The use of cone-beam computed tomography in dentistry: An advisory statement from the American Dental Association Council on Scientific Affairs

The American Dental Association Council on Scientific Affairs

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The emergence of cone-beam computed tomography (CBCT) has expanded the field of oral and maxillofacial radiology. CBCT imaging provides three-dimensional volumetric data construction of dental and associated maxillofacial structures with isotropic resolution and high dimensional accuracy.

A CBCT scanner uses a collimated x-ray source that produces a cone- or pyramid-shaped beam of x-radiation, which makes a single full or partial circular revolution around the patient, producing a sequence of discrete planar projection images using a digital detector. These two-dimensional images are reconstructed into a three-dimensional volume that can be viewed in a variety of ways, including cross-sectional images and volume renderings of the oral anatomy.

Although CBCT units produce a higher radiation dose than one would receive from a single traditional dental radiograph, the radiation dose delivered typically is less than that produced during a medical multichannel computed tomographic scan. CBCT radiation doses also vary widely according to the device used, x-ray energy and filtration, tolerance for image noise and motion artifacts, and the size of the imaging area (field of view [FOV]) that is used to acquire volumetric data1-3 (Table,2,4,5 page 901).

Since CBCT devices were introduced commercially in the United States in 2001, dentists have come to use the technology in increasing numbers. Yet,
although CBCT technologies have advanced rapidly across time, concerns have been expressed about whether the information acquired with CBCT imaging warrants the additional exposure risk, as well as about the level of training, education and experience required to interpret the CBCT data set.1

To provide guidance on CBCT imaging, national and international groups have prepared basic principles,1 position statements6,7 and professional guidelines for CBCT use.4,8 Recommendations for adequate operator education regarding use and interpretation of CBCT imaging also have been published.1,6 In addition, CBCT guidance documents are being developed by dental specialty organizations.9

As with any clinical guidance regarding the acquisition of diagnostic information, dentists must keep in mind their primary ethical obligation to protect patients from harm. Consistent with its mission to serve as a primary resource on the science of dentistry, the ADA Council on Scientific Affairs (CSA) reviewed the current science, guidance and other resources available from professional organizations to prepare this advisory statement of principles for the safe use of CBCT in dentistry. The Council then sought comments and input from a range of stakeholder organizations (listed in the acknowledgments at the end of this article) to develop this collaborative guidance statement for the profession.

PRINCIPLES FOR THE SAFE USE OF DENTAL AND MAXilloFACIAL CONE-BEAM COMPUTED TOMOGRAPHY

The Council recommends adherence to the following principles for the safe and appropriate use of CBCT in clinical practice.

As with other radiographic modalities, CBCT imaging should be used only after a review of the patient’s health and imaging history and completion of a thorough clinical examination.

In accordance with the National Council on Radiation Protection & Measurements10 (NCRP’s) Report No. 145 and standard selection criteria for dental radiographs,11 clinicians should perform radiographic imaging, including CBCT, only after professional justification that the potential clinical benefits will outweigh the risks associated with exposure to ionizing radiation. All radiographic examinations should be indicated clinically and justified appropriately, and such examinations should not be performed for screening purposes. Additional considerations should be weighed prior to the exposure of children and adolescents. These patients are more radiosensitive (that is, their cancer risk per unit dose of ionizing radiation is higher), and they have a longer lifetime risk of developing radiation-induced cancers.12,13

The clinician should prescribe traditional dental radiographs and CBCT scans only when he or she expects that the diagnostic yield will benefit patient care, enhance patient safety, significantly improve clinical outcomes or all of these.

CBCT should be considered as an adjunct to standard oral imaging modalities. CBCT may supplement or replace conventional (two-dimensional or panoramic) dental radiography for the diagnosis, monitoring and treatment of oral disease or the management of oral conditions when, in the clinician’s decision-making process, he or she determines that oral anatomical structures of interest may not be captured adequately by means of conventional radiography.

In accordance with the “as-low-as-reasonably-achievable” (ALARA) principle, radiation dose for dental patients should be optimized to achieve the lowest practical level to address a specific clinical situation. (Author’s note: “Dose optimization” means delivering a radiation dose to the organs and tissues of clinical interest no greater than that required for adequate imaging and minimizing the dose to other structures. The patient’s radiation dose is considered to be optimized when imaging is performed with the least amount of radiation required to provide adequate image quality. The goal of every imaging procedure is to provide images adequate for the clinical purpose. What constitutes adequate image quality depends on the modality being used and the clinical question being asked.) The clinician should limit the radiation dose for CBCT scans by optimizing image quality, using the smallest FOV necessary for imaging a specific anatomical area of interest and using the lowest combination of tube output and scan time (in milliamperes) consistent with adequate image noise content and motion artifact.

CBCT operators should take every precaution to reduce radiation dose and ensure the patient’s safety during CBCT imaging. The use of thyroid collars and lead aprons is recommended in the NCRP’s10 radiation safety guid-

ance for the dental profession. However, it is neither possible nor desirable to use these protective devices in all clinical situations, especially in cases in which the collar or apron may obstruct the area of interest. Protective thyroid collars and lead aprons should be used when they will not interfere with the examination.

A CBCT examination should be prescribed by a dentist who has appropriate training and education in CBCT imaging, including an understanding of the significance of CBCT selection and imaging findings.

CBCT images of the oral and maxillofacial structures that are the subject of the CBCT examination should be evaluated by a dentist with appropriate training and education in CBCT interpretation. (Author’s note: Establishing formal standards for CBCT training and education is beyond the scope of this CSA advisory statement. The Council will share the statement with the Commission on Dental Accreditation and other educational groups for further consideration.)

Regardless of the primary purpose for the selection of CBCT, the complete image data set must be interpreted by an appropriately qualified health care provider (such as a dentist or a physician). The prescribing clinician should receive a thorough radiological report. If the prescriber also interprets the CBCT images, he or she should enter the findings into the patient record and communicate them appropriately to the patient or, if the patient is a minor, to the patient’s parent or legal guardian.

Dentists must abide by applicable federal and state regulations in the provision of dental imaging modalities. This includes following regulations or guidance to ensure a safe working environment for both the staff and the public in relation to CBCT equipment and other sources of ionizing radiation. CBCT unit operators should contact state and local radiation control programs to verify any additional requirements for operation of CBCT, including applicable requirements for licensure or accreditation.

Dentists should use professional judgment in the prescription and performance of CBCT examinations by consulting recommendations from available CBCT guidelines and by considering the specific clinical situation and needs of the individual patient. Given the ongoing development and research in this technology, dentists should stay abreast of the scientific literature and apply an evidence- and science-based approach to the use of CBCT.

This advisory statement calls for appropriate agencies within the ADA and the dental community at large to develop and implement recommendations and criteria for adequate CBCT training and education of dentists or other CBCT unit operators. These recommendations should include but not be limited to patient evaluation, radiation protection, selection of appropriate CBCT imaging parameters, performance of the CBCT examination and image interpretation. The recommendations also must include requirements for predoctoral dental education programs and for continuing education coursework and training.

Facilities considering the installation of

### TABLE

<table>
<thead>
<tr>
<th>Imaging Technique</th>
<th>Effective Dose†</th>
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<tbody>
<tr>
<td>Conventional Radiography</td>
<td></td>
</tr>
<tr>
<td>Four-image posterior bitewings with photo-stimulable phosphor (PSP) or F-speed film and rectangular collimation</td>
<td>5.0</td>
</tr>
<tr>
<td>Panoramic radiograph with charge-coupled device</td>
<td>3.0-24.3</td>
</tr>
<tr>
<td>Cephalometric radiograph, posteroanterior or lateral with PSP</td>
<td>5.1-5.6</td>
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<tr>
<td>Full-mouth radiographs</td>
<td></td>
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<tr>
<td>With PSP storage or F-speed film and rectangular collimation</td>
<td>34.9</td>
</tr>
<tr>
<td>With PSP or F-speed film and round collimation</td>
<td>170.7</td>
</tr>
<tr>
<td>CBCT‡</td>
<td></td>
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<tr>
<td>Dentoalveolar CBCT (small and medium field of view [FOV])</td>
<td>11-674 (61)</td>
</tr>
<tr>
<td>Maxillofacial CBCT (large FOV)</td>
<td>30-1073 (87)</td>
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</tbody>
</table>

* Estimates for adult patients based on data from Pauwels and colleagues, The SEDENTEXCT Project and Ludlow and colleagues.† Measured in microsieverts.‡ Median values for effective dose provided parenthetically.

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CBCT devices should consult a health physicist (or other qualified expert) to perform a shielding analysis based on NCRP reports 145 and 147. Facilities using CBCT systems should consult a health physicist (or other qualified expert) to perform equipment performance and compliance evaluations initially at installation and then follow a schedule in compliance with local, state and federal requirements. The Council recommends that a performance evaluation be completed at least annually. The evaluations should include patient dose estimation to assist the facility with patient dose management.

Staffs of facilities using CBCT should establish a quality control program. This program can be based on the manufacturer’s recommendations or can be established, implemented and monitored by a qualified expert.

SUMMARY

CBCT technologies offer an advanced point-of-care imaging modality that clinicians should use selectively as an adjunct to conventional dental radiography. The selection of CBCT for dental and maxillofacial imaging should be based on professional judgment in accordance with the best available scientific evidence, weighing potential patient benefits against the risks associated with the level of radiation dose. Clinicians must apply the ALARA principle in protecting patients and staff during the acquisition of CBCT images. This includes appropriate justification of CBCT use, optimizing technical factors, using the smallest FOV necessary for diagnostic purposes and using appropriate personal protective shielding.

Disclosure. Members of the American Dental Association Council on Scientific Affairs (CSA) are required to maintain a current conflict-of-interest disclosure to participate in CSA activities. No potential conflicts of interest relevant to this statement were reported.

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