DENTAL RADIATION

Cone beam computed tomography

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BACKGROUND

Cone beam computed tomography (CBCT) is a relatively new tool used in clinical dental settings. This imaging is used to diagnose problems and develop treatment plans. The technique produces a series of 2-dimensional images that are converted into a 3-dimensional reconstruction. It allows dental practitioners to visualize structures in the maxillofacial area more effectively than 2-dimensional imaging and has a wide range of dental applications. Risk from the radiation dose is considered low, but the quantification of doses is complicated. Factors that contribute to the range of doses delivered by CBCT imaging are many, and dentists need to understand them and know how to communicate the risks associated with radiation exposure to their patients.

DEFINITIONS OF TERMS

Radiation-related Terms

Understanding several of the basic concepts related to radiation exposure and dose is helpful in conveying information about the radiation patients may receive from imaging protocols. Some of the more important concepts are radioactivity, absorbed dose, equivalent dose, effective dose, dose area product, and dose height product.

Radioactivity is the emission of ionizing radiation or particles caused by the spontaneous disintegration of atomic nuclei. The number of atoms that decay each second is counted and reported in the unit Becquerel (Bq) or, more commonly, curie (Ci). The exposure to radiation is the charge produced in air from the ionizing radiation, which is measured in roentgen (R).

The *absorbed dose* refers to how much radiation is absorbed or the amount of energy the radioactive source deposits per unit mass of tissue or organ. This is measured in gray (Gy) and is often converted to the *equivalent dose*, which is measured in Sievert (Sv). Mathematically, a radiation dose delivered by x-ray has the absorbed dose in Gy that is equal to the dose in Sv.

Effective dose helps in comparing the doses of ionizing radiation from different sources or to different body parts. This theoretical construct considers the sensitivities of various tissues and sums them across all the body's tissues to produce a single dose value for all dose delivery systems and radiation types. Effective dose cannot be measured but rather is calculated and represents the dose the body as a whole receives.

Dose area product (DAP) correlates moderately well with effective dose for CBCT. DAP is the measure of the amount of kinetic energy released per unit mass when the x-ray beam is traveling through the air multiplied by the cross-sectional area of the x-ray beam the patient receives and is expressed in Gy • cm^2. *Dose height product* is a more recent measure of effective dose, but DAP remains more widely used.

Risk-related Terms

It's also helpful to understand phrases such as risk, acceptable risk, low dose or very low dose, as low as reasonably achievable, and as low as diagnostically achievable. These terms help to convey the importance of a radiation exposure in terms of how it will affect the human body.

Risk refers to the increased probability of a health-related event occurring from radiation exposure. Some of these events are the risk of cancer induction or the risk of death from cancer. Dose is converted to risk using coefficients that have been developed from decades of study of radiation exposures and disease in humans exposed to radiation, including studies of survivors of atomic bombs.

Acceptable risk is the preferred term in risk language for low dose or very low dose. Regulatory agencies view risks between 1 in 10,000 and 1 in 1,000,000 as acceptable risks (Figure 5). Most people consider the activities that yield such risks as acceptable and choose to engage in them daily.

Doses are considered *low* if they are between 10 and 100 mSv and *very low* if they are less than 10 mSv. At doses less than 100 mSv, it's difficult to quantify the risks because epidemiologic studies lose power at these levels and so much background exposure occurs at these levels. There is no threshold where the risk is zero.

Dentists and other medical professionals are generally seeking to ensure that the doses of radiation their patients will be exposed to will be *as low as reasonably achievable* (ALARA). This refers to how radiation releases to the environment or how exposure to

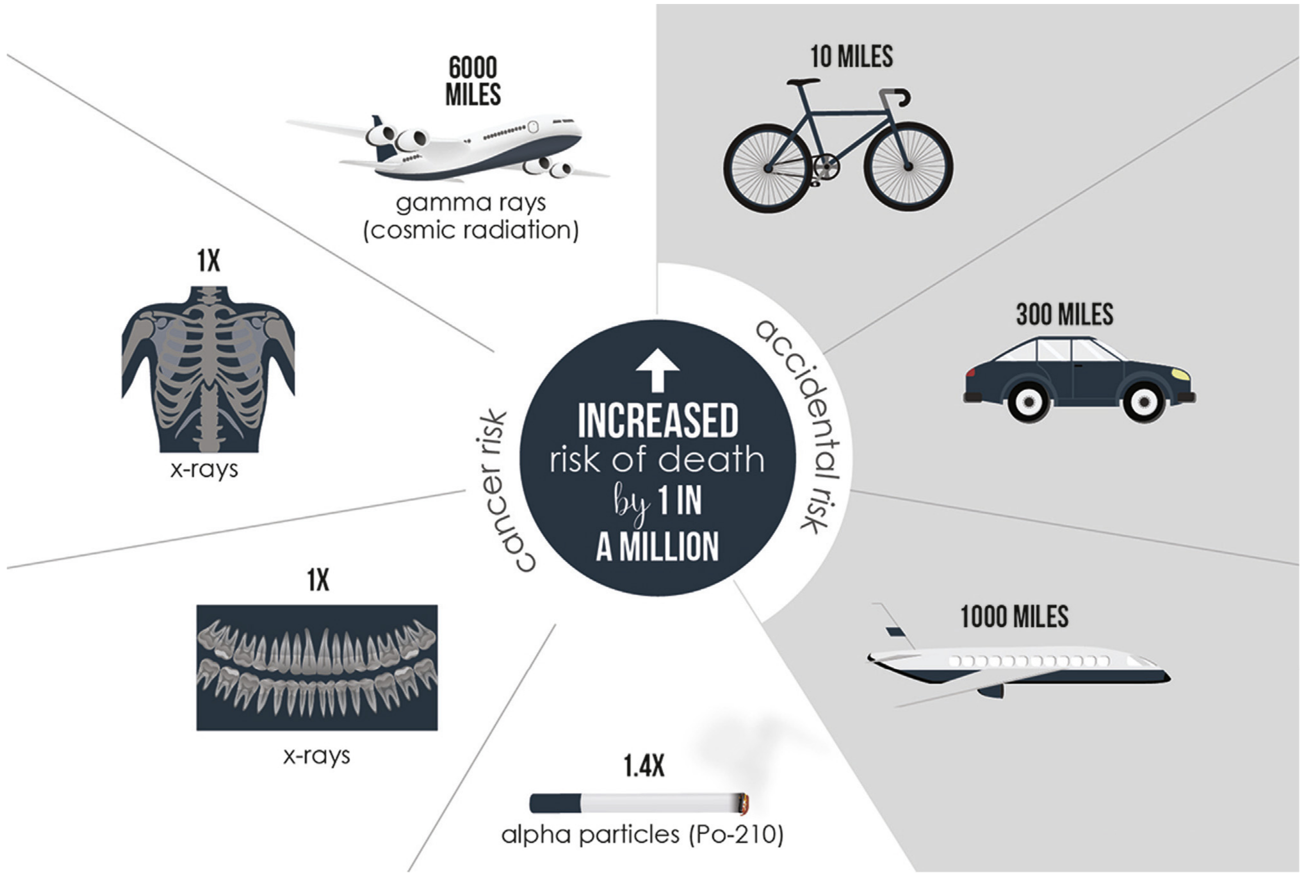

Figure 5. Activities that increase risk of death by 1 in 1,000,000. Permission granted by NCRP to cite in production document not yet available for distribution. (Courtesy of Aanenson JW, Till JE, Grogan HA: Understanding and communicating radiation dose and risk from cone beam computed tomography in dentistry. *J Prosthet Dent* 120:353-360, 2018.)

humans should be moderated. When speaking diagnostically, the appropriate phrase is *as low as diagnostically achievable*. This indicates that the imaging modality has been balanced between the needs for obtaining a diagnostic result and the dose and risk to the patient.

SPECIAL CONSIDERATIONS

Dentists must recognize that some special issues are involved in interpreting the risk of an imaging technique. For example, the risk of cancer from dental CBCTs depends on the organ or tissue that's exposed, and this requires that one know the organ-specific dose to an individual. Such information is not available with a CBCT.

X-rays may pass through organs other than the maxillofacial structures, such as the brain, eye, salivary glands, and thyroid gland. They can also be scattered off bony structures or even the machine and can expose other organs. Dose from CBCT scans differs because of the field of view, the desired resolution, x-ray beam energy, filtration factors, exposure time, receptor technology, and human factors. For example, physical size and age are issues because the anatomic positioning of the thyroid, brain, and salivary glands is slightly more compressed in younger compared to older patients. In addition, the scatter of x-rays off bony structures is more significant because the organs are closer. The dose delivered to critical organs in younger patients can be greater than what their adult counterparts receive based on physical size. Doses delivered to a child may produce a 3-fold increase in the lifetime risk of cancer compared to an adult. Age is

Clinical Significance

The risk associated with radiation exposure during CBCT imaging is negligible but still exists. Patients need to have the information on their risks as well as the benefits of undergoing imaging so that they can make the proper decision regarding whether or not to submit to the test. Dentists need to be familiar with the process of radiation exposure for CBCT as well as other imaging modalities and able to describe it in terms patients will understand. Having a visual comparison such as the one offered in this study can be extremely helpful in the discussion of risks associated with radiation exposure.

critical because younger individuals, specifically, those less than 10 to 15 years of age, have an inherently increased risk of cancer induction related to radiation exposure because of their increased cellular growth rate and continued organ development. In addition, they have a higher risk because there is a longer life expectancy, which allows a longer latency period before cancer is expressed. Age ceases to be a significant factor between ages 10 and 15 years.

EXPLAINING RISK TO PATIENTS

Patients should be given an idea of the risk that is involved in any imaging, which includes CBCT. To do this, it's helpful if the dentist can give them something that will compare the dose from CBCT with other activities with which they are familiar (Figure 5). This will help to put the risk information into a context that will help them make an informed choice.

Aanenson JW, Till JE, Grogan HA: Understanding and communicating radiation dose and risk from cone beam computed tomography in dentistry. *J Prosthet Dent* 120:353-360, 2018

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IMPLANTS

Flap versus flapless surgery

BACKGROUND

Implants provide an excellent choice for edentulous or partially edentulous patients, with a high rate of success. However, the best technique to use in providing these implants remains to be identified. The 2 choices are flap surgery, where a flap is elevated to provide a better view of the implant site and reduce complications, and flapless surgery, where no flap is done. Both have their advantages and disadvantages, and many clinical trials have been undertaken to identify which is the best approach. A meta-analysis of the available literature was done to assess the risks of failure and marginal bone loss associated with dental implants prepared using the flap or flapless procedure.

METHODS

The literature search included the PubMed, Web of Knowledge, and Cochrane Library databases. It extended over the past 10 years and was supplemented by a hand search of the reference lists of the retrieved articles. Thirty-one studies were selected for analysis.

RESULTS

Nine of the studies were retrospective and 22 prospective. They covered a total of 1681 patients who had 4138 implants. Patients ranged in age from 16 to 89 years. Follow-up was 12 months in 28 studies and 3 months in 3 studies. Seven studies focused on single-tooth implants, whereas the remainder covered implants for edentulous or partially edentulous jaws.

The healing strategies of the studies included submerged or nonsubmerged protocols. In addition, 8 studies loaded implants within 2 weeks of placement in both flapless and flap groups, 13 used a delayed loading protocol, and 6 involved both immediate or early loading and delayed loading.

Nineteen hundred seventy implants were placed using the flapless procedure. Sixty-three of these implants failed. Flap procedures were used for 2168 implants, of which 39 failed. Eleven studies reported no failures. The differences in terms of implant failure did not differ significantly between flap and flapless procedures. Five studies showed a statistically significant difference between the 2 procedures with respect to marginal bone loss.

In the meta-analysis, failure rate of the implants was statistically altered by the insertion technique employed. Implants placed with the flapless procedure had an increased risk of implant

Clinical Significance

Dentists must consider the advantages and disadvantages of providing implants using a flap or a flapless procedure. It's imperative to carefully assess the quantity and morphology of bone using imaging preoperatively. This will help to ensure that sufficient bone remains. The computer-guided implantation system may also provide real-time imaging that can ensure the correct position and angulation of the dental drill are achieved, thus avoiding the risk to critical anatomical structures. Flapless procedures offer healthier peri-implant soft tissues and better vascularity of the peri-implant mucosa, which leads to better resistance to inflammation and bacterial invasion. They are also associated with less surgical trauma, higher patient satisfaction levels, a shorter operative time, and better postoperative healing.