Virtual dental implant planning: the next step

By Dov M. Almog, DMD and Michael Nawrocki, DMD

Already in 2005, a report from Kalorama Information estimated that the growth in implant-based dental reconstruction products would outstrip other areas of dental devices and products. According to that report, 40 percent of the western population is missing one tooth or more; in the United States alone, approximately 10 percent of the population is completely edentulous; and every year about 2 million Americans loose a tooth due to sporting accidents.

As a result, there has been a rapid increase in the number of practitioners involved in implant placement, including specialists and generalists, with different levels of expertise. Unfortunately, there has been a simultaneous raise in claims and suits involving dental implants, mostly associated with damage to the mandibular nerve and maxillary sinus perforations. This is in addition to failure associated with poor alignment.

Therefore, considering that dental implants are the fastest growing discipline in dentistry, there is little doubt that cone-beam computerized tomography (CBCT) is the pre-eminent method for viewing and understanding three-dimensional anatomy and the foundation for successful implementation of oral implantology, one of the most important branches of dentistry today.

CBCT carries very important radiographic, restorative and surgical information for dental implant planning, taking the guesswork out of what we do, and it is rapidly emerging as the diagnostic imaging standard of care. This information includes implant trajectory, distribution, depth and proximity to critical anatomical landmarks such as the mandibular canal, maxillary sinus, adjacent roots and alveolar cortical plates and undercuts.

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About the author

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Figs. 1a–c (above and below): CBCT study performed with the iCAT CBCT machine (Imaging Sciences International, Hatfield, Pa.) while the patient wore a radiographic guide (blue shadow). By utilizing ImplantMaster™ software (iDent Imaging, Foster City, Calif.), the prosthetically aligned acrylic teeth in the radiographic guide, plus the residual bone trajectory and the mandibular canal, facilitated the optimal virtual planning of implants’ trajectory, depth, length and diameter. Images are shown in two dimensions: panoramic slice (1a) and cross sections (1b, c). These cross sections correspond to the patient’s lower right and left edentulous region (Nos. 19 and 29). Note the mandibular canal illustrated by the red lines and circles.

Figs. 2a–c (at right): By utilizing ImplantMaster software, a 3-D reconstruction of a patient’s anatomy was achieved and a virtual surgical guidance template (2a, b) was designed and computer manufactured with precise drilling hole distribution and the trajectory for implants Nos. 19 and 29 (2c). Special metal sleeves were assembled in the holes that can house a series of tool inserts that accommodate a diversity of implant systems and drilling sequence as required by each implant brand.

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The collected diagnostic CBCT and the added dimension of 3-D data will result in more predictable outcomes, increasing patient satisfaction and reduced risk of potential claims. If the patient declines the CBCT diagnostic data, the practitioners should obtain and document an informed refusal.\(^2\)

In 1996, Quantitative Radiology (QR) from Verona, Italy, introduced the first dental CBCT machine called the Newtom into the Italian market. This ushered in the era of 3-D dental imaging, sparking a rapid development of dental CBCT scanners by a number of companies.

To date, there are more than 30 such CBCT machines available on the market worldwide produced by a wide variety of companies.\(^3\)

During the last decade, as recognition in the concept of CBCT has matured, and with the wider availability of CBCT 3-D imaging in imaging centers, mobile scanning units and private offices, our profession has been fueled further by the introduction of 3-D derived virtual planning software solutions.\(^4\)

About a dozen of these virtual implant planning software solutions are used for general oral implantology treatment strategy, of which only eight are ultimately used to translate the treatment strategy into an actual physical surgical guidance drilling template, thus taking the guesswork out of oral implantology (Figs. 1, 2).

Utilization of these adjunctive state-of-the-art technologies altered the manner in which we pull together diagnostic data, plan and execute both simple and complex implant cases. These surgical guidance systems offer safer and more predictable placement of dental implants, ensuring accurate transfer of critical restorative and anatomical information to the surgical site.

Additionally, these surgical guidance systems offer an opportunity to maximize a team approach between surgeons, restorative dentists and the labs, creating greater understanding, appreciation and professional camaraderie.

Of the eight 3-D derived virtual planning software solutions that are ultimately used to translate the treatment strategy into an actual physical surgical guidance drilling template, two systems differentiate themselves from all the other systems in that no physical shipment needs to be made to the guide manufacturer.

Being fully automated, digitally manufactured solutions, only digital data is transmitted, which is enough to manufacture the guidance drilling template using 3-D printing technologies. These two systems are: NobelGuide\(^5\) (Nobel Biocare, Yorba Linda, Calif.) and Scan2Guide\(^\text{™}\) (iDent Imaging, Foster City, Calif.).

While NobelGuide can only be used in conjunction with Nobel implants, Scan2Guide is an open platform that can be used with most implant systems on the market.

Because the iDent system is an open system, the company has developed a variety of metal sleeve sizes for placement in the surgical guidance drilling template and a series of tool inserts that accommodate a diversity of systems out there, including the drilling sequence as required by each implant brand.

Conclusion
This report attempts to provide an argument in favor of the utility of CBCT-image-based 3-D-derived virtual implant planning software solutions in oral implantology that are ultimately used to translate the treatment strategy into an actual physical surgical guidance drilling template.

Researchers studying these virtual surgical guidance technologies agree that the quantitative relationship between successful outcomes in oral implantology and CBCT-based dental imaging — coupled with virtual planning and, ultimately, implant placement guided by surgical guidance templates — awaits discovery through large prospective clinical trials.\(^5\)

Based on a series of case reports, it has been demonstrated that using CBCT-based dental imaging along with surgical guidance templates is, without a doubt, a reliable procedure, optimizing our patients’ safety and well being.\(^6\–8\)

A complete list of references is available from the publisher.

(Photos/Provided by Dr. Dov Almog)