Application of Cone-beam CT in the Office Setting
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Rarely in the course of a person’s career does a technique or technology come along that completely transforms the way they practice. In my case, two such events have happened, the most recent of which was the in-office availability of CT. As an oral and maxillofacial surgery resident and throughout my career, I have worked with three-dimensional imaging in the hospital setting, but the inconvenience for office-based patients and the cost prohibited its use in all but the most complicated cases. Even with high-quality digital panoramic and intraoral imaging, the third dimension of dental imaging was an educated guess based on experience, technique, and “rules” that I often found to give inconsistent results. Hospital and imaging center CT scans also had significant limitations because of the inability to manipulate the data. Multiplanar reconstruction was limited to axial, coronal, and sagittal views, and no customization was offered.

The advent of three-dimensional surgical planning software for implant placement, in my opinion, opened the door for the imaging opportunities that we now have available as office-based practitioners. Even though the software required the use of a traditional fan beam CT image file and multiple conversions, it put the data in the hands of the doctor, enabling him or her to make and change treatment decisions based on information that was specific to a region of interest. Further mining of the data allowed the creation of seemingly endless possibilities for diagnosis.

As office-based procedures have become more sophisticated and expectations have risen for highly successful outcomes, immediate and accurate information has become essential for treating our patients. Several cone beam acquisition machines are now on the market and even more software products to use the data. This time is an exciting one in dentistry, when we can reach beyond the limitations of our senses and the two-dimensional
world of the last century in dental radiology to see what’s really happening in the mouth and its associated hard tissues.

Determining if cone-beam CT is right for your practice

Several factors need to be taken into consideration before purchasing a cone-beam CT (CBCT) device for your practice. Like any other large capital acquisition, it needs to benefit your patients and be affordable, either by generating income or by providing such significant information that it becomes essential to patient care. Although specialty practices lend themselves best as candidates for using the information in a CBCT, general practices can also benefit greatly, especially if they perform expanded function procedures.

Although the technology has not yet been perfected for accurate caries detection using the cone beam scanner, the three-dimensional scanning of all the roots of a tooth during endodontic treatment to detect perforation or aberrant canals is useful. That application alone can prevent the loss of countless numbers of teeth each year.

The time-honored method for monitoring periodontal bone loss has been through the use of a periodontal probe and bitewing radiographs. Although this method is inexpensive, it is technique-sensitive and does not allow full visualization of the area. In addition to added visualization with CBCT images, most software includes tools for evaluating and monitoring bone density, which may help assess the effectiveness of treatment, predict the results of treatment, or identify areas of future concern.

To paraphrase the most well-known line in real estate, what are the three most important things in dental implant treatment? Location, location, and location. Anyone involved in the placement and restoration of dental implants knows this to be true. The application of CBCT has changed this area more than any other in dentistry. From three-dimensional planning to CT-directed placement to take advantage of available bone and avoid anatomic structures, the science of implantology has been revolutionized by three-dimensional imaging. Not only has it added safety and accuracy; it has minimized or eliminated the need for supportive procedures like bone and tissue grafts in many situations. Computer-generated surgical guides can be fabricated from the CBCT data to eliminate the work and possible inaccuracy of taking impressions and making traditional guide stents.

In the areas of oral surgery and oral pathology, the data from the CBCT can have a profound impact on decision making. The location and root configuration of impacted and erupted teeth can be seen with exceptional clarity. The proximity to adjacent structures can be seen and measured with digital accuracy. The extension of periapical lesions, areas of bone destruction, and involvement of the maxillary sinus are all clearly defined. Even those “spots” seen on traditional radiography can be pinpointed and diagnosed, eliminating the question of artifact and allowing the dentist to give patients definitive diagnoses.
If your practice does not incorporate enough of these situations to justify acquiring your own CBCT scanner, consideration can be given to sharing the equipment and software with an affiliated practice. Because the information gleaned from the hardware is digital, it can easily be transferred around the corner or around the world. The best arrangements, however, are when the equipment is located in the same building or within walking distance of your practice. Otherwise, you lose one of the important considerations of CBCT for your patients, and that is convenience.

Facility evaluation

An important factor in deciding to implement CBCT in your practice is whether your current office location will accommodate the hardware and software. The earliest office-based CT scanners had complex mechanical requirements and needed significant amounts of space. Modern scanners can fit in the space of a standard panoramic radiograph machine. A dedicated electric circuit is required, but no special heating, ventilation, or air conditioning is routinely needed. Laws vary from state to state regarding radiation safety, but the new machines emit less radiation than older conventional radiograph machines and scan times of less than 10 seconds will soon be routine, lowering the radiation even more. Radiation monitoring is suggested, but our experience has been that the monthly exposure is negligible.

Most CBCT scanners come with the necessary hardware and software to operate the capture station, but making the data available to other computers on your network will be your responsibility. It may not be necessary in small office situations but it is likely that you will want the ability to access the data from multiple locations, so a reliable, high-speed network should be in place in your office. If you intend to transmit images to other offices, a high-speed Internet connection will also be necessary. Currently, the size of the files and the compression available will not allow the whole file to be sent electronically, at least in a practical sense, so printing reports as portable document files (.pdf) and sending them as attachments to e-mails has been a useful tool. Data can also be placed on a CD or DVD for delivery. Many systems include the software to read and manipulate the data as a free service and the systems will copy to the disk when the data are burned.

Acquiring the skills to interpret cone-beam CT

Specialists who train in hospital-based residencies are usually exposed to various advanced techniques in radiology, especially CT. Oral and maxillofacial radiology residencies spend a considerable amount of time training residents in the use of fan beam and CBCT. But what about the general practitioner who wants to incorporate CBCT into his/her practice? This problem is probably the biggest challenge and the biggest opportunity for
the dental community and for the industries that provide the hardware and software. As dentists, we are technically oriented, and learning to operate the equipment requires a short amount of training and practice. Traditional dental radiographs (panoramic, cephalometric, periapical, and occlusal images) can be made from the data and interpreting these data is no different from interpreting those obtained by film techniques. The difference is all of the additional data that are acquired and available. Mini-residencies and short courses are available for several products and techniques and these are becoming more widely available for CBCT. If you are considering the addition of CBCT, you need to be prepared for this issue, because self training can only provide a limited amount of knowledge. Dental schools are beginning to discuss interpretation of CBCT in their curriculum but only to a limited degree. The answer may lie in the use of a specialty reading service.

To consult or not to consult

Because the data are digital, they can be accessed and interpreted with ease by an individual at a distant site. Many oral and maxillofacial radiologists offer analysis and interpretation of CBCT data at a reasonable cost, either on a case-by-case basis or by providing analysis of all your patients on a regular basis. This analysis is usually done by allowing the radiologist remote access to your image acquisition computer by using a high-speed data transmission line. The analysis can be in-depth if a specific concern exists or can be a cursory review to ensure that pathology does not go unrecognized. These reports are then e-mailed back to the dentist for review and inclusion in the patient’s record. The professional fee for this service varies with the volume and type of analysis but should be considered when determining how much to charge for the scan.

The question of liability is one that frequently comes up in the discussion of CBCT. What happens if you fail to diagnose a condition that was clearly visible on the scan? To date, I am not aware of any liability case where failure to diagnose has been the basis for a claim. Nonetheless, it remains a real concern. If the dentist is only able to interpret traditional dental radiographs, then it makes sense to only reconstruct those images and to only charge the patient for those images. Findings outside of the oral cavity and jaws may be visible, as they are on panoramic or cephalometric films, but no clear-cut answer exists as to whether the dentist has an obligation to diagnose them. Soft tissue lesions, the ones most likely to be dangerous and the hardest to interpret, are not readily viewed using CBCT so it is unlikely that a tumor in the brain, for instance, would be “missed” by the dentist reading the scan. That being said, our responsibility to our patients is to provide them the best care we can. If you are going to incorporate CBCT into your practice you should make the effort to learn how to interpret those data and have a radiologist available to consult when needed.
Transition to the third dimension: leaving the past behind?

Several issues need to be considered when making the decision to expand into three-dimensional radiography and retaining your traditional film or digital equipment depends on your scope of practice. If you have a highly subspecialized practice like implantology, you may find that CBCT alone can meet all your needs. CBCT does have limitations at this time that will require most practices to retain some, if not all, of their current equipment. Caries detection is not yet something that can be consistently done with CBCT. Pediatric patients, uncooperative patients, and those who have neuromuscular disorders often cannot remain quiet for the time necessary to acquire the data. Any movement during the scan will render it useless. Claustrophobic patients and those who are tall or wide may have trouble with positioning. Although the radiation dose is small considering the amount of data that is acquired, patients requiring serial examinations may not need a full scan and would be better served with traditional studies for follow-up. At a minimum, the ability to take intraoral radiographs should be maintained until it is determined that it is no longer necessary.

Speaking in code

If your practice files claims with insurance companies, you will need to know the current dental terminology and current procedural terminology codes that apply to CBCT to gain reimbursement for your patients. Box 1 provides much of that information, but the diagnosis code must be specific to each patient’s situation. It should be borne in mind that the existence of a code for the service provided does not mean it is a covered benefit and that some medical insurance companies have limitations on who can bill for certain services.

Health Insurance Portability and Accountability Act and security

We are all familiar with the Health Insurance Portability and Accountability Act (HIPAA) and the need for securing our patient’s protected health care information. Because many offices are now paperless or partially paperless, the protection of the digital information from the CBCT will not require any major change in policy. Because the data will contain some personal information about the subject, safeguards do need to be taken when transmitting these data for analysis or additional opinions from consultants. If someone who is not affiliated with your practice, such as an oral and maxillofacial radiologist, is evaluating the data, it is recommended that an agreement be in place that includes a statement of confidentiality. This agreement is not necessary when working with another dentist or physician in the treatment of a patient, but a disclaimer about confidentiality should be present when the images are sent electronically. Also, if the images are
to be used during professional presentations, any identifying information should be removed.

**Data storage**

Never believe someone who tells you your hard drive has all the capacity you will ever need! The need for speed and storage will always exceed capacity, especially with the use of highly specialized programs. The data compression with most CBCT equipment has improved but the records must be maintained and each image from the i-CAT (Imaging Sciences) is approximately 45 MB. If you have a busy practice, you will quickly exceed the storage space that comes with the acquisition computer. Fortunately, data storage prices have fallen recently and hard drives in the 500 gigabyte to 1 terabyte range are readily affordable. It is important to plan ahead because the machines will slow down significantly when data storage space is limited.

Data backup is also a concern. Most users have found it impractical to burn a CD of each patient’s data to place in a chart. HIPAA regulations, and common sense, indicate that an off-site backup is necessary because for most of us, the volume of data is too large to use an online backup

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**Box 1. Diagnosis and procedure codes**

*Procedures*
- CDT 00363: CBCT
- CPT 70486: CT (maxillofacial without contrast)

*Common ICD9 codes*
- 307.81: Headache, tension
- 351.9: Disorder, facial nerve
- 520.6: Disturbance, tooth eruption
- 523.4: Periodontitis, chronic
- 524.9: Anomaly, dentofacial
- 525.2: Atrophy, edentulous alveolar ridge
- 526.0: Cysts, development odontogenic
- 526.4: Inflammation, jaw
- 714.0: Arthritis, rheumatoid
- 716.18: Arthritis, traumatic
- 733.00: Osteoporosis
- 784.2: Swelling in head/neck
- 802.: Fracture
- 830.0: Dislocation, closed jaw
- 830.1: Dislocation, open jaw
- 848.1: Sprain/strain, jaw
service. Tape backups can be performed and taken off site but they are slow and often require a significant number of tapes. Services are available that keep your original data off site in a secure location and allow you to run your office remotely, which is a great way to protect your information, but the cost is often prohibitive and the speed of data transmission may make it impractical.

In my office, I have found that the use of 500-gigabyte portable hard drives provides the fastest and most practical backup. Two drives are rotated daily and one is always out of the office. They connect to the network and back up all the data overnight so they do not interfere with daily activities. These hard drives are light and compact and recovery, should it be necessary, is quick.

Marketing: internal and external

Marketing is one of those words that often make us uncomfortable in a professional context, but in reality we do it every day, whether it is taking good care of the patients we have, handing out material at a health fair, or advertising in print or other media. Each of us must find our own comfort level. When it comes to CBCT, several possibilities exist. At a minimum, most practices will make it known through a newsletter or other form of communication to their current patients and colleagues that they have incorporated CBCT. If you are planning to expand the scope of your practice through the use of CBCT, you may wish to market further into the professional and lay community. Most CBCT suppliers can help by providing examples of press releases and can add you to their Web sites if they have sections to assist patients in trying to locate doctors who have CBCT capability. Your own Web site is a great way to make your patients and potential patients aware of the services you have to offer. Additionally, most radio and television stations have community service programming at no charge. These programs are constantly looking for interesting stories that can benefit their audience and the acquisition of cutting-edge technology by members of the community is a popular topic.

Looking back

The decision to incorporate CBCT into your practice is one that requires serious consideration and careful planning. I have used it in my practice since 2004 and feel it is an indispensable tool. In the early days of the technology, fewer sources of information existed and a community of users often shared ideas and prompted the advancement of the products. Office-based CBCT has advanced significantly since that time. It has often been described as the “gold standard” for imaging the oral and maxillofacial area and will no doubt become a part of the everyday life of most practices in the coming decades.