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Interactive Computerized Tomography for Dental Implants: Treatment Planning From the Prosthetic End Result

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With the prosthetic end result driving many parameters of dental implant treatment, it is imperative to plan treatment with the final prosthesis in mind. Traditional diagnostic information via periapical and panoramic radiographs are only 2-dimensional, and offer limited information. Through utilizing an interactive computerized tomography (CT) program (Sim/Plant; Materialise, Inc), the clinician can plan on a computer-correct placement of dental implants with respect to position and aesthetics in a 3-dimensional (3-D) view. With the information from the interactive Sim/Plant program, a computer-milled surgical guide stent (Implant Logic Systems) can be made that is based on the desired prosthetic end result for the patient. Through following this protocol a surgeon can place dental implants while taking into account several factors: reducing iatrogenic damage to vital structures; choosing the correct implant size, shape, and surface; hard-tissue density and volume; the relationship of implants to the final prosthesis; and assessment of preexisting pathology.

This article will demonstrate the theory and protocol of the Sim/Plant interactive CT software combined with a surgical stent from Implant Logic Systems.

Background

Computerized tomography has been utilized in medicine since the early 1970s , but it wasn't until 1987 that it was used in dentistry.1 The advantages over traditional radiographic techniques are numerous. The elimination of distortion allows for increased predictability when planning implant cases. Columbia Scientific, Inc, developed a 3-D dental software program in 1988 that worked with standard GE CT scanners. In 1993, Sim/Plant for Windows was developed, allowing clinicians to utilize their own computers to plan an implant case interactively. The further benefits of the Sim/Plant program are the availability to measure bone density, measure accurately the distance to vital structures, mark clearly vital structures such as the inferior alveolar nerve and sinus, and measure the volume needed for a sinus graft. The ability to see implants from a 3-D perspective, allowing verification of parallelism, is advantageous with respect to reducing offset loading of implants.

The full potential of the program is seen when the position of the final prosthesis is translated to the CT scan, allowing placement of implants to correlate to the final end result.2

The Sim/Plant software program is easily learned and intuitive. Three basic views are available on the Sim/Plant screen as well as a 3-D view:

The panoramic view is similar to a normal, 2-dimensional panoramic view (Figure 1), the difference being the view can interactively change in a buccal-lingual direction. The axial view offers a perspective from a coronal/apical direction (Figure 2). A cross-sectional view allows a mesial/distal cross-sectional perspective of the arch (Figure 3); this is extremely helpful in observing bone thickness and looking for anatomic variations. The cross-sectional view also best correlates the position of the prosthesis to the bone. All 3 of these views correlate to each other, so when a marker is moved on one it corresponds to the other 2 views. The final perspective is a 3-D view (Figure 4).

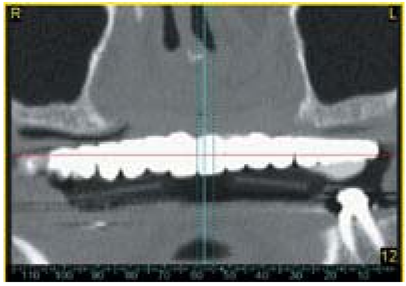

Figure 1. *Panoramic view from Sim/Plant software.*

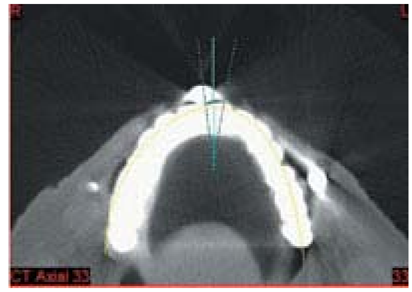

Figure 2. *Axial view from Sim/Plant software.*

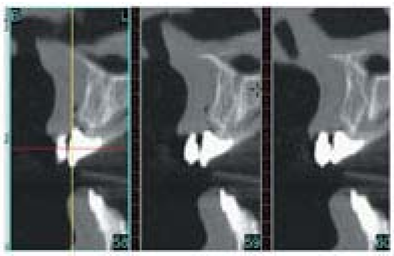

Figure 3. *Cross-sectional view from Sim/Plant software.*

Figure 4. *Three-dimensional view from Sim/Plant software.*

The 3-D view allows the clinician to check for parallelism of implants. Prior to a patient obtaining a CT, a radiographic guide stent must first be made. If the implant site is a full arch, a duplicate of a denture is made so that a radiographic stent can be made from it (Figure 5). If the implant site is bordered by teeth, then an impression of the arch is taken. The radiographic stent for a partially edentulous area could rest on either prepared or unprepared teeth (Figure 6).

Figure 5. *Duplicate of denture for fabrication of radiographic stent.*

Figure 6. *Radiographic guide stent for partially edentulous area.*

The CT is taken at any standard tomography site. The information from the CT now must be translated to the Sim/Plant program. If the CT site has the specific Materialise, Inc, software, the information is immediately placed onto a removable storage disk and can be placed on the doctor's computer. If the CT site does not have the software, the CT data must first be processed by Columbia Scientific and then sent to the doctor. The latter option simply adds time and a processing cost. Either scenario creates the same result of the CT data being able to be analyzed interactively on the doctor's computer.

After the dentist plans the case and places the implants on the Sim/Plant program, the data is sent to Implant Logic Systems for fabrication of a surgical guide stent. The surgical guide stent contains 2-mm guide tubes that direct the placement of the implants during surgery (Figure 7). Specific drills from Implant Logic Systems fit into the 2-mm tubes, creating a pilot osteotomy site. The surgical guide stent itself is made from the actual radiographic guide stent. The radiographic guide stent is sent back to Implant Logic Systems with the plan data on a removable storage disk (ie, Zip disk, Iomega Inc).

Figure 7. *Surgical guide stent with 2-mm metal guide tubes.*

The surgery utilizing the surgical guide stent can be accomplished transmucosally for a full arch case, with flap reflection being done after the initial osteotomy pilot sites are completed. In the case of an edentulous site bordered by teeth, the initial osteotomy pilot drills can be performed after flap reflection. The difference between the 2 is that in the latter scenario, the surgical guide stent can be stabilized with adjacent teeth, allowing for direct visualization of the bone.

Clinical Application: Maxillary Full Arch Reconstruction

Aesthetics is a key priority when planning dental implants to replace teeth in an entire maxillary arch. When utilizing an interactive CT with a surgical guide stent for an edentulous arch, the first step is to create an immediate denture that fulfills the ideal criteria for vertical dimension and aesthetics. This denture can then be utilized to translate the tooth position to the CT, allowing interactive planning for the case. Once the relationship of the final prosthetic tooth position is seen related to the available bone on the CT, the clinician can then decide first if a fixed bridge is feasible or if a removable, implant-supported bar overdenture would better suit the patient.3

Determination of the need to graft bone and the location of implant position are other key decisions that can be made when a final prosthetic position is seen on the interactive CT.4

Case Report

A healthy 52-year-old male presented with hopeless teeth in the maxillary and mandibular arches (Figure 8). After atraumatic extraction of the remaining maxillary teeth, an immediate denture was delivered. After determining the patient was comfortable with the immediate denture with respect to aesthetics and vertical dimension, the immediate denture was then duplicated utilizing a denture duplicator (Lang Manufacturing Inc). The duplicated denture was then sent to Implant Logic Systems so that a radiographic guide stent could be made for positioning during the CT scan. The information now obtained on the CT will show a relationship of the final prosthesis position to the available bone.

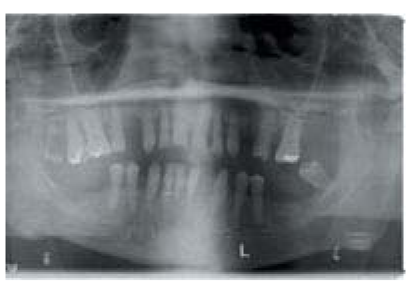

__Figure 8.__ Panograph of preoperative condition showing hopeless teeth.

The patient was then referred for a CT scan utilizing the radiographic stent. Once the CT information was returned via a Zip Disk, it was then loaded into the Sim/Plant program on the computer.

Nine dental implants were planned to support an implant supported fixed prosthesis. The implants were placed in the Sim/Plant program with respect to correlation of the final tooth position of the bridge and with respect to bone availability (Figure 9). There were a few sites where it was determined that both bone grafting and sinus preparation with osteotomes would be utilized (Figure 10). This allows presurgical planning for time, fees, and informed consent. After the case was planned using Sim/Plant, the information was sent to Implant Logic Systems for fabrication of a surgical guide stent.

Approximately 2 weeks later, the patient was draped and prepared for surgery.

After delivery of appropriate local anesthesia, the pilot osteotomies were performed transmucosally through the surgical guide stent using the Implant Logic 2-mm osteotomy burs (Figure 11). The correct depth was predetermined and available on report. The depth of the initial pilot osteotomy preparation takes into account the tissue height, stent height, and bone. Often the initial depths are 22 to 26 mm. After the initial pilot osteotomy preparations were accomplished, a full thickness flap was performed, and the osteotomy sites were visualized (Figure 12).

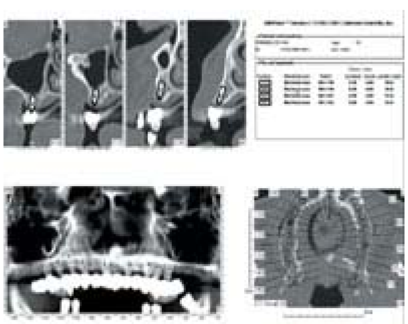

__Figure 9.__ Sim/Plant program showing planning of implant positions.

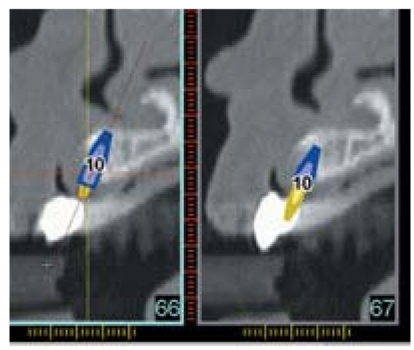

__Figure 10.__ Cross-sectional view of CT showing the need for bone grafting.

__Figure 11.__ Two-mm pilot osteotomies through surgical guide stent.

__Figure 12.__ Visualization of pilot osteotomies after full thickness flap reflection.

At this point normal osteotomy preparations were accomplished utilizing the implant system's normal osteotomy drills, the implant width and depth being predetermined from the Sim/Plant data. Nine Biohorizons dental implants (Biohorizons, Inc) were placed (Figure 13) with their accompanying cover screws (Figure 14),

and primary closure was achieved utilizing continuous sutures (Figure 15). The final panograph reveals 9 implants placed in the correct position for aesthetics and function (Figure 16). Each implant correlates to the correct tooth position and is angulated to reduce offset loading. These tasks were accomplished via the aid of the Sim/Plant interactive CT program and the corresponding computer-milled surgical guide stent.

Figure 13. *Nine Biohorizon implants placed via guidance of a CT stent.*

Figure 14. *Cover screws placed on 9 implants prior to primary closure.*

Figure 15. *Primary closure of 9 Biohorizon implants.*

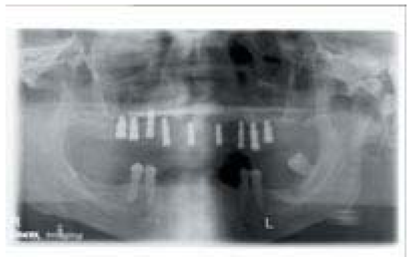

Figure 16. *Panograph showing parallelism of 9 Biohorizon implant fixtures.*

Conclusion

With the utilization of the latest technology of an interactive computerized tomography program, dental implants can be placed in the correct position for aesthetics and function. This preoperative planning also allows for a determination of the need for adjunctive grafting procedures. By including information about the prosthetic end result in the CT scan, the final prosthetic position can dictate the implant placement. The utilization of this treatment planning technology creates excellence in dental implant treatment and offers simplicity for the practitioner.

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Disclosure: Dr. Tischler is on the Biohorizons, Inc, educational speakers panel and receives an honorarium when lecturing.