Clinical Application of Stereolithographic Surgical Guide With a Handpiece Guidance Apparatus: A Case Report

Oguz Ozan, DDS, PhD*
Emre Seker, DDS
Sevcan Kurtulmus-Yilmaz, DDS
Ahmet Ersan Ersoy, DDS, PhD

The success of implant-supported restorations depends on the treatment planning and the transfer of planning through the surgical field. Recently, new computer-aided design and manufacturing (CAD/CAM) techniques, such as stereolithographic (SLA) rapid prototyping, have been developed to fabricate surgical guides to improve the precision of implant placement. The objective of the present case is to introduce a recently developed SLA surgical guide system into the rehabilitation of a 62-year-old male patient with mandibular edentulism. After obtaining a cone-beam computerized tomography (CBCT) scan of the mandible with a radiographic template, the images were transferred into a 3-dimensional (3D) image-based software for implant planning. The StentCad Beyond SLA surgical guide system, which is a combination of a currently used surgical template with pilot hollows and a surgical handpiece guidance apparatus, was designed to transfer a preoperatively defined implant position onto the surgical site without any drill-surgical guide contact. For the fabrication of this system, a surgical handpiece was scanned by a laser optical scanner and a mucosa-supported surgical guide was designed according to the patient’s 3D model, which was attained from the CBCT images. Four dental implants were inserted through the SLA surgical guide system by a torque-controlled surgical handpiece to the interforaminal region via a flapless surgical procedure. Implants were assessed 3 months after surgery, and an implant-retained mandibular overdenture was fabricated. The present case emphasizes that CAD/CAM SLA surgical guides, along with CBCT images and scanning data, may help clinicians plan and place dental implants.

Key Words: SLA surgical guide, CT, dental implant, flapless surgery

INTRODUCTION

In recent years, dental implant rehabilitation has faced demands from the prosthetic and esthetic arenas calling for increasingly ideal outcomes, which require precise planning via advanced radiographic procedures and placement with surgical guides.1,2 Computerized tomography (CT) is a useful tool in the rehabilitation of complex cases when anatomic limitations, reduced bone dimensions, and compromised bone density are present.3 Thus, in the past decade it has become the gold standard for pre-implant assessment of the jaws.4 With the use of a radiographic template during the CT scanning procedure, a restorative implant practitioner can also visualize the location of the planned implants from an esthetic and biomechanical standpoint.5 Various CT-based software programs and navigation systems have been developed to assist with surgery and presurgical planning.6,7 The software allows the practitioner to view a longitudinal and a concentric graph of bone density value around each planned implant8 and graphical 3-dimensional (3D) implant simulation.5 Computer-aided design and manufacturing (CAD/CAM) techniques make it possible to use data from CT not only for planning implant rehabilitation but also to fabricate surgical guides.9 The technique uses stereolithography (SLA), a laser-driven polymerization process that
fabricates surgical guides. These guides, which sit directly on the mucosa or jaw bone, were prepared according to appropriate angulation and depth for selected implant systems.

Compared with conventional flapped surgery, flapless implant placement, which is a less time-consuming, more esthetic, and less invasive technique to restore any type of edentulism, has become increasingly popular. Flapless procedures also ensure reduced intraoperative bleeding and decreased postoperative patient discomfort. However, this kind of implant surgery has generally been perceived as a blind procedure because of the difficulty in evaluating alveolar bone shape and angulation.

This case report describes a designed to guide an operator’s contra-angle handpiece with a surgical guide.

**MATERIALS AND METHODS**

A 62-year-old male patient was referred to the Near East University Faculty of Dentistry Department of Prosthodontics with the complaint of an unstable mandibular complete denture. The patient’s medical history was not remarkable. The patient was satisfied with his existing upper implant supported complete denture. The clinical examination revealed severe mandibular bone atrophy (Figure 1). The patient was informed that implant fixtures could ensure better stability for a lower complete denture. Different treatment options and their possible consequences were discussed in detail with the patient. The patient signed an informed consent document.

For an accurate treatment planning it was decided to use cone-beam computerized tomography (CBCT, NewTom QR-DVT-9000, Verona, Italy). A barium sulfate–containing lower complete denture was fabricated as a radiographic template to accurately measure the thickness of the mucosa based on manufacturer (Ay Tasarim Ltd, Ankara, Turkey) recommendations. To prevent the scatter that may be derived from the radiopaque material, the amount of barium sulfate was adjusted to 5%. The CT images that were obtained with a single-scan technique, with acquisition slices of 0.5 mm, were transferred to a 3D image-based program (StentCad, Media Lab Software, La Spezia, Italy).

After the available bone was evaluated and the prosthetic treatment plan was made, the location and type of the fixtures were selected. The plan was to place 4 implants (SwissPlus, ZimmerDental, Carlsbad, Calif) in the interferominal region (Figure 2). The parallelism and location of the implants were controlled and checked on the planning software. The diameters and lengths of the implants were 3.7 × 12.0 mm, 3.7 × 12.0 mm, 3.7 × 10.0 mm, 3.7 × 12.0 mm from the right to left side, respectively.

With the use of StentCad Beyond (Ay Tasarim Ltd, Ankara, Turkey), a new system that guides the handpiece, a physical transfer of the implant planning to the patient’s mouth was planned for this case. This system is a combination of 2 parts: the first is the handpiece guidance apparatus (Figure 3) and the second is the mucosa-supported surgical template, which is called the “base part” (Figure 4). The handpiece guidance apparatus sits on the handpiece without any movement and remains stable during the drilling procedures. A triangular pin on the handpiece part settles on the triangular tubes, which are on the base part (Figure 5). The triangular tubes were designed according to the planned implant angulation on the software. Thus, the pin and the tube guide the location and angulation of the handpiece, thereby guiding implant placement. The length of the tubes is adjusted according to the implant length. With the full placement of the pins into the tubes, depth control is provided.

To design the custom-manufactured handpiece apparatus, the contrangle (WS-56 E, W&H, Bürmoos, Germany) was scanned by a modified laser optical scanner (NextEngine Inc, Santa Monica, Calif) within a 12-µm accuracy ratio, and the handpiece guidance apparatus was virtually designed according to the scan data (Figures 6 and 7). The base part of the guide was designed according to the patient’s 3D model, which was attained from the CT images. After the treatment plan and scanning/designing procedures were completed, the data were transferred to an SLA machine (EnvisionTec, Perfactory, Gladbeck, Germany) to fabricate the StentCad Beyond surgical implant guide system. The SLA technique is based on the process of photopolymerization, in which a liquid resin (Envision Tec, Gladbeck, Germany) is converted to a solid polymer on exposure to computer-controlled ultraviolet laser radiation. The photopolymer is selectively cured on a layer-by-layer basis, where the
cured area corresponds to the desired cross-section of the required shaped article to be formed, which is in turn taken from the 3D CAD model of the part being produced. The solidified layer is then lowered by the amount of the required layer thickness, and a recoating blade moves over the surface to apply a new layer of resin. The process is repeated until a basic model of the required shape is finished. It should be noted that support structures are used to anchor the part to the build platform during the build process and to enable the production of overhanging features. On completion of the build,
the model is usually post-cured under high-intensity ultraviolet radiation to complete the curing process.\textsuperscript{16}

After the StentCad Beyond SLA surgical guide system was produced, the handpiece part of the surgical guide was attached and locked to the surgeon’s contrangle and checked for fit. Both parts were placed in glutaraldehyde solution before the surgery. Just before the surgery, the base part was placed on the edentulous jaw and checked for stability.

The flapless surgery was performed under local
anesthesia (Ultracain DS forte, Aventis Pharma, Bad Soden, Germany). For better immobilization, the surgical guide was fixed to the underlying jaw bone with 3 osteosynthesis screws (Surgi-tec, Brugge, Belgium) through previously prepared screw holes (Figure 8). During the surgery, a single surgical guide was used because the system guides the handpiece not the drills. The drill holes, which are on the base part, have an appropriate diameter that allows all the drills (including rotary tissue punch drill) to be used and so the implant can be placed (Figure 9). After the required mucosae are removed with a rotary tissue punch (Salvin Dental Specialties, Charlotte, NC) drilling procedures were performed according to implant system’s recommendations and implants were inserted through the SLA surgical guide system by a torque-controlled surgical handpiece (Figures 10 and 11).

During the 3-month healing period, a temporary complete denture was fabricated for the patient’s comfort. After osseointegration, implants were assessed and a new mandibular implant-retained overdenture was fabricated (Figures 12 and 13).

**DISCUSSION**

Placement of dental implants requires precise planning that accounts for anatomic limitations and restorative goals. Diagnosis can be performed with the assistance of CT scanning, and the transfer of planning from the computer to the surgical field is possible with the use of computer-aided surgical guides, which have been proven to be far more accurate than the traditional free-hand method of implant placement. In recent years, rapid prototyping, using SLA modeling, has become a favorable option for fabricating surgical guides. Sarment et al compared the conventional surgical guide with the SLA surgical guide in vitro and reported that implant placement was improved by using an SLA surgical guide. They stated that the clinical significance of this result may be relevant when multiple parallel distant implants are placed and where the degree of accuracy is critical to obtain a single prosthetic path of insertion.

The SLA surgical guides derived from CT scan planning data were found to be highly accurate and easy to use in either bone-supported, tooth-supported, or mucosa-supported configurations. To minimize the possibility of postoperative peri-implant tissue loss and to overcome the challenge of soft-tissue management during or after surgery, the concept of flapless implant surgery has been introduced with the use of mucosa-supported surgical guides for patients with the sufficient bone volume in the implant recipient side. Less traumatic surgery, decreased operative time, rapid
post-surgical healing, fewer postoperative complications, and increased patient comfort are the other advantages of flapless surgery.\textsuperscript{12,13}

The literature contains several studies regarding the clinical success of flapless implant surgery with the help of SLA surgical guides.\textsuperscript{22,23,26,27} Ozan et al\textsuperscript{22} compared the accuracy of flapless and conventional flapped computer-aided implant surgery and found that there was no statistically significance between the two techniques in terms of accuracy.

A recent clinical study by Arisan et al\textsuperscript{23} demonstrated that implants placed using mucosa-supported surgical guides showed the lowest deviations compared with bone- and tooth-supported guides. The authors attributed this result to fixation of the guides with osteosynthesis screws in fully edentulous patients.

Ersoy et al\textsuperscript{17} aimed to evaluate the match between the position and axes of the planned and placed implants with the use of SLA surgical guides. They found angulation deviations between planned and placed implants, which may have resulted from micromovements when the SLA surgical guides were not screwed to the jawbone. Therefore, it is important to stabilize surgical guides with screws to decrease the deviations of the implants. For that purpose use of a single-piece surgical guide with osteosynthesis screws\textsuperscript{23} and insertion of implants\textsuperscript{28} with such a guide have been recommended to reduce deviations.

In earlier SLA surgical guides there was no depth control of the osteotomy drills.\textsuperscript{29} On the other hand, the StentCad Beyond system provides a necessary depth control by full placement of the pins into the tubes. Because the system consists of a single surgical guide that is stabilized with osteosynthesis screws, disadvantages related to the usage of multiple surgical guides and fixation procedures can be eliminated.

Compared with conventional SLA surgical guide systems, the primary benefit of this new system is the guidance of the handpiece not the drills. The guidance of handpiece ensures additional benefits compared with drill-guided conventional systems. Therefore, the system is compatible with drills of all implant systems, and there is no need for any special equipment because the system guides the handpiece not the drills. Also, this method is designed to prevent the drill from contacting the template, tube, or other material. The guidance of the handpiece allows the user to uncover the osteotomy area. Therefore, there is no drill guidance that may cause drill-tube friction and produce metal shavings into the osteotomy, which may impede osseointegration.

Although this technique has many possible benefits, there may also be some limitations, such as mucosal tissue accumulation in implant socket during flapless surgery, the necessity of the mucosa thickness evaluation, and the complex structure of the guide system. The accuracy of mucosa thickness measurement with the aid of barium sulfate–coated denture can be questionable because CT scanners are usually unable to recognize structural differences smaller than 1 mm.\textsuperscript{30} This surgical guide system has a more complex structure than the conventional guides, and therefore, the design and manufacturing procedures are more complicated. Also, the application of the system in the posterior region is not functional, as expected, because of the difficulties of the orientation of pin and hole, but in the anterior regions system, it can be preferable because of its cost-effectiveness over routine techniques (similar with the same manufacturer's conventional system). Moreover, the system requires improvement to provide better frictionless movement between the surgical guide holes and the pin of the handpiece guidance apparatus in order to eliminate vibration during the surgery. In addition more rigid materials should be used to reduce the pin flexibility occurrence during application. Finally, users should also take into consideration that placing the pin into the hole may be difficult, especially in patients who have a small mouth opening.

\textbf{Conclusion}

Both CT-based software and surgical guides may be useful tools to decrease the incidence of implant-associated complications. Besides the advantages of the conventional surgical guides, the StentCad Beyond SLA surgical system has additional benefits, such as the ability to insert the implant with the surgical guide and the elimination of metal shaving into osteotomy site, which may impede osseointegration. However, this system requires improvement to simplify the complex structure of the guide system and to provide better frictionless movement between the pin and hole to eliminate vibration.
during the surgery. This case report presents only one case with 4 implants; therefore, further clinical studies using greater numbers of patients and implants are needed to support the benefits of this system.

ABBREVIATIONS

CBCT: cone-beam computerized tomography  
CT: computerized tomography  
SLA: stereolithographic

REFERENCES