The Use of a Computerized Tomography–Based Software Program with a Flapless Surgical Technique in Implant Dentistry: A Case Report

Hakan Terzioğlu, DDS, PhD[1]/Murat Akkaya, DDS, PhD[2]/Oğuz Ozan, DDS, PhD[3]

Successful implant treatment includes osseointegration, as well as prosthetically optimal positions of the implants for esthetics and function. The aim of this study is to evaluate a patient that was treated with an implant-supported fixed prosthesis with the help of computer-assisted three-dimensional planning. A 52-year-old edentulous man underwent computerized tomographic (CT) scanning, and the cross sections were reformatted. The cross sections were used to construct a surgical guide. Eight ITI Straumann dental implants were placed using a series of supramucosal surgical stents. Following a 5-month healing period, the stability of the implants was confirmed with the use of an Osstell device. Because satisfactory stability was observed, implant-supported fixed partial dentures, incorporating 12 units in all, were made. After 6 months, a second CT evaluation was carried out and the positions of the implants were compared with the treatment planning data. The CT-based software program and surgical stents contributed to the success of this case. INT J ORAL MAXILLOFAC IMPLANTS 2009;24:137–142

Key words: *computerized tomography-based software, dental implant, flaples surgery, implant dentistry*

Successful implant treatment involves osseointegration of implants that are placed in ideal positions for fabrication of a dental prosthesis. Preoperative prosthetic planning is crucial for a successful treatment outcome.[1] Presurgical imaging can provide important information, and the buccolingual images obtained through computerized tomography (CT) can be used to more accurately plan implant placement. The locations, angulations, and depths of implant sites can be determined using CT imaging findings.[2]

Determination of optimal implant positions is only possible using a template that allows the patient to be correctly positioned and the proposed suprastructure visualized in the CT scans and paraxial reformatted images. Furthermore, the transfer of the positions and axial inclinations of the implants from the reformatted CT scans to the jaws must be sufficiently accurate.[3]

CT-based software programs and navigation systems have been developed to assist with surgery and presurgical planning.[4–7] Implant 3D (Media Lab Software, La Spezia, Italy) is a software program that allows three-dimensional (3D) investigation of the bone. With the help of reformatted CT cross sections, implant positions may be decided virtually. In addition, a surgical guide may also be fabricated and used during surgery.[8]

The advantages of flapless procedures include reduced intraoperative bleeding and decreased postoperative patient discomfort. However, flapless implant surgery has generally been perceived as a blind procedure because of the difficulty in evaluating alveolar bone shape and angulation.[9]

This report illustrates the treatment of a patient with implants using a stereolithographic surgical guide fabricated using CT cross sections and a computerized implant planning program.

CASE REPORT

A 52-year-old edentulous man was CT scanned and the cross sections were reformatted. During the scanning process, a barium sulfate–coated complete denture was retained in the oral cavity (Fig 1). The patient's occlusal plane was oriented parallel to the scanning plane. Then the data were transferred to the Implant 3D program. The most appropriate axial

[1]Associate Professor, Department of Prosthodontics, Faculty of Dentistry, Ankara University, Ankara, Turkey.
[2]Professor, Department of Periodontology, Faculty of Dentistry, Ankara University, Ankara, Turkey.
[3]Research Assistant, Department of Prosthodontics, Faculty of Dentistry, Near East University, Mersin 10, Turkey.

Correspondence to: Dr Hakan Terzioglu, Ankara Universitesi, Dis Hekimligi Fakultesi, Protetik Diş Tedavisi Anabilim Dalı, 06500 Besevler, Ankara, Türkiye. Fax: +90-312-2123954.
Email: terzoglu@dentistry.ankara.edu.tr

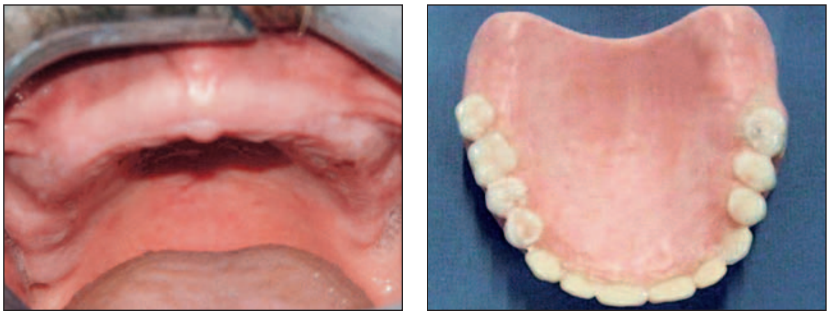

Fig 1 (*Left*) Edentulous maxilla of the patient. (*Right*) Diagnostic denture used during CT scanning, which was processed by adding barium sulfate into polymethyl methacrylate in a 1:10 ratio.

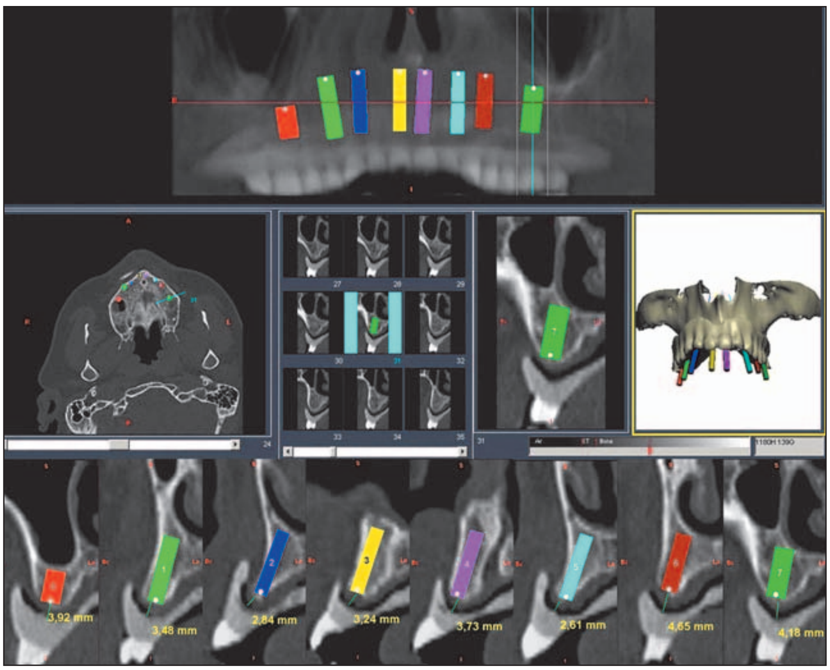

Fig 2 The treatment plan, with implant positions planned using CT-based Implant 3D software.

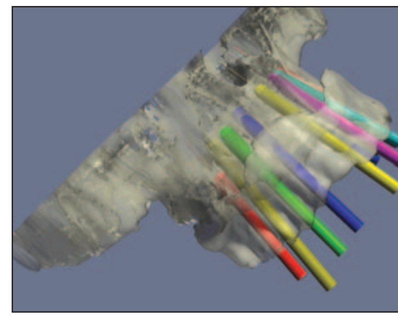

Fig 3 Three-dimensional view of the treatment plan.

section depicting the mandibular anatomy was selected, and a panoramic line was traced. Then the buccolingual cross sections and the panoramic images were reformatted. After the available bone and other prosthodontic treatment criteria were evaluated, the locations and types of implants were selected. The implants were mounted virtually on the selected sections, and the angulations, depths, and diameters were assessed. Parallelism of the implants was also controlled and corrected.

An informed consent document had been signed by the patient. After the treatment plan was completed, the data were transferred to a rapid prototyping machine (P380, EOS, Munich, Germany) and used to fabricate a surgical guide to be used during surgery (Figs 2 to 4). Eight ITI dental implants (Institut Straumann, Waldenburg, Switzerland) were placed with the help of a series of supramucosal surgical stents, which had been fabricated according to each drill diameter by stereolithography and vacuum forming (Ay Tasarim Ltd, Ankara, Türkiye) (Figs 5 and 6). The diameters and lengths of the implants were 4.8 × 8 mm and 4.8 × 12 mm in the first molar regions, 4.1 × 14 and 4.1 × 16 mm in the first premolar regions, 4.1 × 16 mm at both canines, and 3.3 × 16 mm at the central incisors.

Following a 5-month healing period, the stability of the implants was confirmed with the use of an Osstell device (Integration Diagnostics, Göteborg, Sweden) (Fig 7, Table 1). The implant stability quotients indicated satisfactory stability, and the prosthetic rehabilitation phase was started. Eight ITI solid abutments, each 5.5 mm high, were placed and secured with a torque wrench at 35 N/cm (Fig 8). A full-arch maxillary impression was made from polyether impression material (3M ESPE, Seefeld, Germany). Nonnoble alloy (nickel-chromium) substructures for a porcelain-fused-to-metal fixed

Fig 4 The surgical guides.

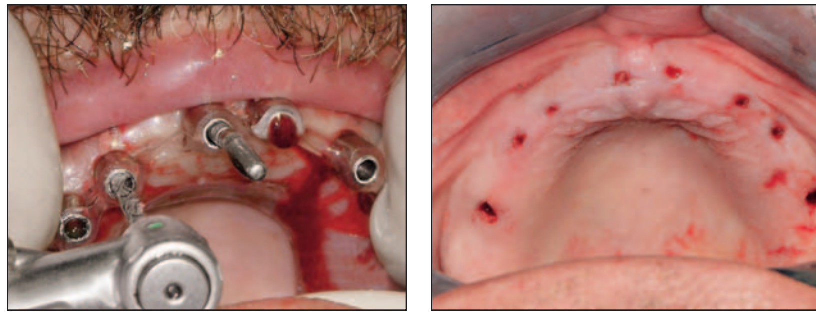

Fig 5 (*Left*) Flapless placement of the implants is accomplished with the help of the surgical stent. (*Right*) View of the mouth after the drilling phase.

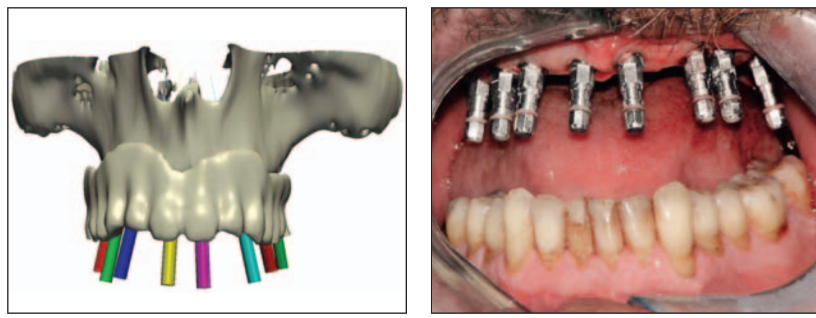

Fig 6 (*Left*) Frontal view of the treatment plan. (*Right*) Frontal view of the mouth after placement of the implants.

Fig 7 The measurement of osseointegration with the Ostell device.

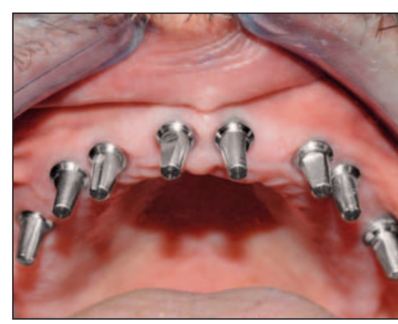

Fig 8 Abutments after being inserted and torqued (35 N/cm) with a torque wrench.

prosthesis were constructed using the lost wax technique. The definitive segmented restorations consisted of four fixed partial dentures in the maxilla. The final prostheses were fitted, the occlusion was adjusted, and the prostheses were affixed with provisional cement (Figs 9 and 10).

After 6 months, a second CT evaluation of the patient was carried out and the data were brought into the Implant 3D software. The implants were clearly observed, without any artifacts (Fig 11). To perform analytic measurement calculations, virtual implants of the same size were placed on the present implants (Fig 12). These 3D data were transferred to Algor software (Pittsburgh, PA) along with the preoperative 3D treatment plan data. In each preoperative

Table 1 Implant Stability Quotients (ISQs) of the Implants After 5 Months of Healing

	ISQ
Right first molar	65
Right first premolar	61
Right canine	63
Right central incisor	60
Left central incisor	60
Left canine	64
Left first premolar	61
Left first molar	67

Fig 9 The buccal and palatal views of the implant-supported porcelain-fused-to-metal restorations.

Fig 10 The patient following cementation.

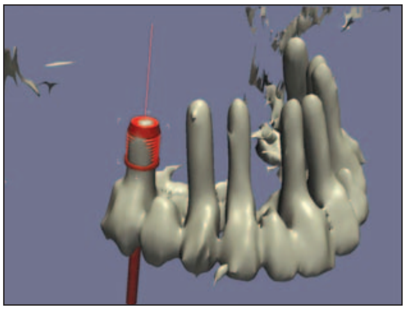

Fig 11 The positions of the implants after the completion of the treatment are clearly shown on the 3D Implant software.

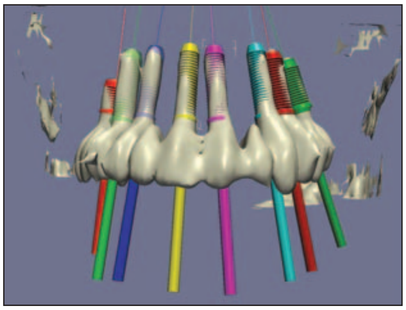

Fig 12 Virtual implants were placed on the present implants.

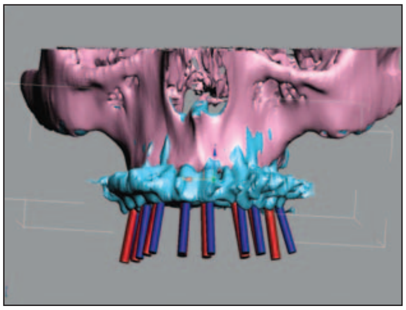

Fig 13 Superimposition of the planned and actual positions of the implants (*red* = planned; *blue* = actual).

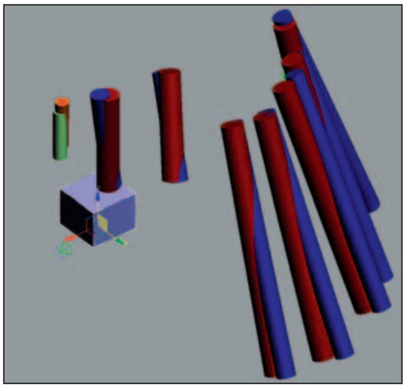

Fig 14 Angular deviations between the planned and actual axes of the implants (*red* = planned; *blue* = actual).

and postoperative model, dummy cubes were placed on spina nasalis anterior and two infraorbital foramina. The dummy cubes are virtual helper objects with no function other than to work as reference points. The postoperative 3D model was linked to the dummy cubes and the data were superimposed onto the preoperative cubes. Since the postoperative model was linked to the dummy cubes, when the cubes were placed on each other, the 3D models were arranged likewise. After the superimposition of the preoperative treatment data and the postoperative implant data, the coordinates of the apical and coronal points of the actual and the planned implants were recorded. Then analytic calculations were performed to evaluate angle deviations, apical and coronal location deviations, and vertical deviations (Figs 13 and 14). To determine the health of the tissue surrounding the implants, panoramic and periapical radiographs of the patient were taken 1 year after the treatment. These showed no complications (Fig 15).

DISCUSSION

Flapless implant surgery is becoming accepted as an alternative protocol for placing dental implants. Surgical templates fabricated using CT data allow the accurate transfer of a presurgical implant plan in flapless implant surgery. The stereolithographic templates can be used in completely as well as partially edentulous situations. The templates can be supported by soft tissue, by bone, or by remaining teeth. The benefits of the 3D CT software technique are apparent for the surgeon, the prosthodontist, and the patient.[10–13] It may also be possible to predict and quantify initial implant stability and bone quality from presurgical diagnosis using routine CT scan data and implant simulation software.[14] The use of a radiographic guide during the CT scan optimizes scanned information and provides a reference during computer-aided implant placement. The use of a barium coating enables the buccolingual positioning of the implant to be correlated with the tooth outline.

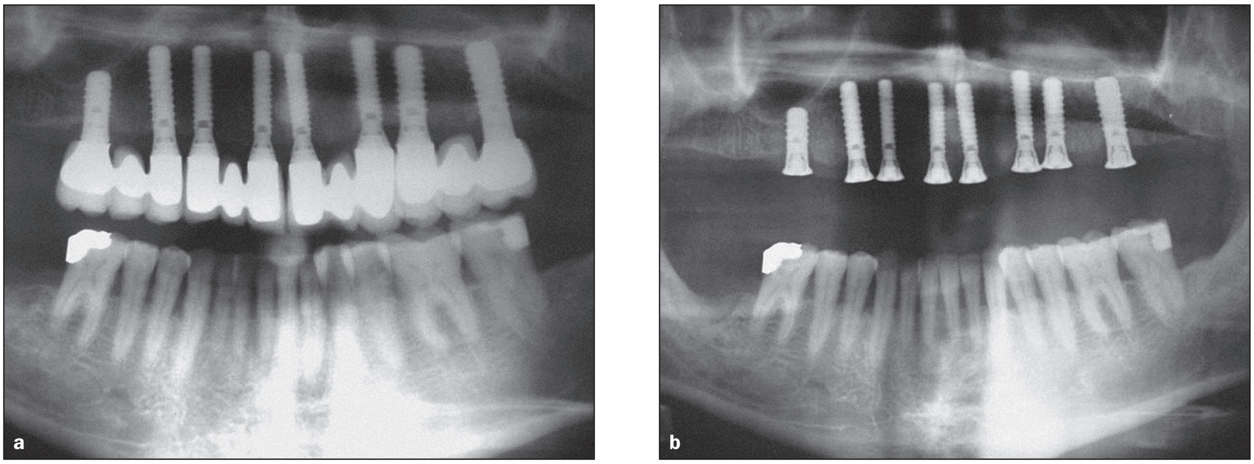

Fig 15 Panoramic views of the patient after (*a*) a 5-month healing period and (*b*) 1 year of follow-up.

Although there are many possible benefits to this technique, some limitations were encountered in the treatment of the present patient. First, in flapless surgery, there is a risk of obstruction of the implant cavity by microscopic pieces of mucosa, which may impede osseointegration during the healing phase. During the surgery, if the template is not fixed horizontally to the bone with small pins, there is a risk of improper seating of the template, which will result in misalignment of the implants.[15] The templates also make it difficult to achieve and maintain the necessary coolness of the site during the surgery. It is also vital to evaluate the depth of each site during the surgery phase. The height of the mucosa, implants, and the guiding steel ring must be accurately calculated; otherwise the cavity may be too shallow to accommodate the implant. Apart from these limitations, the technique is a very valuable tool in achieving successful results.

There may also be some limitations because CT scanners often are unable to recognize structural differences smaller than 1 mm. Also, the soft tissue support of the surgical guides may be altered by several facts such as anesthesia, pressure of the surgical stent, or changes in the mucosa. The precision of the prefabricated provisional or definitive prosthesis is also very important in eliminating possible deviations.

Although these advanced methods aim at improving surgical guidance, accuracy has rarely been measured objectively. Planning and actual placement are related more closely in terms of horizontal positioning (mesiodistal and buccolingual) and implant angulation. In this patient, the mean coronal discrepancy was 0.89 ± 0.29 mm, the mean apical difference was 1.20 ± 0.50 mm, and the mean angular deviation was 5.85 ± 1.43 degrees. The mean vertical discrepancy was 0.05 ± 0.59 mm. This was a very good result in comparison with other studies in the literature.[12,13,16] The current study also showed a strong correlation between the coronal, apical, and angular deviations. One of the main causes of these deviations was the lack of horizontal fixation of the surgical stent. These results indicated that the error resulting from transfer of CT-based implant planning guides is minimal and within the limits of the other studies.

CONCLUSION

Extensive preoperative planning and treatment coordination are necessary for treatment success. Imaging tools, a diagnostic waxup, and a surgical guide, along with a good understanding of anatomy and surgical principles, are essential. Early recognition of problem etiology and prompt treatment may prove to be invaluable to clinicians. Within the limitations of this case, clinical and analytic results seem to support the case that CT-based software and surgical guides may be used to decrease the incidence of implant-associated complications and to better assist the clinician in selecting and applying the most appropriate treatment options. This technique also reduces chairside time and the healing time of the mucosa after surgery with minimal trauma to the oral tissues.

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