inside implant DENTISTRY

"Predictability of implant placement is no longer related to a surgeon's best guess followed by exploratory surgery on the patient."

"Virtual" Implant Treatment Planning—The Future of Implant Dentistry?

Gary Orentlicher, DMD; Douglas Goldsmith, DDS; and Andrew Horowitz, DMD, MD

Dentists have entered a new era in implant dentistry. The major excitement and buzz in the field of implant dentistry in recent years involves the introduction of three-dimensional (3-D) "virtual" evaluations of patients using computed tomography (CT) scan technology or in-office cone beam scanners. Technology can now be used for 3-D diagnoses, virtual treatment planning, and designing surgical guides that allow the surgeon to duplicate a virtual treatment plan at the time of surgery.[1-11] Predictability of implant placement is no longer related to a surgeon's "best guess" followed by "exploratory" surgery on the patient. Virtual treatment planning and computer-generated drilling guides allow minimally invasive surgery, reduced surgical time, and reduced patient discomfort and swelling.[7-10,12-14] It greatly reduces surgical complications such as mandibular nerve injury, sinus perforation, fenestrations, or dehiscences.[3,4,8,10] The use of computer-generated drilling guides provides an accurate means of placing an immediate, temporary, or final prosthesis according to a prosthetically-driven treatment plan.[1-8,10]

What are the goals of the dentist and the patient in treatment planning for dental implants? The dentist wants to place the patient's implants in a predictable fashion while taking into consideration the position of the planned dental restoration, as well as the patient's medical history, bone biology, and individual anatomy. He or she wants the implants to be placed as atraumatically as possible, with minimal likelihood of involving the surrounding vital structures and teeth, and for the implants to be fully surrounded with the highest quality bone to, as best as possible, assure successful osseointegration and success of the overall case. Patients want teeth that look and function like natural teeth and will last a lifetime. They want the treatment to be performed quickly, predictably, successfully, with minimal pain, swelling, stress, complications, and little interruption to their everyday life.

Computerized implantology requires a three-stage process. The patient first has a CT scan while wearing a scan prosthesis following the protocol of the particular proprietary software used by the dentist. The scan prosthesis duplicates the planned implant restorations. The software allows the clinician to review the patient's 3-D bony architecture, the associated anatomic structures, and their relationship to the planned prosthesis. Implants and abutments can then be virtually placed by the dentist on his/her computer screen. A prosthetically-driven treatment plan is created by placing the implants in an ideal relationship to the planned dental restorations and the associated supporting bone. The virtual treatment plan is then electronically transferred to the manufacturer for the production of a stereolithographic surgical drilling guide. The drilling guide and surgical drills with "drill stops" allows the dentist to place implants accurately into their planned positions based on the "virtual" treatment plan (Figure 1 through Figure 23).

The benefits of treatment planning and placing implants using these technologies to the dentist are enormous. Three-dimensional patient evaluation and implant planning allows the dentist to fully examine the patient's bony anatomy before making an incision. It allows detailed 1:1 measurements of the width and height of the available bone in the areas planned for dental implants. Exact identification of

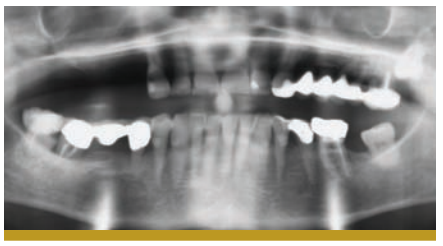

Figure 1 Case 1: Preoperative panoramic x-ray showing the partially edentulous left maxilla of a 67-year-old female patient.

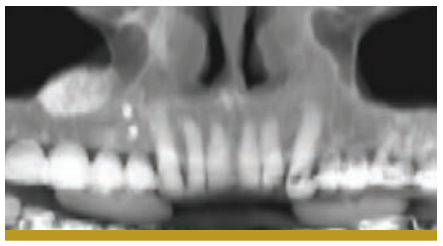

Figure 2 Panoramic x-ray after sinus lift and block graft of the right maxilla.

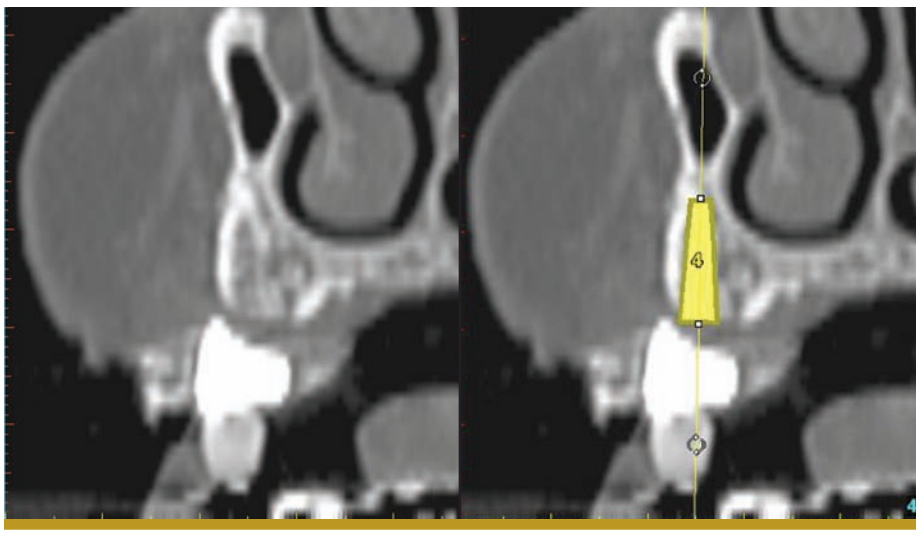

Figure 3 SimPlant Planner (Materialise Dental, Glen Burnie, MD) showing block graft of the right maxilla and one implant placed.

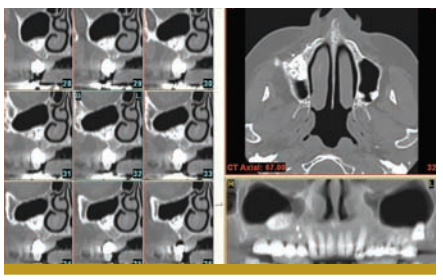

Figure 4 SimPlant Planner showing sinus lift in the right maxilla.

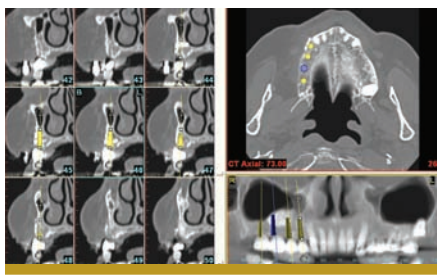

Figure 5 SimPlant Planner—four implants planned.

Gary Orentlicher, DMD
Private Practice
Scarsdale, NY

Douglas Goldsmith, DDS
Private Practice
Scarsdale, NY

Andrew Horowitz, DDS, MD
Private Practice
Scarsdale, NY

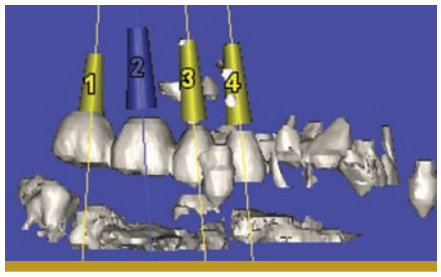

Figure 6 SimPlant Planner—four implants planned.

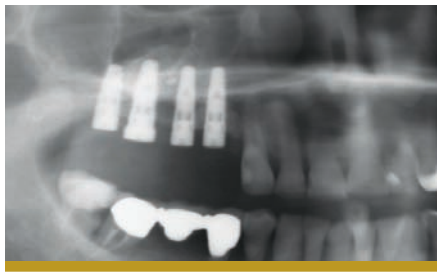

Figure 7 Postoperative panoramic x-ray.

Figure 8 Restorations of the right maxilla.

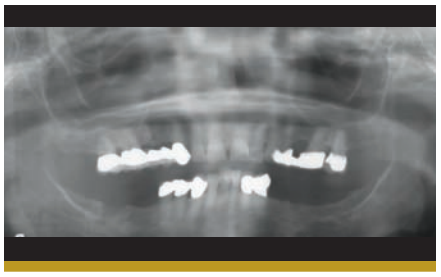

Figure 9 Case 2: Preoperative panoramic x-ray of a 65-year-old female patient with a partially edentulous mandible.

Figure 10 Radiographic guide fabrication using NobelGuide™ (Nobel Biocare AB, Göteborg, Sweden) treatment protocol.

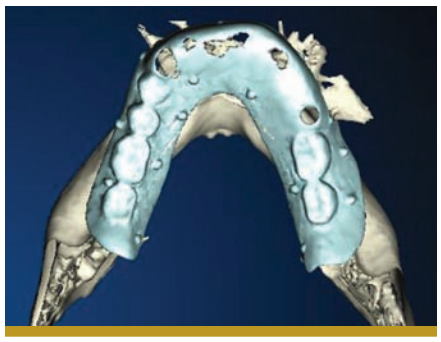

Figure 11 Three-dimensional virtual treatment planning (occlusal) before implant placement using NobelGuide.

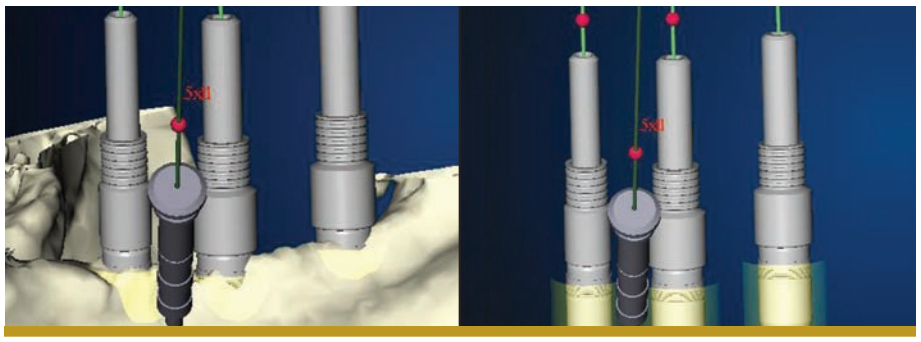

Figure 12 Virtual treatment plan of the left side using NobelGuide.

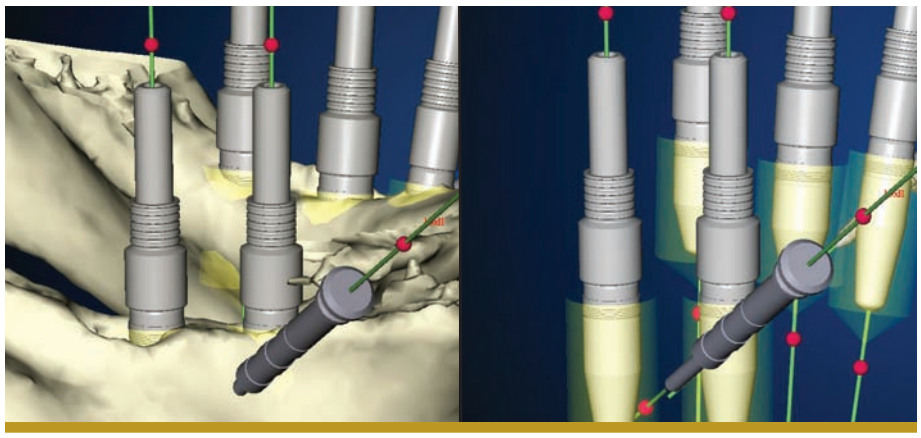

Figure 13 Virtual treatment plan of the right side using NobelGuide.

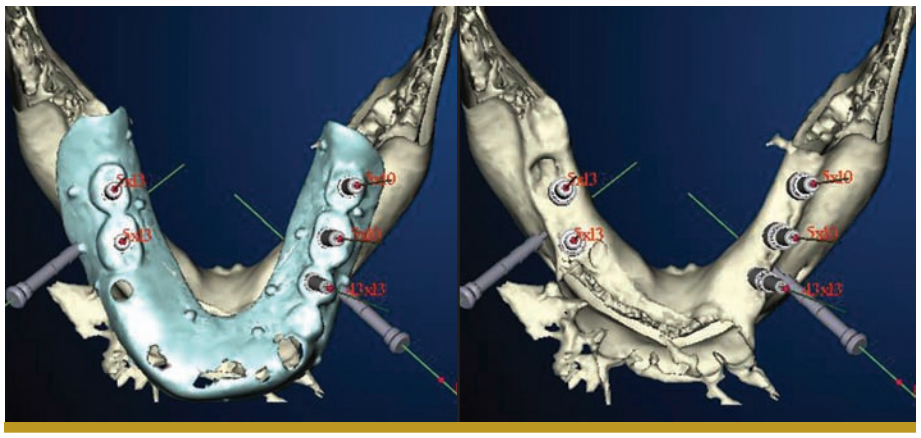

Figure 14 Occlusal view of the virtual treatment plan using NobelGuide.

the inferior alveolar nerve, mental foramen, lingual and buccal concavities, incisive canal, nasal floor, and the maxillary sinuses are all possible. Distances between planned implants, angulations of adjacent implants, angulation differences from one side of an arch to another, evaluation of any prosthesis path of insertion issues, exact placement of screw chambers, and presurgical determination of choice of abutments can all be predetermined. Soft tissue thicknesses, possible fenestrations, evaluation for possible preoperative or intraoperative sinus-lift bone grafting, ridge splitting or ridge augmentation, the volume of bone-graft material necessary, and the preoperative knowledge of the exact lengths and widths of the implants that will be placed are all possible. There are minimal intraoperative surprises.

The authors have found that once the dentist is comfortable and familiar with the drilling instrumentation, placing implants through a surgical guide not only reduces the time necessary to place implants by 50% but it also reduces the stress that the dentist experiences while placing the implants by an equal amount. The positioning of the implants is predetermined by the virtual treatment plan and built into the surgical guide. The implants can be placed with minimal stress or questions.

In the authors' experience, virtual implant planning with surgical guides is most indicated for use in the following cases:

- most cases of three or more implants in a row;
- any case with anatomic problems related to the inferior alveolar nerve, incisive canal, maxillary sinuses, and lingual, buccal, or palatal concavities;
- questionable ridge width or height;
- problems related to the proximity of adjacent teeth;
- implant position that is critical to the planned restoration; and
- patients with medical problems (ie, radiation therapy, bleeding dyscrasias).

Most importantly, this technology allows the surgeon and/or restorative dentist to treatment plan and place implants according to a prosthetically driven treatment plan. The positions of the planned restorations, as they relate to the underlying bone, are determined before surgery. The treatment planning process starts with visualizing the final prosthetic result and working backward from there, with precision.

THE TREATMENT PLANNING PROCESS STARTS WITH VISUALIZING THE FINAL PROSTHETIC RESULT AND WORKING BACKWARD FROM THERE, WITH PRECISION.

If this technology has been shown to increase the accuracy of implant placement, decrease surgical complications, and increase the predictability of implant case outcome, then why is this technology not more widely used in dental implant placement? The answer comes down to time and money.

It takes additional time for the dentist to take impressions, work up the planned positions of the restorations with a diagnostic wax-up of the planned implant prosthetics, fabricate a radiographic template for the patient to wear while having a CT scan, order or take the CT scan, import the CT data into the desired software, plan the case virtually before treating the patient, order the surgical guide, and learn the techniques and equipment necessary to place implants through a surgical guide.

As for money, it will require the patient to incur additional costs for the laboratory work to fabricate the radiographic scan prosthesis, the CT scan, and the fabrication of the surgical guide. The dentist will have to incur additional costs in learning the new technologies, possibly upgrading computer hardware, purchasing new software programs, and learning and purchasing new drilling and instrumentation kits.

Figure 15 Surgical guide fabricated from the virtual treatment plan.

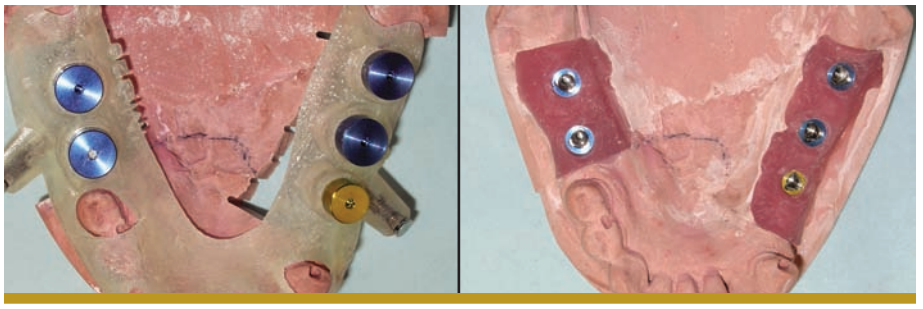

Figure 16 Laboratory models cut out, implant analogs and gingival mask placed.

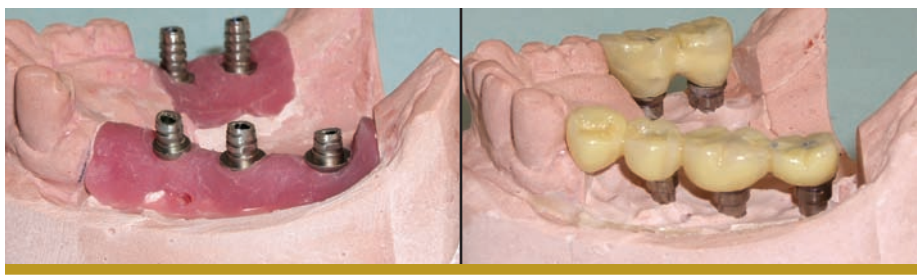

Figure 17 Abutment and provisional bridge fabrication.

Figure 18 Intraoperative insertion of surgical guide and surgical index.

Figure 19 Intraoperative flapless placement of implants.

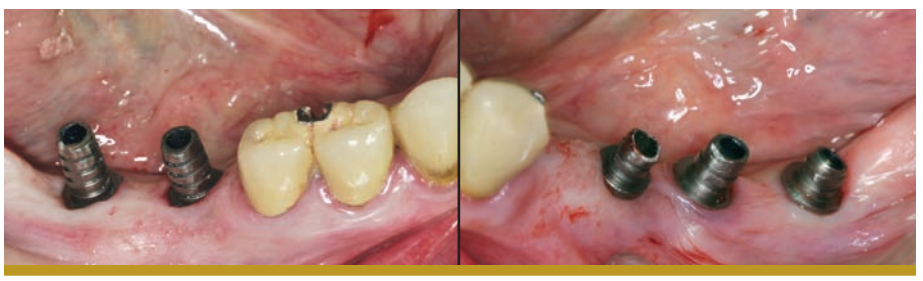

Figure 20 Immediate insertion of abutments.

Dentists may wonder why they should try another way when they have been successfully treatment planning and placing implants non-virtually for many years. Additionally, the dentist may fear that he or she will lose the case if additional costs are presented to the patient and added onto an already expensive treatment plan. Dentists may feel that the additional radiation that the patient will be exposed to by having a CT scan may not be warranted.

Treatment planning and placing implants virtually does require more preparatory steps before surgery for both the dentist and the patient. It requires dentists to commit both time and money to learning these technologies, planning the cases on a computer, and purchasing computer hardware, software, and surgical instrumentation. Dentists have to remember that implant patients are looking for teeth, not implants. In the authors' experience, when presenting an implant treatment plan to a patient, it is all in the presentation. At an implant consult, a patient's biggest fears and first questions are usually:

- How much is this going to hurt?
- What is the recuperation?
- How long am I going to be out of work?

When patients are shown this virtual technology firsthand during a consultation with the dentist and hear that their implants can be placed with minimal, if any, incisions and swelling, that they will likely be able to return to work comfortably the following day, and in some cases immediate restorations can be placed on the implants, there is no "selling" the patients on the technology. The authors frequently hear patients respond with statements such as "Why would anyone do it in any other way?" Patients understand the benefits of the technology better than some dentists.

When it is explained to the patient that using this technology will require a CT scan and cost more, but that in the end they will likely have a result where the implants will be placed in the proper positions with proper spacing for gingival and bone health, with proper angulations to distribute the bite forces well, according to a treatment plan that involves first planning where the teeth are going to be and working backward from there, with minimal surprises encountered at the time of surgery, there are few arguments. The technology sells itself. The authors have not had one patient in the 8 to 10 years that they have been treatment planning cases virtually decide that they did not want to have a CT scan or have their case planned in this way because of financial reasons or because of the additional radiation of a CT scan. Again, it is all in the presentation.

Regarding the instances in which the technology is appropriate or useful, any case can be treatment planned virtually. The authors have used this technology to place single, multiple, or full arches of implants. Implants can be buried (two-stage), placed as a single-stage (healing abutments), or immediately loaded. Implants can be placed after immediate extractions or with concurrent bone grafting procedures. In essence, implants can be placed exactly as dentists have always been placing them, but with more precision and with less pain and swelling for patients.

CONCLUSION

Dentist and patient goals can be accomplished accurately, predictably, safely, comfortably, quickly, and with minimal stress by treating implant patients using CT-based virtual 3-D implant planning and placing implants through surgical guides. It is the authors' opinion that this technology is the future of implant dentistry.

REFERENCES

1. Tardieu P Vrielinck L. Implantologie assistèe par ordinateur: le propramme SimPlant/ SurgiCase™ et le SAFE System™ mis en charge immediate d'un bridge mandibulaire avec des impalt transmuqueux. *Implant.* 2003; 9:15-28.
2. Tardieu PB, Vrielinck L, Escolano E, et al. Computer-assisted implant placement: scan template, simplant, surgiguide, and SAFE system. *Int J Periodontics Rest Dent.* 2007; 27(2):141-149.
3. Vrielinck L, Politis C, Schepers S, et al. Image-based planning and clinical valida-

Figure 21 Immediate insertion of provisional restorations.

Figure 22 Three-month postoperative panoramic x-ray.

Figure 23 Final restorations.

tion of zygoma and pterygoid implant placement in patients with severe bone atrophy using customized drill guides. Preliminary results from a prospective clinical follow-up study. *Int J Oral Maxillofac Surg.* 2003; 32(1):7-14.

4. Sarment DP, Sukovic P, Clinthorne N. Accuracy of implant placement with a stereolithographic surgical guide. *Int J Oral Maxillofac Implants.* 2003;18(4):571-577.
5. Van Steenberghe D, Malevez C, van Cleynen breugel J, et al. Accuracy of drilling guides for transfer from three-dimensional CT-based planning to placement of zygoma implants in human cadavers. *Clin Oral Implants Res.* 2003; 14(1):131-136.
6. Valente F, Buoni C, Scarfo B, et al. Precision of CAD-CAM stereolithographic mucosa-supported drilling guides in flapless implant placement. *Eur J Impl Prosth.* 2006;1(2):15-25.
7. van Steenberghe D, Naert I, Andersson M, et al. A custom template and definitive prosthesis allowing immediate implant loading in the maxilla: a clinical report. *Int J Oral Maxillofac Implants.* 2002;17(5):663-670.
8. van Steenberghe D, Ericsson I, Van Cleynenbreugel J, et al. High precision planning for oral implants based on 3-D CT scanning. A new surgical technique for immediate and delayed loading. *Applied Osseointegration Research.* 2004;4:27-31.
9. Wendelhag I, van Steenberghe D, Blombäck U, et al. Immediate function in edentulous maxillae with flapless surgery including a 3-D CT-scan based treatment planning procedure. *Clin Oral Implants Res.* 2004;15: 1xxiii. Abstract.
10. van Steenberghe D, Glauser R, Blombäck U, et al. A computed tomographic scan-derived customized surgical template and fixed prosthesis for flapless surgery and immediate loading of implants in fully edentulous maxillae: a prospective multicenter study. *Clin Implant Dent Rel Res.* 2005; 7(Suppl 1):S111-S120.
11. Parel SM, Triplett RG. Interactive imaging for implant planning, placement, and prosthesis construction. *J Oral Maxillofac Surg.* 2004;62(Suppl 2):41-47.
12. Hahn J. Single-stage, immediate loading, and flapless surgery. *J Oral Implantol.* 2000; 26(3):193-198.
13. Becker W, Goldstein M, Becker BE, et al. Minimally invasive flapless implant surgery: a prospective multicenter study. *Clin Implant Dent Relat Res.* 2005;7(Suppl 1):S21-S27.
14. Becker W, Wikesjö UM, Sennerby L, et al. Histologic evaluation of implants following flapless and flapped surgery: a study in canines. *J Periodontol.* 2006;77(10):1717-1722.