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Maxillofacial Volumetric CT: An Update and the Importance of the DICOM Standard for Interoperability

This is the fifth of a series of articles in *Inside Dentistry* directed toward keeping the dental profession informed of the trends, advantages, and concerns related to cone beam computed tomography (CBCT). This article is an update following the Fédération Dentaire Internationale (FDI) meeting in Stockholm, Sweden, in September 2008; the American Dental Association Congress in San Antonio, Texas, in October 2008; the Asian Congress on Oral and Maxillofacial Radiology in Nara, Japan, in November, 2008; and the release in the same month of an executive statement on CBCT usage by the American Academy of Oral and Maxillofacial Radiology.

UPDATE ON CBCT SYSTEMS AND SPECIFICATIONS

The trend toward division of the CBCT systems into large field-of-view (FOV) systems for oral surgery, orthodontics, and related applications on the one hand, and the introduction of smaller FOV systems combined with a traditional, digital panoramic system on the other continued at the 2008 annual meetings of the FDI and the ADA and at the Asian Congress on Oral and Maxillofacial Radiology. For

example, the Veraviewepocs® 3D (J. Morita USA, Inc, Irvine, CA) now has a small FOV CBCT that is very similar in size to the original J. Morita Accuitomo 3D, while the Accuitomo itself now has a standard 8 cm x 8 cm flat panel, and systems have been demonstrated in Europe with a 12 cm x 12 cm flat panel. E-Woo/Vatech (E-Woo Technology USA, Houston, TX) is planning to introduce a new hybrid CBCT/panoramic system to the US market. This will undoubtedly compete with the Kodak 9000 3D digital system (Kodak Dental Imaging/Practiceworks Atlanta, GA) that has become an industry standard, given its competitive pricing and recently determined very low radiation dose (reported as 17 microSieverts at the Live Operatory education exhibit at this year's ADA Congress and compared with approximately 3,500 microSieverts annual radiation dosage from natural background sources, 500 microSieverts for a medical multislice CT of a single jaw, or around 35 microSieverts for a digital dental panoramic exposure.)

Another change is that Imtec Corporation (previously of Ardmore, OK), the manufacturer of the ILUMA™ full FOV CBCT system, has been acquired by 3M ESPE (St. Paul, MN), is now no longer sold exclusively by Kodak Dental Imaging/Practiceworks. The system was seen for sale at the Henry Schein booth at the ADA Congress.

At the Asian Congress on Oral and Maxillofacial Radiology, Asahi Roentgen Corporation (Kyoto, Japan) introduced a range of hybrid CBCT systems, the Alioth, which can be customized to vary the FOV of the CBCT equipment and uses either a 2-D digital panoramic view, a cephalometric sensor, or both (Figure 1). This system has not yet been introduced to the US market and would be expected to sell in the United States under the Belmont brand name. Also in the United States, it was announced in November 2008 that the MyRay Skyview (Imola, Italy) has been granted FDA 510k status, which permits sale in the United States. This is a supine CBCT system with a C-arm deployed around a platform. It uses an image

intensifier with circular image dimensions of 4 inches, 6 inches, and 9 inches.

Other than these changes, most companies seem to be holding off until the International Dental Show in Cologne (Spring 2009) before making any radical changes to their CBCT designs, or perhaps it is simply a matter of stabilization of the industry with present designs being found perfectly suitable for their intended use.

EXECUTIVE STATEMENT RELEASED CONCERNING USE OF CBCT

In a statement issued by the American Academy of Oral and Maxillofacial Radiology (AAOMR) Executive Council (EC) in October 2008,¹ it was noted that the AAOMR embraces the introduction of CBCT as a major advancement in the imaging armamentarium available to the dental profession. Cautions were voiced at the same time: namely, that the practitioner should apply imaging procedures based on considerations of patient radiograph selection criteria, dose optimization, technical proficiency, and assessed diagnostic or treatment needs.

The AAOMR EC believes that CBCT examinations should be performed only for valid diagnostic or treatment reasons and with the minimum exposure necessary for adequate image quality. As CBCT imaging involves exposing the patient to ionizing radiation, it should be performed only by an appropriately licensed practitioner (or certified radiologic operator under the supervision of a licensed practitioner) with the necessary training. In states where CBCT is considered to be a medical device, a dental assistant could conceivably not have the necessary credentials to make a CBCT exposure. Further, documentary evidence should be provided to demonstrate the diagnostic or treatment guidance needed of each CBCT examination.

It was noted by the council that there may be a misconception among some practitioners that the user has no responsibility for radiologic findings beyond those needed for a specific task, (eg, implant



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Figure 1 The Asahi Roentgen Alioth seen with a panoramic sensor mounted in front of the CBCT flat panel. This unit was shown at the Asian Congress on Oral and Maxillofacial Radiology, Nara, Japan, November 20-22, 2008.

treatment planning). In the opinion of the council, this assumption is erroneous. To support the diagnostic necessity of the procedure and facilitate patient understanding, they note that it is desirable that a separate patient consent be obtained for the CBCT procedure before imaging. It is desirable for practitioners to undergo specific training to perform CBCT examinations successfully. The practitioner who operates a CBCT unit, or requests a CBCT study, needs to examine the entire image dataset. This is predicated on a thorough knowledge of CT anatomy of the entire acquired volume, anatomic variations, and observation of abnormalities and disease processes. The field of view will vary with system, positioning, and collimation, and can include intracranial structures, the base of the skull, the paranasal sinuses, the cervical spine, the neck, and the airway spaces. Qualified specialist oral and maxillofacial radiology (OMFRs) operators may be able to assist diagnostically when practitioners are unwilling to accept the responsibility to review the whole exposed tissue volume.

CBCT IS RAPIDLY BECOMING A MATURE INDUSTRY AND MANY PRACTITIONERS ARE FINDING THIS TO BE AN INDISPENSABLE ADJUNCT TO THE TREATMENT THEY PERFORM.

3-D imaging, including CBCT, undoubtedly is becoming the standard of care for many procedures in dental and maxillofacial practice. This represents a paradigm shift in dental diagnostic imaging and it will take time for dental education to catch up. Practitioners who graduated in pre-CBCT days should have their knowledge updated through continuing education and training programs.

DICOM INTEROPERABILITY: A KEY INGREDIENT FOR GETTING THE MOST OUT OF CBCT

The key feature of CBCT image output that makes the systems interoperable is the use of image files that are conformant with the Digital Imaging and Communications in Medicine standard version 3 (DICOM v3). This is the International Standards Organization (ISO)-referenced standard for all diagnostic imaging including medical, dental, and veterinary imaging, and includes all modalities such as X-ray, visible light, and ultrasound. In January 2008, we demonstrated the fusion of DICOM image files from 3-D visible-light photography and CBCT datasets made using a variety of systems. Whereas the use of DICOM image files took several years of demonstration and interactivity between vendors participating in DICOM working group (WG) 22 (Dentistry) and the ADA Standards Committee on Dental Informatics WG 12.1—and is now available from most top vendors—it is still necessary to ask the vendor for DICOM conformance, or you might find you are buying a nonconforming product. CBCT is a different matter. The vendors have accepted that to be non-DICOM conformant is a nonstarter commercially, because it would preclude the many necessary adjunctive services using third-party software.

While the software provided with the CBCT system is perfectly adequate for diagnostic uses, most users of CBCT systems employ additional software for such purposes as dental implant planning, orthodontics, and orthognathic surgery planning. Increasingly, these third-party software “add-ons” specifically require DICOM files with appropriate header fields. Examples of such a service are the Keystone implant planning software Easy Guide (Burlington, MA), SimPlant (Materialise, Leuven, Belgium), and Procera (Nobel Biocare, Gothenburg, Sweden) among others. Orthodontic planning is accommodated by Dolphin 3D (Dolphin

Imaging, Chatsworth, CA) and InVivo Dental (Anatomage, San Jose, CA), among others. For the purposes of this discussion, recent advances and works in process for InVivoDental will be used to show the future growing potential of CBCT for clinical practice, and also the importance of DICOM interoperability as the basis for these advances.

CBCT CONTINUES TO BE A MAJOR FOCUS NATIONALLY AND INTERNATIONALLY

At the 2008 ADA Annual Session, the CBCT demonstration was increased to six CBCT systems operating behind an expanded set of transparent lead panels right at the entrance to the commercial exhibit. The CBCT systems demonstrated included the Kodak 9000 DS, the J. Morita Veraviewepocs 3D, the Sirona Galileos, the AFP/QR New Tom VG, the Soredex Scanora 3D, and the ISI i-CAT Next Generation. Demonstrations continued for 3.5 days with sequential 30-minute non-commercial presentations by selected users of each of the systems. The CBCT Live Operatory was also connected to an interoperability demonstration booth via the Mipacs system (Medicor, North Carolina). At the interoperability booth, a number of third-party users of digital images demonstrated the use of DICOM output images for use within various applications.

CONCLUSION

CBCT is rapidly becoming a mature industry and many practitioners are finding this to be an indispensable adjunct to the treatment they perform, especially in planning the placement of implants, but also in planning the removal of impacted teeth (such as the mandibular third molars), in determining the ability to use surgical orthodontics to move impacted maxillary canines, and in examining the root morphology of teeth planned for endodontics, among other activities. Despite the downturn in the world economy, new systems are still being released and existing ones are upgraded on a regular basis. For this reason, this is very unlikely to be the last in this series of articles.

REFERENCE

1. Carter L, Farman AG, Geist J, et al. American Academy of Oral and Maxillofacial Radiology executive opinion statement on performing and interpreting diagnostic cone beam computed tomography. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod.* 2008;106(4):561-562.