CT-Based Dental Imaging for Implant Planning and Surgical Guidance

A CASE REPORT

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Abstract

CT-based dental imaging for implant planning and surgical guidance carries both clinical and radiographic information for implant positioning as far as trajectory, depth and distribution. The significance of accurate planning and surgical guidance as it pertains to critical anatomical landmarks, such as the mandibular canal, maxillary sinus and adjacent teeth, cannot be overstated. This case report describes a systematic approach to the planning and surgical placement of a single, implant-supported crown, using 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.

THERE HAS BEEN A RAPID INCREASE in the number of practitioners involved in implant placement. They include specialists and generalists, with different levels of expertise.

When reviewing imaging modalities for 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 CT scans to aid in planning the surgery and produce the physical surgical drilling template guides. These templates are computer manufactured in such a way that they perfectly match the planned implant location, trajectory and depth. They stabilize the drilling procedure while the dental practitioner placing the implants performs the procedure by restricting the degrees of freedom of the drill trajectory and depth.

At present, the primary manufacturers in this sector are Materialise, Leuven, Belgium (http://www.materialise.be/simplant/main1_ENG.html); Oralim; Medicim NV, Sint-Niklaas, Belgium (http://www.medicim.com/products_oralim.html); Implant Logic Systems, Ltd., Cedarhurst, NY (http://www.implantlogic.com/); med3D GmbH, Heidelberg, Germany (http://www.med3d.de/); and I-Dent, Ltd., Hod Hasharon, Israel (http://www.ident-surgical.com/).

The quantitative relationship between successful dental implant treatment outcomes and CT-based dental imaging, coupled with surgical template guidance, is unknown and awaits discovery through large prospective clinical trials. However, the concept of using CT-based dental imaging, coupled with surgical template guidance, has become evidence-based through review 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 maxillary second premolar region, using CT-based dental imaging for implant planning and surgical guidance. Because of the proximity of the implant site to the maxillary sinus and adjacent teeth, measures had to be taken when planning the

implant trajectory to avoid damaging these structures. The simple steps described in this report resulted in the accurate transfer of critical radiographic trajectory information to the surgical site, avoiding the need for a maxillary sinus grafting procedure, while maintaining a safe distance from the adjacent teeth.

Case Report

A 51-year-old white female was referred by a general dentist to a periodontist and prosthodontist in Rochester, NY, for periodontics and prosthodontic treatment considerations. The medical and dental histories were recorded, and a complete series of radiographs was made. Medical history was non-contributory. The clinical examination revealed generalized periodontitis with localized advanced bone loss. The chief complaint noted by the patient was a desire to "improve the health of (her) gums and stop the gum bleeding."

Following careful assessment, it was determined that the upper right second premolar was hopeless and required extraction (Figure 1).

Impressions were made of both arches using stock trays and irreversible hydrocolloid *(Jeltrate Plus, Dentsply Caulk, Inc., Mildford, DE)* and poured in stone *(Quickstone, Whip Mix, Louisville, KY)*. The diagnostic casts were articulated in a semi-adjustable articulator *(Hanau H2, Hanau Teledyne, Buffalo, NY)*, using a centric relation record and a facebow transfer.

During the following visit, treatment options were discussed with the patient. All options encompassed generalized periodontal therapy that included extraction of the upper right second premolar. One option included a sinus grafting procedure, which the patient refused, primarily because of the level of anticipated surgical invasiveness.

Following an introduction of the CT-based dental imaging planning and surgical guidance protocol to the patient, a decision was made to pursue that plan.

Twelve months following extraction of tooth #4 and socket preservation, a diagnostic wax-up was done to establish the desired prosthetic orientation of the upper right second premolar. Wax was used to block out all undercuts on all the teeth on either side of the edentulous area, and a light coat of lubricant was applied to the palatal and occlusal surfaces of the cast. Two layers of a 3 mm vacuum-formed thermoplastic material, such as Thermoforming Material *(T&S Dental & Plastics Mfg., Myerstown, PA)*, were used to make the shell template. Once the vacuum-formed shell template was separated from the cast, it was trimmed circumferentially. The wax-up from the cast was removed, and the upper right second premolar region was relined with Jet Acrylic *(Lang Dental Mfg. Co., Wheeling, IL)* and set back on the cast.

Restorative determination of the most appropriate placement of the implant was determined by placing a radiopaque indicator over the surgical site.[9,10] A 5/32" diameter drill in a laboratory handpiece was used to drill an access hole through the template, using a trajectory consistent with the planned prosthetic trajectory. A generic sewing pin was centered in the access hole and

Figure 1. Following careful periodontal, restorative and long-term prognosis consideration, it was determined that upper right second premolar was hopeless and required extraction.

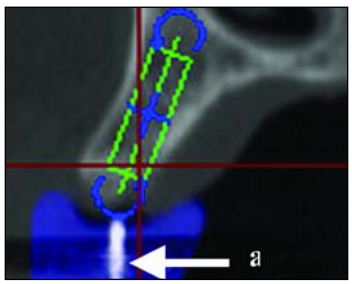

Figure 2. 3-D reconstruction of patient's anatomy was achieved and surgical guidance trajectory was determined using radiopaque restorative indicator (a), residual bone trajectory and anatomical landmarks (i.e., alveolar bone width and maxillary sinus) as guiding basics.

Figure 3. Metal guiding sleeve is inserted into predetermined computer-manufactured drilling hole and secured by adhesive to template.

secured with Triad Gel, a light-curing composite *(Dentsply International Inc., York, PA)*. Both ends of the pin were trimmed flush with the surface of the template.

A Coned Beam CT study was performed while the patient was wearing the radiographic guide, using the i-CAT 3-D imaging technology *(Imaging Sciences International, Hatfield, PA)*. Using ImplantMaster *(I-Dent, Ltd. Hod Hasharon, Israel)*, a 3-D 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 spot set for drilling, using the radiopaque restorative indicator, the residual bone trajectory and anatomical landmarks as guiding basics (Figure 2). I-Dent guiding sleeve *(I-Dent, Ltd. Hod Hasharon, Israel)* was assembled, giving the template rigidity in the drilling zone (Figure 3). The metal guiding sleeve system is based on the use of a primary bushing that is inserted into the predetermined hole and secured by means of an adhesive to the template.

The implant surgery was done using a standard protocol[11] for the Straumann Implant System *(Straumann USA LLC, Andover, MA)*. The patient was anesthetized with lidocaine 2% with 1:100,000 epinephrine. The osteotomy and subsequent implant drilling procedures were performed using the personalized surgical template that fits snugly onto the patient's teeth during the implant procedure. The Template has 2.2 mm, 2.8 mm and 3.5 mm sleeve apertures, corre-

Figure 4. Osteotomy and subsequent implant drilling procedure were performed using the personalized surgical guidance template.

Figure 5. Straumann implant, 4.1 mm diameter, 10 mm length, was placed in optimal position, considering surrounding anatomical landmarks and patient's occlusion.

Figure 6. Final upper right second premolar porcelain-fused-to-metal restoration cemented in place.

sponding to each successive drill in the Straumann surgical kit. After the final drill was used, a Straumann implant (4.1 mm x 10 mm, Standard Plus, regular neck) was placed (Figures 4 & 5).

As predictably indicated in the CT-based planning (Figure 2), in order to accommodate the restorative requirements, the implant trajectory was such that the buccal bone overlying the implant was thin. Therefore, crushed cortical bone allograft and Biogide Collagen Barrier *(Geistlich Biomaterials, Wolhusen, Switzerland)* were placed. The flaps were sutured with Gore-Tex CV-5 suture material *(W.L. Gore & Co., West Palm Beach, FL)*.

Following eight weeks of healing for osseointegration to occur, the healing cap was removed and a yellow 4.0 mm RN solid 6 degrees abutment *(Institut Straumann AG, Basel, Switzerland)* 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 in and the patient was satisfied with its esthetics and function, 3M RelyX Luting Plus *(3M ESPE Dental Products, St. Paul, MN)* luting agent was used to cement the crown in place (Figure 6).

Conclusions

Outcomes assessment, including cost-to-benefit analysis, in this area of dentistry is difficult. However, the increased cost associated with CT-based imaging planning and computer-generated surgical guidance templates is justified from a consumer perspective. The correct placement of a dental implant is crucial for the fabrication of a functional and esthetic restoration. The restorative dentist must provide the surgeon with information for proper placement in three dimensions.

By incorporating the restorative planning during the preoperative assessment of the implant site by using a radiographic template with a radiopaque indicator in conjunction with a CT-based imaging system, the treatment was optimized from anatomical, restorative, functional and esthetic points of view. It allowed for a physical transfer of the implant planning to the patient's mouth safely and predictably.

In the case described here, the final restoration was functional and esthetic, did not compromise adjacent teeth or anatomical structures, and was well accepted by the patient. This CT-based treatment planning protocol and surgical guidance template can be adopted for more complex case management. ■

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