





One millionth of a Sievert

3. **Effective Dose** is the most common way to express dosage in medical radiography because it correlates most closely with health risk. It is similar to equivalent dose except that it also accounts for the type of tissue being exposed. Various organs are assigned weighting factors by the ICRP, and the effective dose uses these factors to express the potential damage as if the radiation was being exposed to the entire body. Effective dose is also most commonly measured in microsieverts ( $\mu\text{Sv}$ ).

## What variables affect radiation?

When evaluating the radiation exposure of a certain procedure or device, there are many variables that can affect the resulting dosage. Some of the key factors include: x-ray generator (sometimes informally called the “tube head”) voltage, generator current, exposure time, distance from source, and beam size.

### PEAK KILOVOLTS (kVp)

Determines how fast electrons travel from the cathode to the anode & therefore how much energy the x-ray photons possess when they travel out of the tubehead.

**The generator voltage**, expressed in peak kilovolts (kVp), determines how energetic the electrons are that travel from the cathode to the anode and therefore how much energy the x-ray photons possess when they travel out of the generator.

**The generator current**, expressed in milliamps (mA) determines the rate at which electrons are emitted from the generator.

**Time** is simply the duration of the exposure. Both time and mA are both directly correlated: doubling either time or mA and holding all else equal will result in double the dosage. A 10 second scan at 3 mA will produce the same amount of dosage as a 3 second scan at 10 mA (again holding all else equal).

### MILLIAMPS (mA)

Determines rate at which electrons are emitted from the tubehead.

**Distance** is simply how far the source is from the patient. The intensity of the x-ray is proportional to the inverse square of the distance, which means that if a source is moved to a distance that is twice as far from the patient, the dosage will be 75% less (one quarter of the original value).

$$\text{Intensity} \propto \frac{1}{\text{Distance}^2}$$

Lastly, **beam shape** has a large effect on the dosage. Collimation is the use of a device to narrow the beam emitted from an x-ray source. Lead collimators absorb stray radiation to create precise beams that only hit the areas of interest and reduce unneeded radiation exposure to parts of the body that are not being imaged. If a collimator opening is larger, as it is in a dental CBCT as compared to a panoramic, the dosage increases. Similarly, if the beam is exposing a wider section of the anatomy, as it does with larger field of view CBCT's, this will also increase dosage absorbed.

## How does CBCT compare to other tools?

For most panoramic units and Dental CBCT units, the range of kVp, mA, and exposure time is not dramatically different and for machines that have both capabilities, it can be exactly the same. A study comparing many Dental CBCTs was published in the European Journal of Radiology in 2010. According to this study, scans from most large field of view (FOV) machines ranged from 83  $\mu\text{Sv}$  to 194  $\mu\text{Sv}$ . Scans from small FOV machines ranged from 19  $\mu\text{Sv}$  to 40  $\mu\text{Sv}$ .

According to the paper “Patient risk related to common dental radiographic examinations: the impact of 2007 International Commission on Radiological Protection recommendations regarding dose calculation” published in The Journal of the American Dental Association in 2008, a typical panoramic x-ray can result in a effective dose of about 14  $\mu$ Sv. A typical full mouth series (FMX) that includes 18 intraoral radiographs results in about 171  $\mu$ Sv of effective dose.

## ALARA Recommendations

As Low As Reasonably Achievable (ALARA) is the concept of minimizing the patient exposure while still being able to acquire useful images. Doctors will make every effort to limit the beam to their area of interest only.

In 2010 The American Association of Endodontists and the American Academy of Oral and Maxillofacial Radiologists released a joint position statement for selecting Endodontic patients for CBCT scans. Their position states that CBCT should not be used routinely and patients should only be selected if clear symptoms are present for conditions that traditional diagnostic imaging would not help identify.

*For those endodontic cases that require a CBCT, they recommend a small Field of View CBCT as preferred over large-volume CBCT because a small FOV offers:*

1. Increased spatial resolution to improve the accuracy of endodontic-specific tasks such as visualization of small features including accessory canals, root fractures, apical deltas, calcifications, etc.
2. The highest possible spatial resolution that provides a diagnostically acceptable signal-to-noise ratio for the task at hand,
3. Decreased radiation exposure to the patient,
4. Time savings due to smaller volume to be interpreted.

In 2012, The American Academy of Oral and Maxillofacial Radiology also issued a position on use of CBCT in dental implantology. The AAOMR recommends that cross-sectional imaging be used for the assessment of all dental implant sites and that CBCT is the imaging method of choice for gaining this information.

*Finally, to help patients put the dosage numbers into perspective, it may be worth comparing these to some effective doses of common phenomenon from everyday life. According to the United Nations Scientific Committee on the Effects of Atomic Radiation, the average worldwide background radiation is about 2400 $\mu$ Sv per year or approximately 6.7  $\mu$ Sv a day. A cross-country flight is about 30  $\mu$ Sv. Using these estimates, we can do a rough comparison with every day experiences (CBCT values are the median of the ranges above).*

Study	Effective Dose ( $\mu$ Sv)	Days of Background Radiation	Cross Country Flights
FMX (round cone)	171	25	6
Panoramic X-Ray	14	2	< 1
Small FOV Dental CBCT	29	4	1
Large FOV Dental CBCT	139	21	5

Overall, CBCT offers fantastic diagnostic capabilities when compared with traditional radiographic tools. Clearly, doctors will be practicing ALARA by carefully weighing whether the higher radiation risk outweighs the risk to the patient of a suboptimal treatment plan. However, it is also useful to consider how to best explain these tradeoffs to a patient so that the patient has confidence in the resulting plan.

*For more than 35 years, ImageWorks has been providing the best in imaging solutions to dental health professionals. Our objective is to improve both patient care and practice efficiency by offering solutions that perform at the highest level while seamlessly integrating with your existing technology. We aspire to make sure digital x-ray technology conforms to the patient, not the other way around.*



please visit us at [www.imageworkscorporation.com/panoura18S](http://www.imageworkscorporation.com/panoura18S),

email us at [custserv@imageworkscorporation.com](mailto:custserv@imageworkscorporation.com), or call us at (914) 592-6100.