Cone Beam Computerized Tomography-based Dental Imaging for Implant Planning and Surgical Guidance, Part 1: Single Implant in the Mandibular Molar Region

Dov M. Almog, DMD
James LaMar, DMD
Frank R. LaMar, DDS
Frank LaMar, DDS

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Dov M. Almog, DMD, *is in private practice limited to prosthodontics in Rochester, NY, and is a clinical associate professor in the Department of Oral Diagnostic Sciences at the University of Buffalo, School of Dental Medicine in Buffalo, NY. Address correspondence to Dr Almog at the Dental Implants and Reconstruction Center, 1960 Clinton Avenue South, Rochester, NY 14618.*

James LaMar, DMD, *and* ***Frank LaMar, DDS,*** *are in private practice limited to dental implants in Rochester, NY.*

Frank R. LaMar, DDS, *is in private practice limited to prosthodontics in Rochester, NY, and is a clinical assistant professor in the Division of Prosthodontics at the University of Rochester Eastman Dental Center, Rochester, NY.*

Computerized tomography (CT)-based dental imaging for implant planning and surgical guidance carries both restorative information for implant positioning, as far as trajectory and distribution, and radiographic information, as far as depth and proximity to critical anatomic landmarks such as the mandibular canal, maxillary sinus, and adjacent teeth. This case report describes a systematic approach to the planning and surgical placement of a single implant-supported crown, utilizing CT-based dental imaging for implant planning and surgical guidance. The simple steps result in the accurate transfer of critical radiographic information to the surgical site.

Introduction

There has been a rapid increase in the number of practitioners involved in implant placement, including specialists and generalists with different levels of expertise.

Although the significance of accurate planning and surgical guidance as it pertains to critical anatomic landmarks such as the mandibular canal, maxillary sinus, and adjacent teeth cannot be overstated when reviewing imaging modalities for the preoperative assessment of the dental implant site, many conflicting variables need to be considered. The amount of information provided, its accuracy, and its applicability need to be weighed against cost, convenience, availability, radiation dose, and expertise required to produce and read the output of each modality.

Currently there are a number of software systems that analyze computerized tomography (CT) scans to aid in planning surgery and produce the physical surgical drilling template guides. These templates are computer manufactured in such a way that they identically match the location, trajectory, and depth of the planned implant. As the dental practitioner places the implants, the templates stabilize the drilling by restricting the degrees of freedom of the drill trajectory and depth.

The quantitative relationship between successful outcomes in dental implant treatment and CT-based dental imaging, coupled with surgical template guidance, is unknown and awaits discovery through large prospective clinical trials. However, using CT-based dental imaging together with surgical template guidance is becoming a reliable procedure based on a series of recent preliminary clinical studies and case reports.[1–8]

In this case report, the authors describe a systematic approach to the planning and surgical placement of a single implant-supported crown in the mandibular second-molar region. The report describes the use of Cone Beam CT-based dental imaging for both implant planning and surgical guidance. Due to the proximity of the implant site to the mandibular canal, measures had to be taken when planning the implant trajectory to avoid damaging this critical anatomic landmark. The simple steps described in this report resulted in the accurate transfer of critical radiographic trajectory and depth information to the surgical site while maintaining a safe distance from the adjacent teeth.

CASE REPORT

A 21-year-old Caucasian male was referred to a prosthodontist in Rochester, NY, for a consultation and prosthodontic treatment consideration. A clinical examination, including a panoramic radiograph, revealed a missing second, lower-right molar and impacted upper- and lower-right molars (Figure 1). The medical history was noncontributory. The chief complaint noted by the patient was a desire to "replace the missing lower right molar in order to prevent overeruption of the opposing tooth."

Impressions were made of both arches using stock trays and irreversible hydrocolloid (Jeltrate Plus Dentsply Caulk, Inc., Mildford, Del) and poured in stone (Quickstone, Whip Mix, Louisville, Ky). The diagnostic casts were articulated in a semiadjustable articulator (Hanau H2, Hanau Teledyne, Buffalo, NY) through the use of a centric-relation record and a face-bow transfer.

Following careful assessment, the treatment determined best in this case was the consideration of extracting the impacted upper- and lower-right molars and placing an implant-supported crown to replace the missing second, lower-right molar. During the following visit, the treatment options were then discussed with the patient and his parents. Following an introduction of the Cone Beam CT-based dental imaging planning and surgical guidance protocol to the patient and his parents, a decision was made to pursue the previously discussed treatment option.

Six months following the extraction of the impacted upper- and lower-right molars (teeth No. 1 and No. 32) and socket preservation, a diagnostic wax up was completed to establish the desired prosthetic orientation of the missing second, lower-right molar. Wax was used to block out the undercuts on all of the teeth, and a light coat of lubricant was applied to the buccal, lingual, and occlusal surfaces of the cast. A 3-mm thermoplastic material, Thermoforming Material (T&S Dental & Plastics Mfg, Myerstown, Pa) was used to fabricate the vacuum-formed template. The vacuum-formed shell template was separated from the cast and circumferentially trimmed. The wax up from the cast was removed, and the missing second, lower-right molar region was relined with Jet Acrylic (Lang Dental Mfg Co, Wheeling, Ill) and placed back on the cast.

The next step was to place a radiopaque indicator over the surgical site. This indicator is an imaging aid that represents the most appropriate trajectory of the planned implant and prosthetic location.[9,10] A $^{5}/_{32}$-inch-diameter

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FIGURE 1. A panoramic radiograph revealed a missing lower-right second molar and impacted upper- and lower-right third molars. FIGURE 2. A Cone Beam CT study was performed while the patient was wearing an imaging guide with radiopaque restorative pins seen in the panoramic slice (A) and cross-section (B). These pins represent optimal prosthetically-driven access holes and trajectory for tooth No. 31. Residual bone trajectory and the mandibular canal were also used as guiding basics for implant trajectory, depth/length, and diameter. A 3-dimensional reconstruction of a patient's anatomy was achieved, and a surgical guidance template (C) was designed and computer-manufactured with a precise drilling-hole location and trajectory. FIGURE 3. The primary sleeve from the metal guiding sleeves system was inserted into a predetermined hole and secured by means of an adhesive to the template. FIGURE 4. An osteotomy and subsequent implant drilling procedure was performed utilizing the personalized template. FIGURE 5. The Zimmer implant, 5.7 mm in diameter and 11.5 mm long, was placed in the optimal position, considering the surrounding anatomic landmarks and the patient's occlusion. FIGURE 6. The final lower-right second molar porcelain fused to metal implant–supported restoration that was cemented in place.


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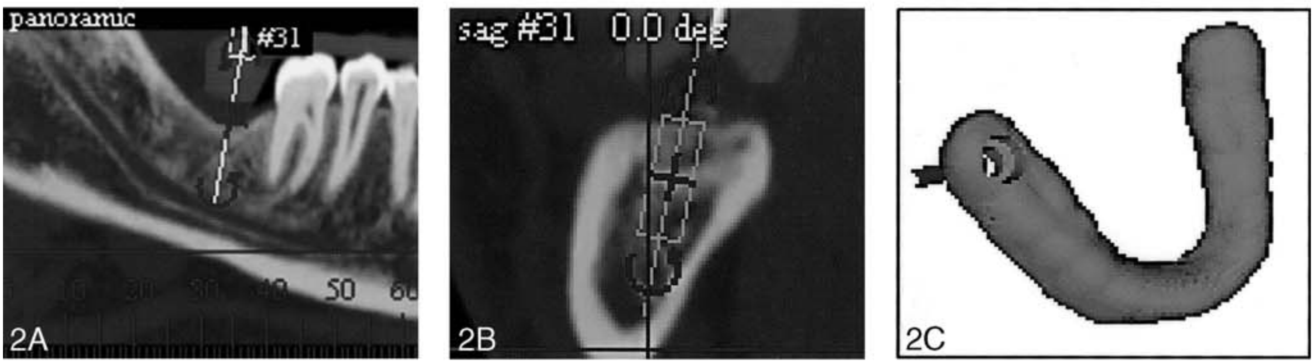
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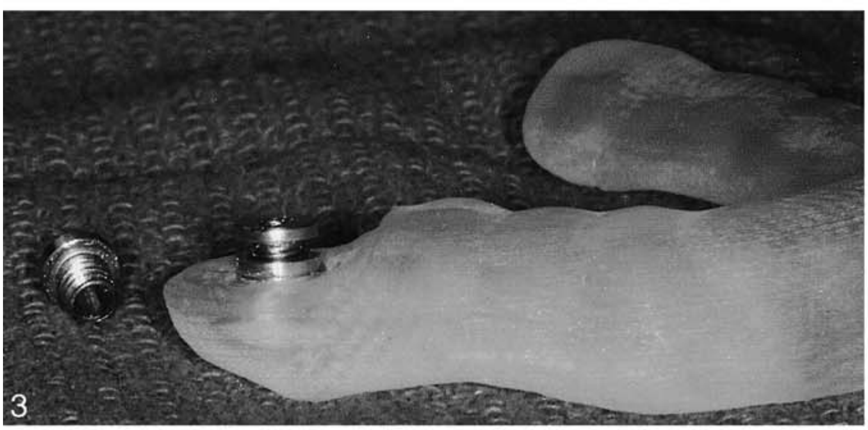
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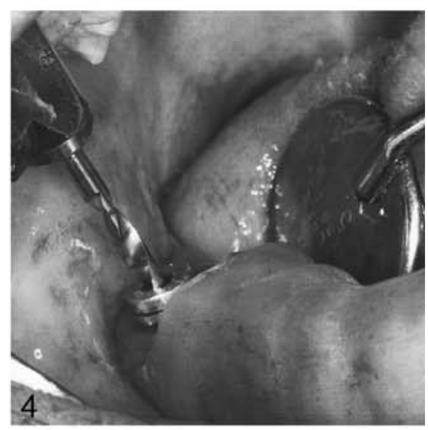
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drill, a laboratory handpiece, was used to create an access hole through the template, utilizing a trajectory that was consistent with the planned prosthetic trajectory. A generic sewing pin was centered in the access hole and secured with Triad Gel, a type of light-curing composite (Dentsply International Inc, York, Pa). A laboratory handpiece drill was used to trim both ends of the pin flush to the surface of the template.

A Cone Beam CT study was performed as the patient wore the imaging guide, using the i-CAT 3-D imaging technology (Imaging Sciences International, Hatfield, Pa). When planning the case in a 3-dimensional environment, the radiopaque pin placed in the imaging guide, the residual bone trajectory, and the regional anatomic landmarks were used as guiding basics (Figure 2). Utilizing ImplantMaster (I-Dent, Ltd, Hod Hasharon, Israel), a 3-dimensional reconstruction of the patient's anatomy was achieved and a surgical guidance template was designed and computer manufactured with a precise drilling hole at the precise drilling spot. A metal-guiding sleeve system (Hi-dent, Ltd, Rochester, NY) was assembled in the drilling hole; this gave the template rigidity in the drilling zone (Figure 3). The metal-guiding sleeve system was based on the use of a primary sleeve that was inserted into a predetermined hole and secured by means of a super glue (Ellman Cyanodent, Ellman International, Inc, Oceanside, NY) to the template. Its inner diameter of the primary sleeve suited the largest diameter drill that was used. The smaller sleeves screwed into the primary sleeve and were locked into place. The smaller sleeves were screw-cut to suit the primary sleeve and reamed out to suit the subsequent diameter sleeves used.

The implant surgery was done using a standard protocol for the Zimmer system (Zimmer Dental, Carlsbad, Calif). The patient was anesthetized with lidocaine 2% with 1:100 000 epinephrine. The osteotomy and subsequent implant-drilling procedures were performed utilizing the personalized surgical-guidance template that fit snugly onto the patient's teeth during the implant procedure. The surgical-guidance template had 2.2-, 2.8-, and 3.5-sleeve apertures, corresponding to each successive drill in the Zimmer surgical kit. After the final drill was used, a Zimmer implant (5.7 mm $\times$ 11.5 mm, Standard Plus, regular neck) was placed (Figures 4 and 5).

Following 8 weeks of healing for osseointegration to occur, the healing cap was removed and a gold 6.0-mm RN solid 6^0abutment (Zimmer Dental, Carlsbad, Calif) was torqued to 35 Newton-cm. An impression was taken using Impergum Penta-Soft (3M ESPE AG, Dental Products, Seefeld, Germany), and a porcelain-fused-to-metal crown was fabricated. Once the crown was tried and the patient was satisfied with its esthetics and function, the 3M RelyX Luting Plus (3M ESPE Dental Products, St. Paul, Minn) luting agent was used to cement the crown in place (Figure 6).

CONCLUSIONS

Outcomes assessment in this area of dentistry is difficult, primarily due to bias and variability in clinical research. Observed differences can be due to differences among investigators and/or interest groups rather than differences in the treatments. Furthermore, once cost-to-benefit analyses are conducted, the increase in cost associated with CT-based implant planning and computer fabrication of surgical templates must be justified from a consumer perspective (ie, the value associated with the increased safety and predictability of dental implants).

In the present case, by taking a CT-based study along with an imaging template with a radiopaque pin that represents the restorative planning, the treatment was optimized. It helped the clinician safely and predictably transfer the optimal-implant trajectory and distances from the adjacent tooth and mandibular nerve to the patient's mouth.

The final restoration was functional and esthetic. It did not compromise adjacent teeth or anatomic structures, yet was well accepted by the patient. In recent months, the authors have also successfully put into practice this very same Cone Beam CT-based planning and surgical guidance protocols in more complex cases involving multiple dental implants.

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