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Cone-beam computed tomography: Time to move from ALARA to ALADA

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ABSTRACT

Cone-beam computed tomography (CBCT) is routinely recommended for dental diagnosis and treatment planning. CBCT exposes patients to less radiation than does conventional CT. Still, lack of proper education among dentists and specialists is resulting in improper referral for CBCT. In addition, aiming to generate high-quality images, operators may increase the radiation dose, which can expose the patient to unnecessary risk. This letter advocates appropriate radiation dosing during CBCT to the benefit of both patients and dentists, and supports moving from the concept of "as low as reasonably achievable" (ALARA) to "as low as diagnostically acceptable" (ALADA). (***Imaging Sci Dent 2015; 45: 263-5***)

KEY WORDS: Radiation, Cone-Beam Computed Tomography; Dental Implants

Cone-beam computed tomography (CBCT) has revolutionized the dental diagnosis and treatment protocol. Since its introduction early in the first decade of this century, the number of CBCT machines in dental hospitals, private clinics, and radiology centres has grown tremendously. Few of the early CBCT machines used image intensifiers with a large field of view (FOV). Thus these machines were exposing patients to a larger radiation dose than newer CBCT machines but still comparatively less than that from conventional multislice CT.[1] Conclusions of a 2009 systematic review demonstrated that the most common uses of dental CBCT are for maxillofacial surgery (41%), dentoalveolar pathology (29%), orthodontics (16%), and implantology (13%).[2] In maxillofacial surgery, common uses of CBCT include temporomandibular joint assessment, arthrography, odontogenic cysts and tumours, trauma, cleft pathology, orthognathic surgery, oral cancer, osteomyelitis, bisphosphonate-related osteonecrosis of the jaw, and obstructive sleep apnoea. For orthodontic purposes, mini-implant placement, cephalometry, and identifying tooth positions were found to be the most common indications for CBCT scans.[3]

With such diverse applications, CBCT has become an indispensable third eye of dentistry. But just as every good thing has limitations, so does CBCT technology. Criteria have been laid down by the American Academy of Oral and Maxillofacial Radiology for the role of CBCT in implants, endodontics, and orthodontics.[4] However, there is growing concern among patients and researchers at large over the misdiagnosis and inappropriate referral of patients for CBCT. While the risk from dentomaxillofacial imaging is small for an individual, when multiplied by the large population of patients who are exposed to diagnostic imaging, the radiation risk becomes a significant public health issue.[1]

Since the advent of CBCT technology, marked improvements in hardware and software components have reduced the radiation dose to the patient. These improvements include changes in sensor technology, a smaller field of view depending upon the application, and pulsed radiation technique following the radiation dosage principle of ALARA: "as low as reasonably achievable".[5] Along with this, various exposure protocols have also been devised by manufacturers: child mode, adult mode, high-resolution mode, high-definition mode, and end-

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odontic mode, for example. But is this sufficient for every scenario of dental practice? Diagnostic imaging contributes to individual and population exposure to ionizing radiation, and it has been suggested that as much as 1.5%-2.0% of cancer cases in the United States may be related to X-ray exposure from CT imaging.[6]

Recent studies have confirmed that cancer risk extends to X-ray exposure from diagnostic imaging of the maxillofacial complex. In a recent study conducted by Ludlow et al. on CBCT dosimetry using various CBCT machines from various manufacturers and different FOV settings, it was found that increasing the FOV height brings new and potentially radiosensitive tissues into the area of direct exposure, while increasing the width of the beam simply increases the dose to tissues already being exposed.[1]

Dental CBCT was introduced to replace medical CT for the craniofacial region and to lower the total radiation dose to the patient. However, due to a lack of strict guidelines and ignorance about the role of CBCT in dentistry, it has become a substitute for conventional radiography, including periapical, bitewing, and panoramic radiographs. Mandibular third molar impaction is one such scenario where CBCT is routinely being used without prior assessment on panoramic radiograph and lack of evidence of involvement of the mandibular canal with the roots of impacted teeth. The radiation doses from full FOV dental CBCT scans have been measured to be 4-42 times the dose from a panoramic radiograph.[7]

Therefore, clinicians ordering dental CBCT should be mindful that frequent use of supplemental CBCT results in non-negligible increases in the total radiation dose to the patient.[3] An increasing number of CBCT images are being performed on children and adolescents, which is concerning, as children are more sensitive to radiation, particularly in the thyroid gland, gonads, and breast tissue, and the cancer risk per Sievert is highest at a younger age and decreases with age.[3]

In medical radiology, the Image Gently campaign has increased the awareness of radiation safety in paediatric populations and has recently been extended to include dental radiology procedures.[3] To address the important goals of the Image Gently campaign, paediatric protocols should be designed that will reduce the dose to the patient without compromising the diagnostic quality of the images.

A position paper published by the European Academy of Dental and Maxillofacial Radiology (EADMFR) on training for the use of CBCT clearly states that a general dentist who is prescribing, justifying, or carrying out CBCT and interpreting the images should have adequate training and understanding of this technology.[8] Guidelines, in the form of selection criteria, can provide the clinician with a helpful framework within which to work. It has been recommended that CBCT be reserved as a supplementary imaging technique where conventional radiography has failed to answer the question for which imaging was performed. Considering that higher radiation doses are typically used when CBCT examinations are performed compared to conventional radiographs, it is even more important that anyone using this technique understands the justification of patient exposure, optimization of patient dose, and protection of staff from radiation.[9] It is important for oral and maxillofacial radiologists to know and communicate the dose and associated risk of specific examinations to their patients and referring practitioners. It is critical for healthcare providers to weigh the potential benefit of diagnostic information against the expense and risk of the imaging procedure.[7]

If “pretty pictures” are being obtained when only a diagnostic image is needed, we are doing the patient a disservice. We as imaging specialists should educate our colleagues about the difference in risk between “diagnostically acceptable” and “beautiful” images. This has brought us to a new concept of ALADA “ as low as diagnostically acceptable”, which is a modification of ALARA, “as low as reasonably achievable”.[1,10] Depending upon the indication of the scan, the appropriate FOV, mAs, and kVp settings and high definition/high resolution parameters should be selected to obtain a diagnostically acceptable and interpretable image.

Implementing this concept of ALADA would require the strict regulation of guidelines on CBCT referrals followed by an evidence-based assessment of image quality for specific diagnostic tasks with exposure and doses associated with a given level of image quality.

Two decades after the introduction of CBCT, it is time to move from ALARA to ALADA.

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