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Utilizing Digital Imaging to Enhance the Team Approach to Implant Treatment

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The team approach to dental implants where the surgeon and restorative doctor collaborate can be highly enhanced through the use of cone beam computerized tomography (CBCT).[1] The key to fully utilizing CBCT on a practical level between surgical and restorative doctors is utilizing a digital imaging company (360 Imaging, N-Sequence, 3D Diagnostix) that bridges both the technology and communication aspects of all parties involved including the patient.

For the first time, because of these imaging companies, there exists a practical workflow that will provide convenient processing, planning, and communication of CBCT imaging results allowing for improved patient care involving dental implant treatment. Furthermore, this new paradigm workflow allows the restorative dentist to become involved in treatment planning, creating a true team approach.

The key for a restorative dentist to communicating with a surgeon is to be able to relate the final prosthetic end result to the surgeon.

This article will review the benefits of CBCT, and this new workflow protocol that allows for better treatment planning with all doctors involved in restoring a patient's edentulous mouth with dental implants.

TRADITIONAL VERSUS NEWER TEAM APPROACHES TO IMPLANTS

Unfortunately, the "traditional" team approach to implant dental treatment often consists of a restorative dentist sending a patient to a dental surgeon and the surgeon placing dental implants with minimal input from the referring doctor. This lack of adequate communication between the surgical and restorative doctors usually takes place because of an inability to communicate efficiently and effectively. The consequences of such a scenario often result in implants being placed in less than ideal positions for aesthetics and prosthetic loading. When an implant is not placed in a position to obtain ideal loading, the consequences can lead to bone loss and implant failure.[2] This is a problem for all parties involved and, in the end, the patient could suffer.

If the restorative doctor could help "guide" a surgeon to place dental implants based on the prosthetic end result, the outcomes would be more predictable offering a higher rate of patient success. The other advantages of the restorative doctor being involved with planning an implant case from the beginning is improved communication between the patient, the restorative doctor, and the surgeon. These improved communications create better informed consent and a better overall treatment experience for a patient.[3]

How can a restorative dentist help guide a surgeon to place a dental implant or bone graft? The answer lies in understanding that implant dentistry is a prosthetically-based discipline supported by surgical procedures. The key for a restorative dentist communicating with a surgeon is to be able to relate the final prosthetic end result to the surgeon.[4] The communication tool to best facilitate this is CBCT. With a digital imaging company as a partner, it is possible for CBCT information to be easily relayed to all parties involved, creating a safer and improved prosthetically based treatment plan.

Figure 1. Duplicate maxillary denture used to make radiographic stent.

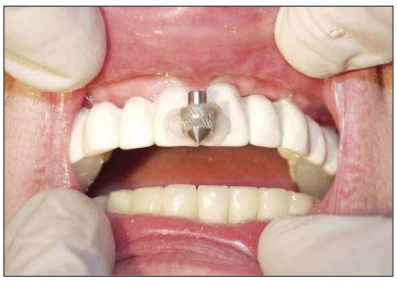

Figure 2. Radiographic stent that defines tooth position to CT.

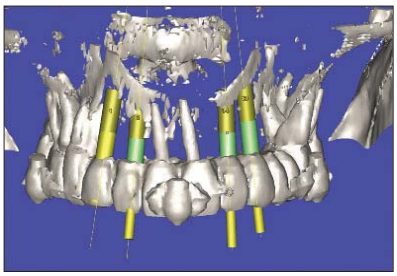

Figure 3. 3-D view of cone beam CBCT showing tooth position.

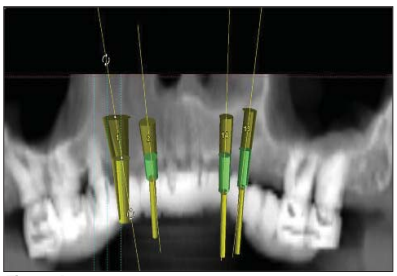

Figure 4. Panographic view of cone beam CT showing position of dental implants.

REVIEW OF CBCT

The use of CT has been utilized in medicine since the early 1970s, but it was not until the late 1980s that it was used in dentistry. The advantages of CT compared with traditional radiographic techniques are numerous, namely, offering a 3-D view with unparalleled accuracy and clinical information.

The benefits of this technology have fur-

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ther clinical practicality when a CBCT machine can be placed in a dental practice, offering immediate results. In-office CT has many clinical applications for implant dental treatment.

In 1979, GN Hounsfield and AM Cormack were awarded the Nobel Prize in medicine for the invention of CT. The CT is one of the most important methods of radiological diagnosis, delivering nonsuperimposed cross-sectional images. The American Academy of Oral and Maxillofacial Radiology "parameters of care" outlines rationalization for diagnosis, treatment planning, and follow-up for different aspects of dental conditions. These conditions include temporomandibular joint dysfunction, diseases of the jaw, and dental implant treatment planning. Traditional radiographs can adequately address these parameters, but CT can help to offer improved results due to the enhanced data presented.[5]

A CT image comprises slices along a plane of the object being viewed. The slices, called voxels, are then reconstructed. The x-ray energy from a CT scan is directed toward an object from multiple orientations, and the decrease in intensity is measured along a series of linear paths. The x-ray intensity reduction is a function of x-ray energy, path length, and the material linear attenuation coefficient. Beers Law characterizes these parameters; an algorithm is then used to reconstruct the distribution of x-ray attenuation.[6] For most dental offices, CT has not been widely utilized due to the cost of the procedure, radiation dosage, proximity to a CT site, and a dentist's unfamiliarity with interpreting CT results. The use of CBCT can negate these concerns and allow for improved[7] diagnosis and patient safety. The basic components of a CT device consist of an x-ray source, a series of detectors measuring attenuation along multiple beam paths, and a rotation device around the object being measured. There have been 5 generations of CT since Hounsfield's invention in 1967. Each CT improvement is based on the organization of device parts and physical motion of the beam capturing the data.

Currently, a fan beam (FB) CT scanner is typically seen in a hospital or CT site setting. With an FBCT, data is acquired using a narrow, fan-shaped beam. The spiral radiation pattern offers information in slices that enlarge the area being targeted. Each slice is slightly overlapped and then reconstructed. The image detectors from the FB are arranged in an arc around the patient.

A CBCT utilizes a cone beam shape instead of a fan, and is more specifically targeted, allowing a better view of the head and neck. The cone-shaped x-ray beam transmits to a solid-shaped sensor to capture an image in a single rotation, whereas with a conventional CT, multiple slices are stacked. CB technology is quicker and has less radiation due to no overlap of slices.[8] The radiation exposure with CBCT is 20% that of a conventional CT and equivalent to a full-mouth series of x-rays. The amount of radiation from a CT depends on kVp and mA values. With a full-mouth series of radiographs using 150 µSv, a CBCT can be used from 45 µSv to 650 µSv.[4,9]

Ideal treatment planning and diagnosis with an in-office CT is a reality with CBCT machines that are readily available for dental practitioners. In-office CBCT machines currently available in the US include the following: i-CAT (Imaging Sciences International), 3-D Accuitomo (J. Morita), ILUMA (Kodak), NewTom VG (Dent-X, parent company AFP Imaging), CB MercuRay (Hitachi), Instrumentarium VT (PaloDEx Group), ProMax 3D (Planmeca), Galileos (Sirona), and PreXion 3D (PreXion). The small footprint, speed of scans, reduced radiation, and ease of use create a realistic opportunity for dentists to have a CBCT in their offices. Once a CT is taken of a patient, the information is reformatted. Various medical imaging software applications are available to read data from a CBCT. Examples of imaging programs available are SimPlant (Materialise Dental), Implant Logic Systems (BioHorizons), Noble Guide (Noble Biocare), EasyGuide (Keystone Dental), and Dolphin (Dolphin Imaging), which reads data from a CBCT in DICOM (digital image communication in medicine) format. This is a standard format for medical imaging for any CT scanner and allows the segmentation of anatomical structures. The segmentation allows a 3-D volumetric rendering and navigation between voxels and 3-D panning, rotating, and zooming.[10]

The interactive nature of a computer-generated CT offers many advantages over a film-based CT. The simultaneous axial, panograph, cross-sectional, and 3-D views allow intuitive planning for dental implants and bone grafting. Utilizing computer-generated CBCT allows for ideal treatment planning for many different aspects of implant dentistry and bone grafting.

BENEFITS OF DENTAL IMPLANTS:

Figure 5. CT imaging company sequence of events that simplify the planning process.

Figure 6. Radiographic guide showing final tooth position.

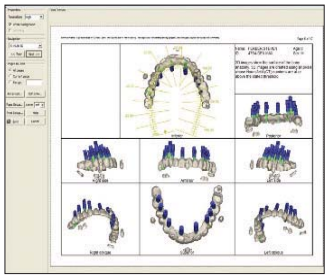

Figure 7. Data from CBCT showing a 3-D rendering and report of implant case.

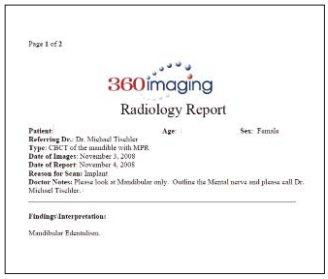

Figure 8. Radiology report from CT by oral maxillofacial radiologist.

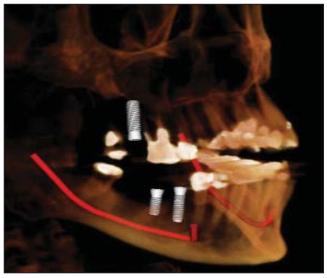

Figure 9. 3-D view that can be seen online by surgeon and restorative doctors.

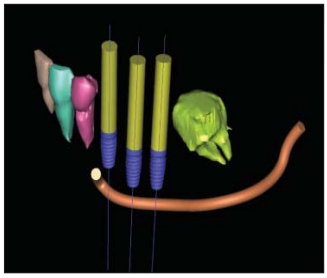

Figure 10. Nerve mapping performed by CT imaging site.

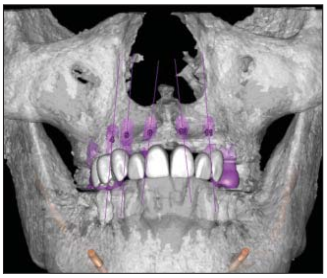

Figure 11. Treatment plan created by CT imaging site with guidance from surgeon and restorative doctors.

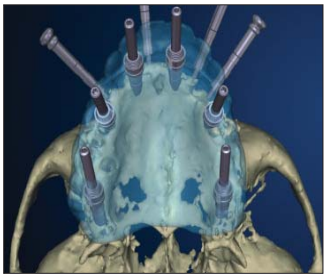

Figure 12. Surgical guide on CT program that will guide placement of dental implants.

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IMPORTANCE OF GRAFTING BONE

It has been well established in the literature that dental implants are the ideal way to replace missing teeth. The statistics repeatedly show that other forms of tooth replacement offer disadvantages over dental implants and that the success rate of dental implants are superior to dentures, fixed tooth borne prosthetics, and bonded bridges.[11] The chewing capacity of a dental implant supported prosthesis is far superior to a removable tissue borne prosthesis, and this translates to better health for our patients. Dental implants or natural teeth are the only ways to stimulate bone and prevent bone loss and it has been established that once a tooth is lost, the surrounding bone will be lost also unless a dental implant is placed. When there is inadequate bone available to support a dental implant, various bone-grafting techniques are available to predictably restore the lost volume of bone.

CREATING THE TEAM APPROACH WITH CBCT: THE NEW PARADIGM

The process to treatment planning with CBCT starts with the restorative dentist creating a radiographic guide based on the prosthetic end result desired. This is a crucial step allowing the desired prosthetic position to be seen on a CBCT.[12] This can be done in a fully edentulous patient, through creating a duplicate of a denture (Figure 1) that fulfils the parameters of aesthetics, and function. This duplicate denture can then be made with radiographic markers in the tooth position so that tooth position can be seen when a CBCT is taken via this stent. In a partially edentulous patient, articulated study models can allow a laboratory to create a radiographic stent that defines tooth position (Figure 2). Then, once a CBCT is taken the tooth position can then be seen on the scan (Figure 3).

Once a scan is taken with a radiographic template relating the final tooth position, a CBCT software program can be used to visualize the bone position and implant position that will support the final prosthetic result (SimPlant [Materialise Dental], Implant Logic Systems [Biohorizons], Noble Guide [Noble Biocare], EasyGuide [Keystone Dental], Dolphin [Dolphin Imaging]). It can then be ascertained if bone grafting is needed to obtain the desired implant position to support the results expected (Figure 4).

It is often the case that the restorative dentist and the surgical dentist do not have access to a CBCT software program or the skills to utilize it. Furthermore, it is rare that both dentists could find the time or a way to mutually communicate about a case. Through the utilization of a digital imaging company, the entire process of CBCT processing and communication between all doctors involved has been made extremely convenient to the surgical doctor, restorative doctor and ultimately the patient (Figure 5). This is a true example of technology allowing for a safer and more predictable treatment outcome.

A new paradigm of treatment planning is now possible, because the digital imaging company facilitates every aspect of translating the information from the CBCT into the hands of both the surgical and restorative doctor. The process starts with the restorative doctor treatment planning for tooth replacement with dental implants and creating a radiographic guide showing the desired final tooth position (Figure 6). The patient then has a CBCT taken at a CBCT site. The CBCT site then relays the information from the CBCT to the imaging company (Figure 7). This transfer of CBCT data via a DICOM file is transferred to the processing company via a HIPAA complaint portal. This requires a software program to be installed on the CBCT sites computer. The CBCT processing company then takes over to initiate facilitation of the remainder of the process. The third party company will now: 1) Create a radiology report by an oral maxillofacial radiologist indicating any pathology (Figure 8); 2) Convert the DICOM data into a 3-D view that can be visualized by the surgical and restorative dentist and the patient (Figure 9); 3) Clean up any scatter and enhance the processed DICOM file including nerve mapping (Figure 10); 4) Create an initial treatment plan based on the prosthetic request of the restorative doctor (Figure 11). These 4 steps can be viewed live on a Web-based communication program such as Microsoft Office Live Meeting. At this point a surgical guide for the surgical dentist can be created from the CBCT data, facilitating implant position and orientation during surgery (Figure 12).

When the treating doctors and radiology experts at the imaging company meet online, changes to the plan can be made between the surgical and restorative dentists with regard to implant position, need for bone grafting, number of implants, size of implants, number of appointments, prosthetic steps, and many more factors relative to the case. The restorative doctor can now relay this information back to the patient creating clear communication and improved informed consent.

One of the main advantages of this scenario is that it is truly convenient and offers a high degree of visual and audible communication between the treating doctors. The Internet meeting time can be arranged well in advanced allowing for uninterrupted time to plan the case. The other advantage is that the restorative doctor now has a say in the surgical plan and is helping to guide the case from the prosthetic end result. The knowledge that the restorative doctor gains from a preoperative consult with the surgeon allows for better communication with the patient. For the first time this can happen in a practical and predicable manner. Previous to this scenario, the many inconveniences and lack of availability to "put it all together" made the team approach happen infrequently.

CONCLUSION

The new treatment planning paradigm presented in this article, benefits everyone involved in the implant treatment process. These advantages include, better medical legal protection for the doctors, improved safety and predictability for the patient, and in the end, an increase in the dentist's treatment planning for dental implants with the ideal tooth replacement option of dental implants.

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Disclosure: needed

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