Using cone beam technology in orthodontics

Edward Lin explains the benefits of adding cone beam technology to the orthodontic armamentaria

Since cone beam computed tomography (CBCT) was introduced to the dental profession in the 1990s, dental practitioners have entered a new era in radiographic imaging. Producing a three-dimensional (3-D) image more quickly and easily than the conventional medical CT, and providing more information than 2-D imaging, the cone beam CT provides accurate multi-planar 3-D imaging that specifically suits dental imaging needs across all specialties (Bourgeois, 2007). Some dentists who do not have in-office CBCT capability have referred patients out to hospitals or imaging centers for medical CT scans. However, compared to the traditional medical CT, the advantages of using CBCT for imaging the maxillofacial area are numerous: increased accuracy, reduced scan times, reduced exposure to radiation, and cost (Cho, et al, 2008).

Basics of Cone Beam Technology

Very important differences exist between the method of image capture for conventional medical CTs and CBCT. Hospital scans emit fan-shaped beams that gather data in multiple slices and then reassemble them. Cone beam scans capture data in a cone-shaped pattern, scanning the entire area of interest in a single rotation. Cone beam scans can be accomplished as quickly as 8.9 seconds, and reconstructed in less than 30 seconds (Figure 1). Images are ready to be viewed nearly immediately, are dimensionally accurate, and are non-magnified with measurements at a 1:1 ratio (Ballrick, et al, 2008).

Cone beam machines are available in several fields of view. A full or extended field of view is nearly full skull, while the medium field of view refers to capturing one or both arches extending to the temporomandibular joint (TMJ) area. The small field of view captures several teeth. Certain fields of view can be more pertinent to different specialties. For example, orthodontists require craniofacial anatomical landmarks to be visible in their

Learning Objectives

After reading this article, readers should be able to:

• Discuss the basics of cone beam technology
• Describe the types of dental treatments for which cone beam is applicable
• Explain radiation exposure levels of cone beam compared to other imaging modalities
• Discuss how using cone beam benefits the orthodontic practice

Figure 1: CBCT can provide rapid scan and reconstruction (Image Courtesy of i-CAT)
continuing education

radiographs to facilitate case planning, and thus the full or large field is indicated for this specialty. For facial reconstructive and orthognathic surgeries, full field allows a view of complete facial structures and anatomical relationships (Howerton, 2009).

Once the scan is complete, 3-D imaging software allows for the images to precisely replicate the positions, shapes, and measurements of the scanned areas including the maxilla, mandible, TMJ, sinuses, nasal cavity, and area back to the cervical spine. In addition, this imaging method can create axial, coronal, and sagittal views, which previously could not even be obtained (Figure 2). Within the software, these views can be sliced and rotated for diagnostics and treatment planning.

The data captured during the scan is in the Digital Imaging and Communications in Medicine (DICOM) format, a standard for handling, storing, printing, and transmitting information in medical imaging (Howerton, et al, 2008). The transfer of this data allows clinicians to use a variety of 3-D planning programs (Figure 3). Not all scan data is created equal: captured data can have “noise” inherent to digital information at large. This can cause blurriness in the 3-D images within native and other software programs. Investigating how each machine’s data appears in third-party software, or asking labs that are familiar with a variety of data sets which ones look less noisy is recommended before clinicians invest in the technology.

Uses for CBCT scans

When exploring areas of the maxillofacial region, CBCT scans help to uncover many potential conditions and facilitate precautions before dental treatments. Some possible applications for CBCT scans include:

- Examination of the mandible and maxilla for possible placement of dental implants
- Determination of the status of existing implants
- Reduction of possible complications involving the nerves and sinuses in dental treatment
- Exploring the condition of the hard tissue of the TMJ
- Discovering abnormalities or pathologies in the scanned area
- Determining the extent of alveolar ridge resorption
- Assessing relevant structures prior to orthodontic treatment
Continuing education

- Determining the precise position of impacted teeth
- Establishing facial symmetry, as with cephalometric views
- Assessing airway space in sleep apnea studies
- Determining the position of the mandibular nerve in relation to impacted teeth, especially the mandibular third molars, prior to their removal (www.ConeBeam.com).
- Creating computer-aided design (CAD) therapeutic appliances where the imaging of roots are of benefit over capturing only the crowns of the teeth.

Cone beam’s 3-D view gives a more detailed look with information not available on 2-D radiographs. The cone beam scan allows dentists to view the relationship of impacted teeth to other anatomical structures without superimposition. In addition, while apical resorption can be detected on 2-D x-rays, it is limited to the buccal and lingual aspect of the roots. However, the CBCT scan’s axial plane can result in a 360-degree view of the entire area of resorption (Bourgeois, 2007). Cone beam CT also provides stronger indication of bone quality than is capable with panoramic radiography (Serman, 1989).

Radiation Considerations

Radiation exposure is of paramount interest to the patient and the dentist in any radiological process. The potential of cone beam scanners for collimating the primary x-ray to the region of interest allows for the reduction of radiation exposure. Because of this capability, while the entire craniofacial complex may be imaged for such applications as orthognathic evaluations, the clinician can choose to image only the mandible without the maxilla, or to capture specific areas of the TMJs through the machine’s collimation, thereby narrowing the field of view as needed (Bourgeois, 2007) (Figure 4).

CBCT technology has been measured at doses equivalent to a full-mouth series and “as low as 2 panoramic radiographs, depending upon the setting in use.” (Ballrick, et al, 2008). With keen attention to radiation levels, dentists and other medical professionals ascribe to the ALARA (As Low As Reasonably Achievable) protocol that guides practitioners to expose patients to the least amount of radiation possible while still gaining the most pertinent information for proper diagnosis.

Again, here the differences between dental and hospital scans are very apparent. The average medical CT scan of the oral and maxillofacial area can reach levels of 180-2100 microsieverts (μSv), the measurement of radiation absorbed by the body’s tissue (Sedentexct, 2009). These significant levels are attributed to the method of exposing tissues to radiation. With the hospital scan, because the anatomy is exposed in small fan-shaped or flat slices as the machine makes multiple revolutions around the patient’s head to collect adequate formation, there is overlapping of radiation. In contrast, the dental scan’s one, single cone-shaped beam rotation...
Continuing education

(Figure 5) decreases the patient’s exposure by up to 10 times less radiation (www.ConeBeam.com).

Many factors correlate to exposure from CBCT machines. The technology offered by the manufacturer and the type of sensor used to capture the data are initial considerations for the dentist. Radiation exposure is not always dependent on field of view. For example, CBCT radiation exposure using a small field can be greater than that of a standard full field of view because of these factors. However, a standard full field of view at a standard resolution can be as little as 36 μSv. Those machines that collimate can also provide additional reduction in radiation exposure. Another factor is voxel size; the smaller the voxel the greater the resolution (similar to pixel size in 2-D images) and the more exposure. For other comparisons of exposure, consider that a typical 2-D full-mouth series runs approximately 150 μSv while a 2-D digital panoramic image ranges between 4.7-14.9 μSv (Sedentexct, 2009) (Figure 6).

Dentists who do not own their own CBCT machines still can take advantage of 3-D imaging. Many imaging centers and even colleagues who have CBCT machines can provide fellow dentists the opportunity to acquire this valuable diagnostic information.
Continuing education

Figure 8: Reconstructed pan from a 3-D scan (Tru-Pan)

Figure 9: CBCT offers precise location of impacted teeth in three dimensions

Native 3-D imaging software allows clinicians to manipulate images, create any plane of section, locate anatomical landmarks, take measurements, and share that information with colleagues (Bourgeois, 2007). Because the images taken by cone beam machines are saved in DICOM files, scans can be printed out, saved on a CD, or emailed to referring dentists or specialists.

Cone beam and orthodontics

CBCT is an imaging modality that is being more frequently applied to orthodontic assessment (Farman, et al, 2009). From a radiation-protection point of view, conventional images may deliver the lowest doses to patients. When 3-D imaging is required in orthodontic practice, a CBCT is preferred over a CT image (Silva 2008).

CBCT technology saves time and effort in the orthodontic practice. With a cone beam system, all possible radiographs can be captured in under 1 minute, and the orthodontist has the diagnostic quality of periapicals, panoramics, cephalograms, occlusal radiographs, and a TMJ series at his or her disposal, along with views that cannot be produced by regular radiographic machines, such as axial views and separate cephalograms for the right and left sides (Kau 2005) (Figure 7).

While there is a need for 2-D panoramics in the orthodontic practice, for many orthodontists, a 3-D machine (which also serves as a traditional 2-D digital panoramic) is the best of both worlds. It has the added benefit of being able to reconstruct the 3-D scan data into a panoramic (along with other typical orthodontic views), thereby giving the clinician numerous radiographic options in one system. Dr. David Hatcher, a dental radiologist, has noted that both a panoramic and a cephalogram can be reconstructed through cone beam data, but with even better quality and with the added benefit of a view of the joint in the fossa with the teeth in occlusion all at once (Hatcher, 2008) (Figure 8). The reconstructed panoramic can also give a much better view of root alignment. Reconstructed cephalograms are also very clear and can be extracted as either a postero-anterior (PA) or antero-posterior (AP) view. The dataset can also be used to extract slices of the TMJ with amazing clarity (Hatcher, 2008).

Probably the greatest use of this data is the knowledge gained with regard to tooth position. Because the 3D view allows for views from all angles, orthodontists can obtain the most comprehensive information possible for orthodontic treatment planning. With these scans, orthodontists can detect morphology, inclination, displacement, position of the roots, impacted or supernumerary teeth, and palatal morphology (Cevidanes, 2006) (Figure 9).

Additionally, the science of robotic archwires has also grown to include cone beam 3-D imaging. For instance, highly sophisticated software and CAD applications are now available to create a 3-D computer model of the bite by using advanced imaging technology, an original method of orthodontic movement that can decrease treatment time by up to 40%. To obtain the necessary views, the 3-D images can be captured with an intraoral camera scanner or by CBCT. Utilizing cone beam to create the required 3-D CAD model can shorten scan time from 30 minutes to 20 seconds. The scan offers full anatomical details so that orthodontists can see the roots and the crowns of the teeth (Figure 10), not just the crowns, resulting in more accurate robotic archwire setups. Plus,
Continuing education

Edward Y. Lin, DDS, MS, graduated with a Bachelor of Arts degree from the University of Chicago. He continued his dental education and orthodontic residency at Northwestern University Dental School. Dr. Lin maintains a full-time private group practice in Green Bay, WI. He has lectured extensively nationally and has also taught at both Marquette University and the University of Minnesota Orthodontic Residency Programs. He was also a speaker at the International Congress on 3-D Dental Imaging in 2008 and 2009. Dr. Lin is involved in the American and Wisconsin Dental Associations, the American Association of Orthodontists, the Midwestern and Wisconsin Society of Orthodontics, and the World Federation of Orthodontists, as well as local and national study clubs. Dr Lin also volunteers at the Northeast Wisconsin Technical College at the Community Dental Clinic.

The expanding use of CBCT technology is beneficial to both patients and practitioners (Ballrick, et al, 2008), and is especially important to orthodontists because its ability to capture the entire anatomy needed for orthodontic treatment planning. When used correctly and responsibly, the data derived from CBCT imaging provides insight into treatment planning that is unachievable with other imaging methods, and allows clinicians to provide more predictable patient care.

**References**


Using cone beam technology in orthodontics

1. Compared to the traditional medical CT, the advantages of CBCT imaging the maxillofacial area include:
   a) increased accuracy
   b) reduced scan times
   c) reduced exposure to radiation
   d) all of the above

2. Because orthodontists require craniofacial anatomical landmarks to be visible in their radiographs to facilitate case planning, what field of view is indicated for this specialty?
   a) small
   b) medium
   c) large or full
   d) 3-D is not indicated for orthodontics

3. Capturing 3-D data during the scan in the _______ format allows a universal standard for handling, storing, printing, and transmitting information.
   a) JPEG
   b) TIFF
   c) DICOM
   d) AVI

4. Some possible applications for CBCT scans include:
   a) examination of the mandible and maxilla
   b) determining the precise position of impacted teeth
   c) establishing facial symmetry, as with cephalometric views
   d) all of the above

5. The potential of cone beam scanners for collimating the primary x-ray beam to the region of interest by cone beam scanners creates:
   a) time savings for the patient
   b) a reduction of radiation exposure
   c) financial gain for the office
   d) a nice looking scan

6. There are many factors that correlate to exposure from CBCT machines, including:
   a) the technology offered by the manufacturer
   b) the physical size of the machine
   c) voxel size
   d) a and c

7. Which radiographs have the greatest radiation exposure?
   a) A CT scan of the oral area
   b) A full-mouth intraoral series
   c) An i-CAT scan
   d) A panoramic x-ray

8. With a cone beam system, all possible radiographs (panoramic, cephalograms, occlusal radiographs, and TMJ) can be captured in:
   a) three separate appointments
   b) under 1 minute
   c) 5-20 minutes
   d) in 45 minutes

9. Probably the greatest use of CBCT data is the knowledge gained with regard to:
   a) how many appointments the patient will need
   b) heredity factors
   c) tooth position
   d) all of the above

10. Utilizing the science of robotic archwires with cone beam 3-D imaging offers which of these advantages?
    a) Increased treatment time
    b) Orthodontists can see the root and the crowns of the teeth, resulting in more accurate robotic archwire setups
    c) The radiographic scan is also used for diagnostic applications
    d) b and c
I use my i-CAT® for...

Everything!

Records, Diagnosing, Treatment Planning, Communication with Patients & Referring Doctors, SureSmile®, Digital Models

I i-CAT® because...

Great Leadership
Great Product Development
Great Service and Support

3-D is no longer the future, it is the now and present!

Dr. Ed Y. Lin, DDS, MS
Green Bay, WI

The i-CAT® delivers a complete orthodontic work-up, including cephalometrics, supernumerary, TMJ, impactions, SMV, spinal, airway, and panoramic in just seconds!