

# Digital Implant Planning for a Minimally Invasive Surgery Approach: A Case Letter of a Full-Arch Rehabilitation

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## INTRODUCTION

Prosthetically directed implant placement using computer software ensures precise fixture placement and predictable prosthetic outcomes.<sup>1,2</sup> Computer-guided implant dentistry allows the clinician to position specific implants into presurgically determined sites, taking into account both the jawbone anatomy and the planned prosthesis within the computerized tomography (CT) images.<sup>1,3</sup> In addition, to obtain the optimal final tooth position, the appliance should be scanned. The use of an appliance scan is essential to digitally plan the treatment and to design and then fabricate a surgical template. The planned prosthesis is integrated with anatomical data using single- or dual-scan protocols.<sup>3</sup>

In the single-scan appliance, a radiopaque template allows the teeth to be identified as well as the soft tissue in the CT study.<sup>4</sup> However, scatter from neighboring restorations can obscure the view of teeth in the scan appliance. Also, the use of radiopaque templates reduces the image quality of the jaw bone.<sup>3,5</sup> In the dual-scan protocol, the patient is scanned with the scan appliance and then the scan appliance is scanned alone with different exposure parameters. The planning software converts the CT scan files and merges the 2 scans by matching radiopaque markers, so that the prosthesis will be visible over the available osseous anatomy, avoiding the image's noise.<sup>2</sup> In totally edentulous patients, it is possible to use the existing denture as a scan appliance.<sup>6</sup> If the prosthesis is not well fitting and the teeth are not in the correct positions, a new appliance should be fabricated. The potential for patient satisfaction is increased if the patient's acceptance of the prosthesis is obtained before CT scans are done.<sup>7</sup>

The transfer of the virtual planning by means of a surgical drilling guide provides significant benefits in the simultaneous placement of multiple implants, especially in large edentulous areas. Computer-aided design/computer-aided manufacturing

(CAD/CAM) technology allows safe flapless surgery to be performed via mucosa-supported guides.<sup>3,4,8-10</sup> The opportunity for an immediately loaded prosthesis can be facilitated by such protocols.<sup>11</sup>

In this case letter, a detailed clinical treatment protocol using CAD/CAM computer-guided technology for a maxillary full-arch rehabilitation is presented.

## CASE REPORT

The patient, a 67-year-old man, presented with a maxillary complete denture. Because of his dislike for the removable prosthesis, he was interested in a fixed implant-supported prosthesis.

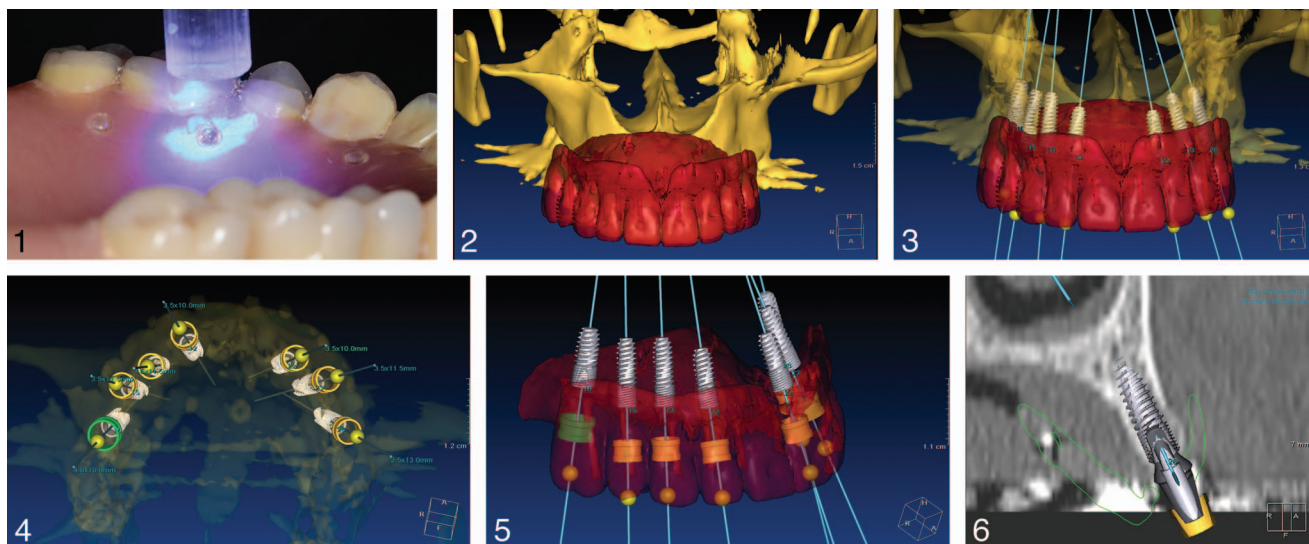
Since the existing prosthesis was not well fitting, a new maxillary complete denture was fabricated after an esthetic and functional evaluation. The patient wore the denture for 4 weeks. After the patient indicated satisfaction with the prosthesis, the esthetic and functional aspects of the prosthesis were assessed. This prosthesis was used for the fabrication of a radiological template. Dimples 1 mm in diameter were prepared on the denture's flanges and filled with quartz spheres as radiographic markers. The spheres were attached using light-curing adhesive (Figure 1). Quartz is a radiopaque material, and the spheres have defined diameters; therefore, the modified denture became a scan appliance with radiopaque reference points. The removable prosthesis was stabilized during the cone beam CT imaging process by having the patient close on a radiolucent bite record. The maxilla was first scanned, with the patient wearing the denture. The scan appliance was then CT scanned with different exposure settings allowing the denture to be clearly visualized. The 2 DICOM files (maxillae and maxillary dentures), were imported into the implant planning software (Osstem Guide, Cybermed, Seoul, Korea) and geometrically matched, superimposing the reference points (quartz spheres; Figure 2).

Besides an adequate bone model, derived from scanning the patient with the ideal fitting denture in situ, the second scan allows optimal visualization of the prosthesis. Afterward, by an accurate fusion while maintaining image quality, the presurgical planning procedure can be achieved and controlled on the integrated model. The planning software (Osstem Guide) allows the clinician to evaluate the osseous tissue in

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**FIGURES 1–6.** **FIGURE 1.** Scan appliance. Denture with radiographic markers used as reference points to superimpose dual-scan images. **FIGURE 2.** Computerized tomography data integration. Three-dimensional view of jawbone and scan appliance after dual-scan data realignment. **FIGURES 3–5.** Prosthetically driven implant planning. Virtual placement of implants and design of surgical template in 3-dimensional views. **FIGURE 6.** Prosthetically driven implant planning. Cross-sectional view of implant planning processing data.

relation to the planned prosthesis and consequently determine the number of needed implants and their position, size, and angulation.

In the present case, 7 implants (Osstem GS III, Osstem Implant, Seoul, Korea) and 3 transalveolar horizontal stabilizing pins (Anchor Screw, Osstem Implant) were virtually inserted (Figures 3–6). Following the development of the implant treatment plan, a data set was generated and transferred online to the model and surgical guide manufacturer. There, the data were used to produce a CAD/CAM surgical guide for a flapless surgery protocol (Figures 7 and 8).

The surgical guide was positioned and fixed using 1.5-mm transalveolar stabilizing pins, while the patient occluded firmly on an interocclusal index. A precise positioning of the implants was achieved using the metallic sleeves incorporated into the guide. These cylinders could receive removable stainless-steel drill guides with varying inner diameters. The drilling sequence was executed for each implant starting with the soft-tissue punch and ending with the last drill through the guide for implant insertion (Figures 9 through 12). The metallic sleeves guide the implant position, angulation, and depth for a totally guided surgery protocol. The Osstem Guide drilling sequence for GS III Osstem Implants was followed.

Immediately after the surgery, an impression was made, using polyether impression material and standard impression coping. The fiber-reinforced composite screwed prosthesis was fabricated and delivered in about 24 hours (Figure 13). The removable denture was used as a guide for its fabrication. One-year follow-up shows the stability of transmucosa emergence profile and peri-implant bone (Figures 14 and 15).

The present innovative protocol enhances prosthodontic-driven placement of implants using a safe and monitored flapless surgery approach. This protocol also improves patient care and reduces the likelihood of unpredictable and undesir-

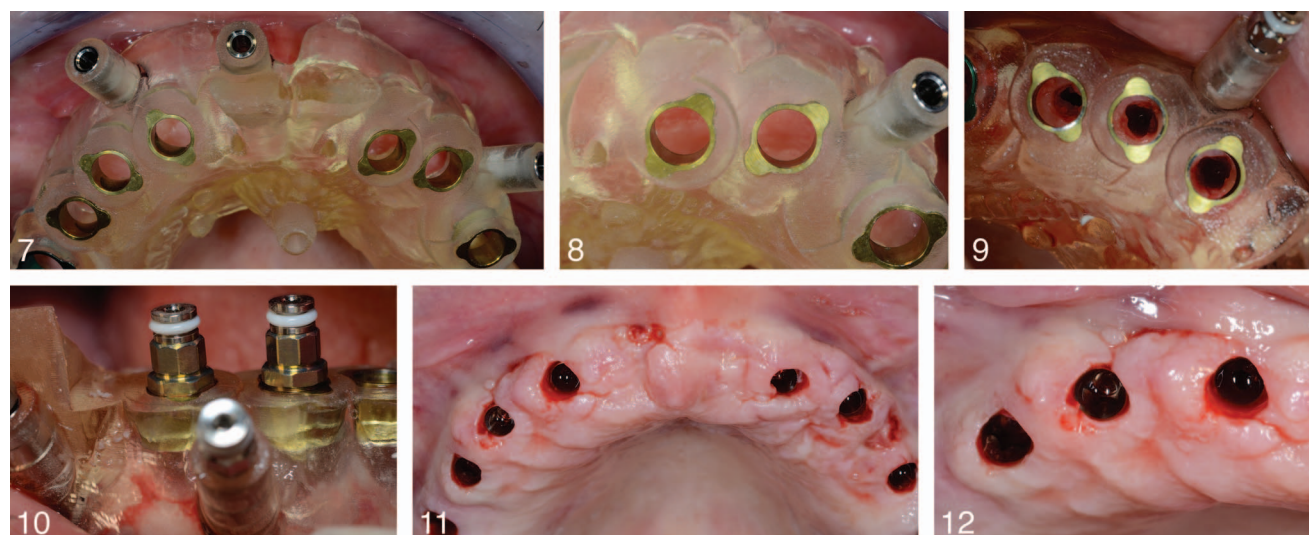
able outcomes. Nevertheless, its correct management requires advanced surgical and prosthetic clinical expertise.

## DISCUSSION

Implant preoperative planning can ideally be performed using 3-dimensional (3D) imaging.<sup>12</sup> By using a scan appliance, the case can be planned from both a prosthetic and surgical perspective, making implantology a predictable restoratively driven process. Different methods for surgical guide manufacturing have been proposed to transfer the planning on CT images to the surgical field. It can be manually fabricated or computer controlled (CAD/CAM) fabricated. The surgical guide should closely fit with tissue surface to accurately transfer the preoperative treatment plan.<sup>3</sup> The increased availability of devices for 3D radiologic diagnosis allows the more frequent use of CAD/CAM-produced surgical guides for implant placement. CAD/CAM-based manufacturing processes require an accurate reproduction of the scanned structures.<sup>13</sup> The dual-scan protocol allows the clinician to achieve this goal.<sup>3,6,14</sup> The superimposition of various data in medicine has been described by several authors.<sup>15–19</sup> The described technique enables a high rate of precision for the fabrication of a CAD/CAM surgical guide.

In such accurate guided surgery procedures, no flaps are elevated.<sup>11</sup> The advantages of the flapless surgery include maintenance of circulation, preservation of soft-tissue architecture plus hard tissue volume at the site, decreased surgical time, improved patient comfort, and reduced healing time.<sup>20</sup> The main disadvantage is the inability to directly visualize anatomic landmarks; however, this is overcome using an accurate and detailed presurgical computer-guided planning protocol.<sup>21</sup>

Implant planning procedures enhance the feasibility of immediate loading procedures. Presurgical prosthetic planning



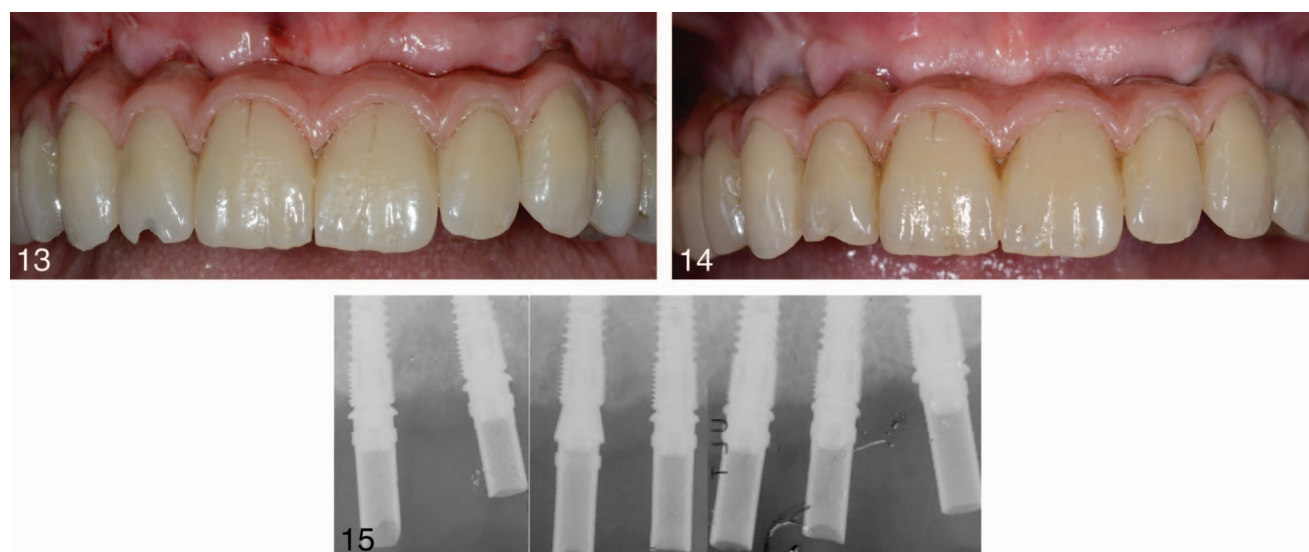
**FIGURES 7–12.** **FIGURES 7–8.** Computer-aided design/computer-aided manufacturing–fabricated surgical template. **FIGURE 7.** Surgical template positioned intraorally. **FIGURE 8.** Drilling sleeves' particular. **FIGURES 9–10.** Implant placement. **FIGURE 9.** Osteotomy site preparation. **FIGURE 10.** Implant positioning. **FIGURES 11–12.** Postoperative intraoral view. Flapless implant placement completed, after surgical template removal.

is extremely important for successful loading of dental implants. This type of planning becomes essential when an immediate loading protocol is used.<sup>22,23</sup> Immediate implant provisionalization allows the clinician to preserve and recontour soft tissue by the fabrication of restorations producing an optimal emergence profile.<sup>24</sup>

Flapless implant positioning appears to be a useful and safe procedure when based on accurate and reliable 3D image data and a dedicated implant planning software.<sup>25</sup>

Nevertheless, there are some disadvantages and contraindications with the flapless surgery approach that must be carefully considered. The disadvantages include (1) potential

thermal damage secondary to reduced access for external irrigation during osteotomy, (2) increased risk of malposed angle or depth of implant placement, (3) decreased ability to contour osseous topography when needed to facilitate restorative procedures, and (4) inability to change the dimensions of keratinized gingival tissues around emerging implant structures.<sup>20,21</sup> A totally guided approach is associated with high risks and needs exquisite attention to procedural details in all phases of treatment.<sup>11</sup> Excessive alveolar ridge resorption is a contraindication for use of flapless surgery. Therefore, the surgeon should verify that an adequate volume of good-quality, nonmobile soft tissue remain surrounding the



**FIGURES 13–15.** **FIGURE 13.** Immediate prosthetic outcome. Postoperative view of immediate loaded fiber-reinforced composite screwed prosthesis. **FIGURES 14–15.** Follow-up. **FIGURE 14.** Clinical 1-year follow-up. **FIGURE 15.** Radiographic 1-year follow-up. Note the optimal soft-tissue healing and the peri-implant bone stability.



emerging implant for optimal function and esthetics. Finally, when intraoperative findings necessitate additional access or visualization, the surgeon must be experienced and prepared to proceed with surgery performed via an open flap approach.<sup>20</sup>

### CONCLUSIONS

Current trends in implant dentistry focus on less invasive procedures and healing time reduction. The positive psychological aspects for the patient should not be underestimated. The use of 3D planning combined with immediate loading results in an accurate, safe, and predictable procedure for the rehabilitation of edentulous jaws.

The reproducibility and high precision of the proposed technique enables the prosthodontic-driven placement of immediate loaded implants with flapless surgery protocols and avoiding bone grafting for a large number of edentulism cases.

Further in vitro and in vivo evaluations should be performed to validate the accuracy and the clinical impact of the described protocol.

### ABBREVIATIONS

3D: three-dimensional

CAD/CAM: computer-aided design/computer-aided manufacturing

CT: computerized tomography

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