan of the Green-Mousse impression or the solid cast instead of mailing the physical one.

13. After receiving an e-mail notification of the completed digital registration (typically this takes 2-4 business days), download the planning file from www.anatomodel.com. (Fig. 19)

Fig. 19

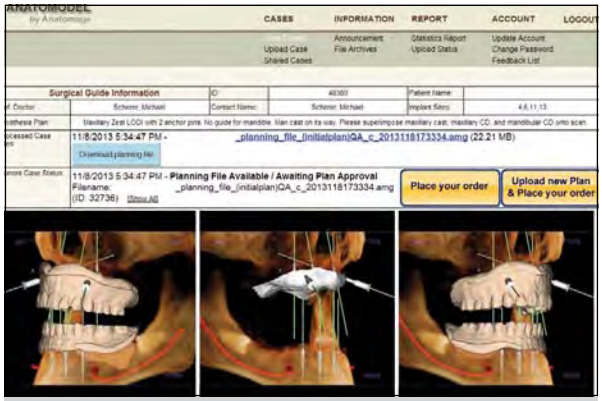


FIG. 19: Anatomage will digital superimpose the denture scan on the patient scan and will return a planning (.amg) file for review.

Fig. 20A

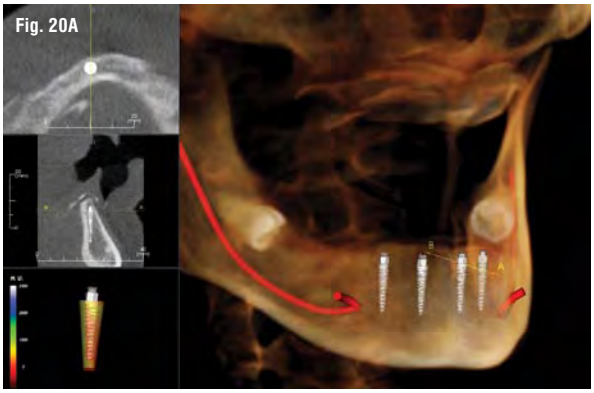
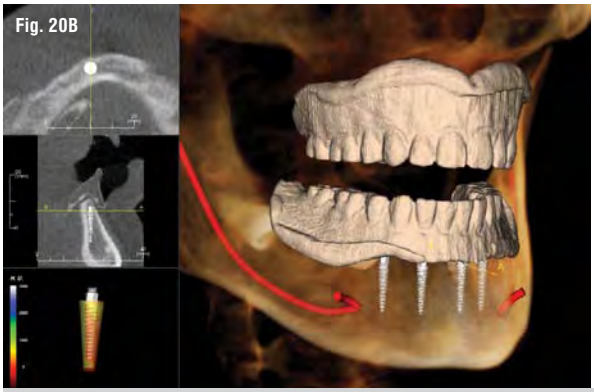


Fig. 20B



FIGS. 20A/B: Import .amg file into InVivo software to review surgical plan and modify implant position, angulation, size and length according to prosthetic goals.

14. Open the .amg file into Invivo software and review the proposed implant positions in relation to the superimposed restorations. (Figs. 20A & B) If changes are necessary, modify the implant position, angulation, size & length according to previously mentioned restorative factors.

15. Confirm final implant positions by either placing the order or by uploading the modified .inv file for re-submission. Confirm the final surgical plan modification by writing in the comment box on the website during file upload.

16. A soft-tissue supported surgical guide will be fabricated based upon the Green-Mousse digital plan. (Fig. 21)

Fig. 21

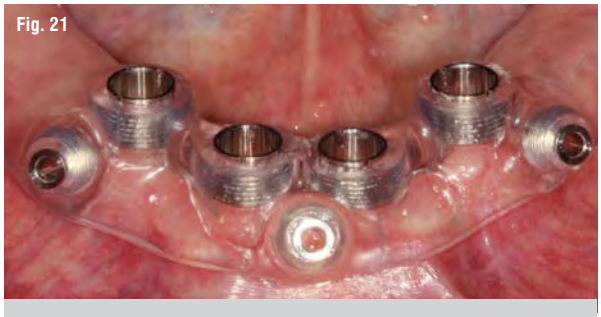


FIG. 21: Final soft-tissue supported surgical guide.

Conclusion

Presented is a clinical technique to incorporate a radiopaque tissue-bearing surface impression onto an existing prosthesis allowing a clinician to digitally visualize tooth position, denture base contours, and edentulous ridge conformation. This article describes a technique using Green-Mousse PVS in which a clinician easily registered the soft-tissue ridge and digitally registered a virtual restoration without having to fabricate a distinct radiographic template. In addition, the clinician can utilize Green-Mousse to optically scan or pour a tissue cast for digital registration and fabrication of the soft-tissue supported implant surgical guide.

Utilization of Green-Mousse allows an easy and reliable transfer and confirmation of the intraoral edentulous ridge to a digital implant software suite. Based upon the digital registration, the clinician and imaging laboratory can virtually plan dental implants based upon soft-tissue visualization and bone volumes for the creation of a soft-tissue supported implant surgical guide. While this digital registration is possible with traditional radiographic guides and techniques, these techniques typically involve increased laboratory expense and chair-time. This approach to dental implant treatment planning represents a paradigm shift in the traditional philosophy of radiographic guide usage. Using a Green-Mousse impression in the intaglio of a denture with cotton roll soft-tissue separation, digital registration is simplified and facilitated making a distinct radiographic guide unnecessary. The clinician can have complete confidence that the entire soft-tissue appearance will be accurately captured in order to fabricate a well-fitting soft-tissue supported implant surgical guide. ■

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