Cone Beam Scanning – The Good, the Bad and the Ugly!

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Introduction

Nothing in radiology for our dental practices has captured dentists’ attention as quickly as cone beam CT scanning technology. Impacting decision-making across almost all dental disciplines and specialties, the adoption of cone beam imaging has grown far faster than digital intraoral or even digital panoramic imaging techniques. This is good for the profession and even better for the patient as dentists and dental specialists can now visualize anatomy and pathology like our medical colleagues. Radiographic “interpretation” has been simplified now that we look at dental problems in 3 anatomic planes of section and in 3D color (Figures 1-4). And, our patients can actually see their problems in “life-like” reality instead of peering at gray shadows they cannot understand. Cone beam imaging IS GOOD! The following three cases demonstrate this easily.

On the other hand, the cost of the scan, the increased exposure dose for “stand-alone” machines and the reticence of third party payers to reimburse dentists for better imaging data from the scans IS BAD!

However, the reluctance of some dentists to review or have reviewed all the data in a cone beam scan is just UGLY!

Why, you ask? I’ll answer that later. First let me show you cases to support my opinion of the “GOOD”.

Case 1 - This 11 year-old white male was referred as part of an orthodontic assessment for cone beam examination because of anterior crowding and an impacted maxillary left permanent canine with retained primary canine. Following radiographic evaluation of this large volume scan, a severe pan-sinusitis was recorded as part of the findings, and the following recommendation made:

“Recommendation: This patient should be referred to his primary care physician and/or an otolaryngologist for clinical and endoscopic examination of the paranasal sinuses if clinically symptomatic.”

This finding and recommendation is quite commonly made by oral and maxillofacial radiologists as part of the routine and systematic radiographic evaluation of the large cone beam volumes. In this case, appropriate treatment will follow the recommendation. That is GOOD. Would the patient die or be harmed if this were missed by a dentist? Probably not. Can the treatment of this occult finding, the pan-sinusitis, improve the patient’s life? Definitely yes. Is this the way “healthcare” is supposed to work? Undeniably yes! BUT, before you get too comfortable with my answer to the question of “will the patient be harmed?”, consider the following information below, provided for patients, published online for the American Rhinologic Society by J.M. Dutton, MD.1

Complications of Sinusitis

1. Intracranial Complications - The frontal, ethmoid and sphenoid sinuses are separated from the intracranial cavity by a layer of bone (Figure 1). If the infection passes through this bone it may infect the tissue and fluid that lines the brain, causing "meningitis". In even more severe cases the infection may spread to the brain itself causing an "abscess", or collection of pus. These problems are life threatening and require prompt and aggressive treatment.

2. Orbital Complications - The frontal, maxillary, ethmoid and sphenoid sinuses sit immediately above, below, between and behind the eyes, respectively (Figure 2). For this reason, infections of any of the sinuses may spread to the orbit, causing a wide spectrum of complications from mild inflammation of the eyelid to abscesses with possible blindness.

3. Vascular Complications - The carotid artery and cavernous sinus are two large vascular structures that border the sphenoid sinus. Infections that involve either of these structures may lead to aneurysms or infected blood clots in the intracranial cavity, both of which are potentially fatal.

4. Asthma - A number of patients suffer from both asthma and chronic sinusitis and, for these individuals, flare-ups of the sinusitis can lead to asthma attacks. Many studies have shown that resolving the sinus condition will result in dramatic improvement of the asthma.

5. Loss of Smell and Taste - Sinusitis may diminish the senses of smell and taste, since the two are interconnected. This may be either temporary or permanent, depending on the nature of the injury. In most cases, the cause is poor airflow to the olfactory nerve (which detects odors) and by improving the nasal airway the senses of smell and taste improve. This is particularly true in patients who suffer from nasal polyps. However, in some cases chronic sinusitis may permanently injure these nerve endings.

6. Osteomyelitis - Some recent studies suggest that bone becomes actively involved during a chronic sinus infection, making the infection more difficult to treat. This may even cause the destruction of bone that leads to the intracranial and intraorbital complications discussed above.
If you are requesting/ordering a cone beam scan that includes the maxillary sinus and there are changes in that airspace, remember that ALL of the paranasal sinus spaces communicate with each other. Even a partial view of the antrum which demonstrates complete opacification mandates review of the remainder of the spaces.

**Figure 1**

**Top left.** This is an axial view at the level of the condyles demonstrating almost total obstruction of the antral spaces at this level. **Top right.** An axial slice at the mid-orbit level showing opacification of a large portion of the ethmoid air cell complex bilaterally. Fortunately for this patient, the sphenoid sinus region is spared for now. **Bottom left.** A coronal section showing communication of the right antrum inflammation with the right ethmoid air cells. **Bottom right.** Frontal sinus involvement.
Case 2 – A 62 year-old white female sent for implant assessment. The medical history was unremarkable.

**Figure 2**

*Top left.* Larger FOV image showing loss of joint space between C3 and C4 as well as osteophyte formation. *Top right.* Sagittal image of the same region suggesting large area of subchondral cyst formation. *Bottom.* 3D color reconstruction of the vertebral body showing a simple depression mimicking subchondral cyst formation.
Although no recommendations were made, the patient learned that she had osteoarthritic changes in her neck. This explained her reported neck pain, treatable with simple anti-inflammatory medication as needed. Again, for the patient, this is **GOOD**!

**Case 3**

This 51 year-old white female was referred for the evaluation of “TMJ problems”. Below are the 2D grayscale multi-planar images and 3D color reconstruction images showing the altered morphology of both in the grayscale images, but the “reality” of the osteophyte formation on the left condylar head in color is even more apparent. She had intermittent, moderate pain in both her TM joints.

*Figure 3a*

*Comparative images of the right (top) and left (bottom) TMJ condyles imaged using the “cube tool” in OnDemand3D™ (CyberMed International, Seoul, Korea).*
Top. 2D grayscale image at 0.016 mm slice of the left TMJ complex displaying an altered shape sometimes called a “bird beak”, reported in the past to be the characteristic sharp angle of an osteophyte seen in osteoarthritis. Bottom. 3D color reconstruction showing actual shape of the left condyle and the true osteophytic changes.

The dentist was able to show the patient all of the boney changes in her joint complex and help her understand her joint symptoms graphically. This, too, is VERY GOOD!
So much for the “Good” obtainable from cone beam images. All of the patients in these cases benefitted from the advanced imaging capability of the cone beam devices and post-processing software. Better and more precise diagnoses were simplified, and appropriate recommendations made.

Now it’s time to explain the “Bad”.

The cost of the scan is higher than any other dental radiographic procedure. In the US the fees for a scan run between a low of about $175 to as much as $700. The typical fee being approximately $350. This is much higher than the fee for even the most expensive “panoramic” image of about $150. However, the data obtained in the scan may actually save money in the long run for some procedures such as implant placement. If only 2 dimensional imaging, such as a panoramic “x-ray” is used, the chances of misplacing an implant fixture is increased. This can result in BOTH the dentist and the patient incurring additional costs. It could also result in a lawsuit. There is little doubt that the “standard of care” for implant imaging will be cone beam imaging in the next few years, and it very well may be a lawsuit that mitigates this change. The morbidity costs for an implant “misadventure” will be reduced as dentists and dental specialists adopt cone beam imaging as their routine radiographic evaluation protocol. Though some dentists might consider this increased radiographic cost BAD, in actual fact the cost of cone beam imaging compared to medical CT is actually much less and with better data. So there also is a GOOD side to this cost/benefit equation.

There is also an increased x-ray dose to each patient with cone beam imaging. Certainly if a 2 dimensional image will suffice to assist a diagnosis it should be used. For instance, there is no justifiable reason to expose a patient to ANY cone beam radiation dose just to obtain a panoramic image. Soma manufacturers have made this claim to dentists, possibly to convince them on the sale of the unit. I have already cited some examples where a simple panoramic image is more appropriate, such as evaluation of the development of the mixed dentition. If an abnormality such as a supernumerary tooth is apparent in the initial panoramic film, a subsequent cone beam examination could be ordered and used to precisely determine its location and plan a necessary
surgical procedure. On the other hand, all cone beam machines operate at substantially lower x-ray doses than medical CT machines, and the cone beam procedures cost less. So there is really little reason to order a traditional medical CAT scan for any implant procedure. The added x-ray dose and added cost is not justified. Cone beam imaging will become the standard of care for presurgical implant site assessment.

The reticence of third party payers to reimburse dentists for cone beam procedures is frustrating. There are CDT (Clinical Dental Treatment) procedure codes, agreed upon by the payers, but most have stated they will not reimburse anyone for these scans. This is BAD, but this will change. As stated above, the morbidity costs will be reduced by using cone beam imaging. Payers will see the advantages of the dentist having more accurate data for many procedures better evaluated by cone beam imaging. This too will be GOOD.

And finally, the “Ugly” side of cone beam imaging.

In my humble opinion, dentists have two primary reasons for ignoring the responsibility they incur when ordering or performing a cone beam scan. The first reason is a lack of confidence in their ability to interpret regions in the scan with which they are not familiar. For example, many dentists do not want to be responsible for missing pathology in the following areas:

1. The vertebral column
2. The airway
3. The paranasal sinuses (maxillary, sphenoid and frontal as well as the ethmoids)
4. The nasal cavity
5. Soft tissue structures like muscles, glands, tonsils and adenoids
6. Anything in the “brain cavity”

Unfortunately for we dentists, teeth do cause sinus symptoms in some cases, sinus problems are NOT restricted to the maxillary sinus in many cases but can involve all of the other spaces as they communicate with each other, osteoarthritis can affect the C-spine and the TMJ condyles simultaneously, and we do get training in soft tissue problems like salivary gland disorders. So, in effect, we dentists ARE responsible for much more than the teeth and gums. There is a patient attached to the tooth! Dentists can acquire sufficient knowledge in cone beam imaging to be able to
interpret certainly the limited volume scans of the dental bases. If they are going to employ this technology or the images from it, they should seek additional education about the modality.

The second reason dentists elect to ignore the remainder of the scan outside their region of interest is financial, pure and simple. Some dentists do not want to charge the patient “extra” for an interpretation by a specialist. They feel that this extra fee may reduce the acceptance of the proposed treatment; that is, cost them the revenue for the proposed elective procedure. This reason is absurd and dangerous in my opinion, and borders on malpractice. I, and others, have already addressed this “position” in other articles.4,5

Some dentists think they can have a patient sign a waiver or document, refusing to have the scan reviewed, to protect themselves from any liability. This practice is indefensible. Patients are not skilled enough in the art and science of dentistry to make the decision to refuse to have the volume read. They cannot diagnose their conditions or potential conditions. If a diagnosis was “missed” because no one looked at the scan, someone will be liable – the dentist or lab who owns the equipment and performed the image acquisition and the referring dentist or dental specialist who ordered the image(s). Friedland6 recently cited literature and state law that demonstrated these “waivers of liability” adopted by dentists “carries no weight and would be null and void in any legal proceeding”.

Even the major malpractice insurer, Fortress Guardian, who indemnifies members of the American Association of Oral and Maxillofacial Surgery, has written that they will not honor any such waiver7. Dentists and dental specialists may have heard that such waivers can be used, information usually delivered by some cone beam company or some “legal expert” on behalf of the company at a “manufacture-sponsored cone beam event”, and come away thinking they are absolved of any responsibility to look at the entire scan or refer it for professional interpretation. This is a very dangerous position. One which probably WILL be decided in a court of law – and not in favor of the dental professional I’m afraid.

Conclusions

It is remarkable that we can now have such precise images to help simplify our treatment planning and decision-making. Cone beam imaging, when appropriately applied to a diagnostic task is
obviously **GOOD** for both patient and doctor. I repeat “when appropriately applied” because the dentist must determine which applications require cone beam imaging to keep the patient’s x-ray dose to a minimum and to keep healthcare costs down. Inappropriate use of cone beam imaging simply to generate fees to accelerate the return on investment (ROI) is **BAD**! Failure to look at the entire volume or refer the volumes to a specialist when one is unskilled, unable because of time constraints or worried about “added cost” to the patient and losing procedures is just **UGLY**! And if diagnoses are missed because the dentist did not refer or take the time to look at all of the data and not just the intended area of surgery, then it will get even **UGLIER** in court when the patient learns that their problem could have been diagnosed if only someone had taken the care to have all of the x-ray information read. This information is offered to help you decide when and why to use cone beam imaging and how to do it as professionally as possible.
References

Abstract

There are significant advantages, but also some drawbacks to cone beam imaging. Without sounding trite, there are “Good”, “Bad” and “Ugly” aspects. By far, in my opinion, the “good” things about cone beam technology and the incredible images we get from the technology for clinical decision-making and patient treatment far outweigh any serious disadvantages for adopting this technology. However, it is always prudent to point out all aspects of any new technology, especially when it appears to have been so quickly embraced by our profession. This article is an attempt to inform you, my colleagues, of the tremendous contributions cone beam imaging can make to your practice, but present some cautionary aspects as well as you consider using it in your practice.