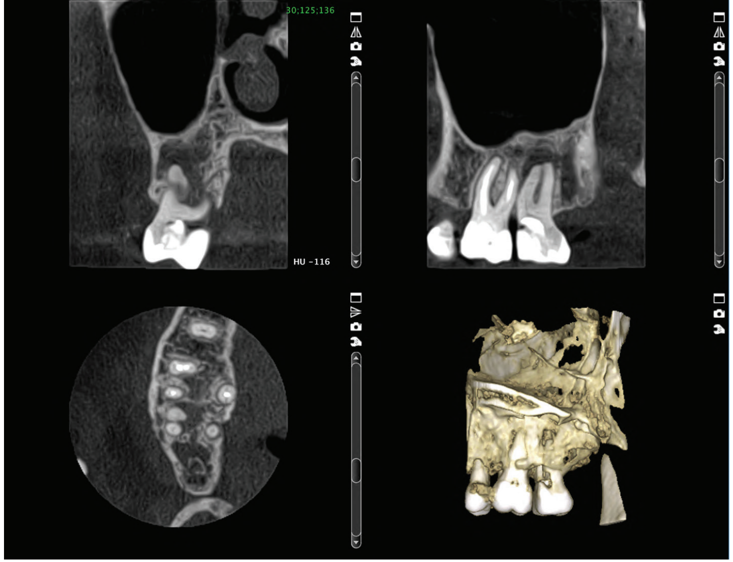
RESPONSIBLE RADIATION

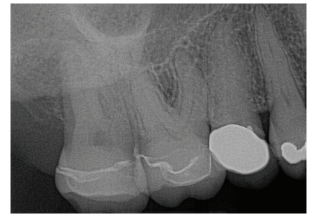
PLANMECA

“Traditional” dentistry has changed exponentially over the last couple of decades. Solutions for delivering better dental care are constantly evolving—from diagnostic techniques to treatment protocols and improved materials, dentistry is always evolving.

Currently, 3D radiography is taking center stage as this technology is becoming more mainstream. At first, 3D Cone Beam Computed Tomography (CBCT) simplified diagnosis and many complicated procedures in oral surgery, implantology and endodontic treatments. **Now, general practitioners are finding CBCT imaging is a must-have tool as it provides clear advantages over traditional 2D radiography.** Let’s take a closer look.



VS.



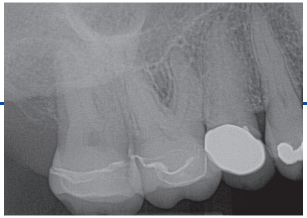
With 2D X-rays, clinicians have to compensate for superimposition of anatomy, possibly obscuring the information needed to make a diagnosis, and distortion leading to loss of spatial information.[1]

We have known for decades that lesions in cortical bone can be detected with an X-ray, but only under certain conditions. There must be a perforation of the bone cortex, or extensive damage to the enamel before it's detectable on a 2D radiograph. At that point, doctors may have missed the opportunity for early intervention and unfortunately, this can result in loss of the tooth or the need to see a specialist. Neither scenario is ideal for the patient.

There have been a number of studies comparing the diagnostic accuracy of 2D versus 3D radiography. In one study, 2D digital periapical radiographs were able to correctly identify a periapical lesion only 24.8% of the time, while 3D CBCT was able to identify the lesion 100% of the time[2].

Patient Presents with Pain

2D DIAGNOSTIC PROTOCOL



Take up to 2 intraoral periapical images 9–18 μSV.

Results inconclusive.

Diagnosis and treatment plan accordingly.

Put area of interest on a watch.

or

Refer to specialist & more radiation. Unknown μSV

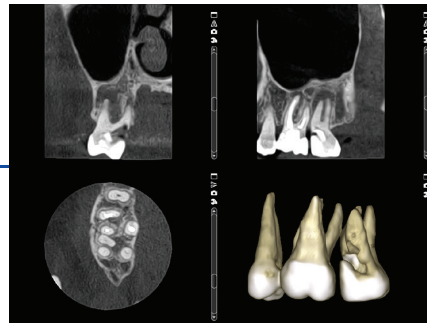
Total Radiation: **9 – 18+ μSv**

In one study, 2D digital periapical radiographs were able to correctly identify a periapical lesion only 24.8% of the time.

In another study 3D imaging was found to be twice as reliable in detecting periapical lesions compared to 2D digital periapical radiography and 2.5 times more accurate when imaging in the maxilla.[3] This is due to the fact that 3D solves the loss of spatial information in the buccal-lingual dimension. It can also image each root individually without the limitations of anatomical superimposition.

Patient Presents with Pain

3D DIAGNOSTIC PROTOCOL



Order a 3D PA ø4x5 cm, normal resolution ULD at 10 μSv.

Arrive at 100% accurate dignosis and treatment plan accordingly.

Total Radiation: **10 μSv**

It's clear that CBCT technology has numerous benefits over 2D radiography, yet it remains the standard of care for diagnosis in dentistry. Why is this?

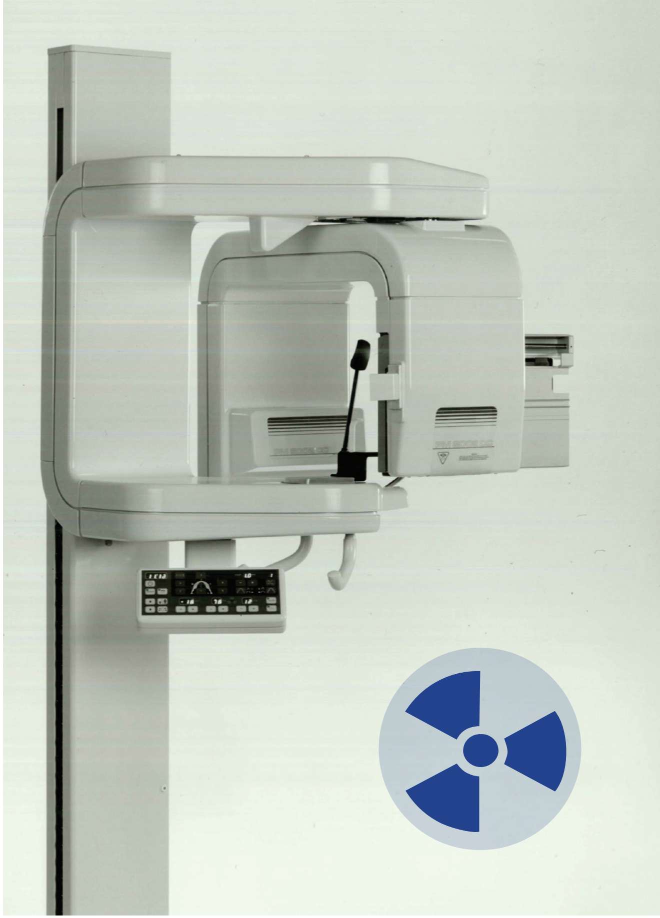
Historically, CBCT imaging produces high levels of radiation. It's been estimated that 1.5–2% of cancers may be attributable to CT imaging.[4] Therefore, governing dental bodies have published guidelines for the use of CBCT imaging to mitigate patient risk from potential harm and unnecessary X-rays.

In 1993 the National Council on Radiation Protection and Measurements (NCRP) released Report No. 116, Limitation of Exposure to Ionizing Radiation. This report introduced the ALARA principle, "As Low As Reasonably Achievable," which means that practitioners must be able to justify an image, and must be diligent to use the lowest reasonable amount of radiation exposure.

ALARA

"As Low As Reasonably Achievable"

To practice this principle, dentists must be mindful of the field of view, exposure time, shielding, and required justification for taking the image.



A variation on the ALARA principle was later introduced. This is known as the ALADA, "As Low As Diagnostically Achievable." Advances in medical imaging, most notably CT imaging and cardiovascular nuclear medicine, pushed for this change to potentially save lives. More importantly for the dental community, it brings a critical part of the conversation to the forefront, the use of the lowest amount of radiation needed to make an accurate diagnosis.

ALADA

"As Low As Diagnostically Achievable"

The U.S. Food and Drug Administration states, "To help reduce risk to the patient, all exams using ionizing radiation should be performed only when necessary to answer a medical question, treat a disease, or guide a procedure. If there is a medical need for a particular imaging procedure and other exams using no or less radiation are less appropriate, then the benefits exceed the risks, and radiation risk considerations should not influence the physician's decision to perform the study or the patient's decision to have the procedure. However, the "As Low as Reasonably Achievable" (ALARA) principle should always be followed when choosing equipment settings to minimize radiation exposure to the patient."[5]

The American Dental Association Council on Scientific Affairs made an advisory statement on the use of Cone Beam Computed Tomography in 2012. The council stated, "CBCT should be considered as an adjunct to standard oral imaging modalities. CBCT may supplement or replace conventional dental radiography for the diagnosis, monitoring and treatment of oral disease or the management of oral conditions when, in the clinicians decision-making process, he or she determines that oral anatomical structures of interest may not be captured adequately by means of conventional radiography."

Considering these guidelines, many organizations have continued to promote 2D radiography as the first option for a diagnosis in dentistry.

The preceding statements present a conundrum to the dentist. We already realize that a 2D radiograph will not be adequately diagnostic the majority of the time. And, if a 2D radiograph is inconclusive, the dentist may opt to have a second or third X-ray taken at a different angle. At that point, the patient has been exposed multiple times and there still may not be a diagnosis. The dentist may opt to send the patient home to "watch and wait," only to return if the symptoms worsen or don't improve. Alternatively, they may refer the patient to a specialist for an evaluation, where they will likely be exposed to more X-ray images.

In addition to repetitive exposure to X-rays, this lack of a diagnosis leads to a delay in treatment causing the condition to worsen. The opportunity for early intervention and the ability to practice minimally invasive dentistry has been missed.

Eventually, a CBCT may be taken and a diagnosis can be made, but at what cost to the patient? If the typical protocol outlined above was followed, a patient has been exposed to X-ray radiation multiple times if the initial 2D periapical (PA) was inconclusive. This process is frustrating to the dentist who wants to be able to help their patient, and it's frustrating to the patient who continues to suffer needlessly.

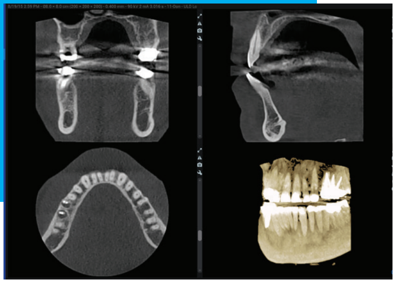
As CBCT technology has advanced, radiation levels have reduced, and doctors have options in choosing the resolution, timing, and exposure levels to reach lower effective patient dose. Unfortunately, image degradation is the result of lower levels of ionizing radiation, a less than desirable outcome. Without a diagnostically relevant image, clinicians have little choice but to use higher resolution settings and use CBCT imaging sparingly.

But it doesn't have to be that way.

JB Ludlow and J Koivisto tested a variety of CBCT machines and wide range of exposures. The purpose of the study was to evaluate doses from different combinations of volume size and exposure parameters on child and adult phantoms. The second purpose was to determine if there was a loss of quality with different doses.

Planmeca, a pioneer in CBCT innovation, has developed **Planmeca Ultra Low Dose™ (ULD) technology**. This produces dramatically lower patient radiation dose, but it does so without statistical loss in image quality.

Ø11x8 cm image, Low Resolution, Ultra Low Dose™
9 µSv



Planmeca ULD

Dosimetry of Orthodontic Diagnostic FOVs Using Low Dose CBCT protocol

0920

JB Ludlow[a], J Koivisto[b]

[a]University of North Carolina-Chapel Hill, School of Dentistry, Chapel Hill, North Carolina,
[b]University of Helsinki, Department of Physics, Helsinki, Finland

Introduction

Use of ionizing radiation in diagnostic medical examinations has increased over the last 20 years to the point where the annual per capita dose to the US population from all sources has doubled.(1) The risk of this exposure is significant, and it has been estimated that from 1.5% to 2% of all US cancers may be attributed to computed tomography (CT) studies alone.(2) Use of CT scans in children delivering cumulative doses of about 50 mGy might almost triple the risk of leukaemia and doses of about 60 mGy might triple the risk of brain cancer.(3) The range of doses produced by dental CBCT units is large with some examinations approaching doses associated with medical CT imaging. (4) Dosimetry of CBCT examinations for pediatric patients has not been established for many units that are currently used in orthodontic imaging.

Objectives

The purpose of this study was to evaluate doses resulting from various combinations of field size and exposure parameters using child and adult phantoms on a Promax 3D Mid CBCT unit. A second aim was to acquire contrast/noise ratio (CNR) data and modulation transfer function (MTF) data to examine the relationship of these measures of image quality to examination dose.

Effective doses resulting from combinations of field size and exposure parameters that might be used for orthodontic diagnosis tasks were acquired using a Promax 3D Mid CBCT unit (Planmeca Oy, Finland). Specifically doses for a protocol involving reduced exposure and proprietary reconstruction called "ultra low dose" (ULD) was compared with standard exposures. Contrast to noise ratio (CNR) and modulation transfer function (MTF) were calculated as quantitative measures of image quality.

Methods

Doses resulting from various combinations of field size, exposure protocol, and child or adult anthropomorphic phantoms using the Promax 3D MID CBCT unit (Helsinki, Finland) were measured with Optical Stimulated Luminescent (OSL) dosimetry using previously validated protocols. (5-6)

Optical Stiumlated Luminescence dosimeters (OSLDs) (NanoDot, Landauer, Glenwood, IL)

- Placed at 24 locations in 10-year-old child and adult phantoms (CIRS, Norfolk, VA) (figure 1).
- Multiple exposures made for each dosimeter run
- Dosimeters read 3 times with Microstar ii reader (Landauer, Glenwood, IL) – average dose used
- Dose values were adjusted for sensitivity of dosimeters to effective kV of x-ray source
- Doses divided by number of exposures to obtain dose per scan

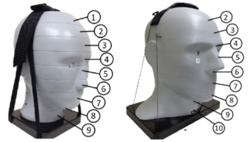


Figure 1. Child (left) and adult (right) dosimetry phantoms

Equivalent dose (H_T) determination

- Doses were determined in the organs and tissues listed in ICRP Report 103 (7)
- Average absorbed dose in each tissue or organ was used to calculate equivalent dose (H_T) $H_T = \sum W_R \times D_T$,

Effective dose (E) determination

- Calculated in µSv as: $E = \sum w_T \times H_T$, where E is the product of the tissue weighting factor (w_T), which represents the relative contribution of that organ or tissue to the overall risk, and the equivalent dose (H_T).

Image Quality Assessment

- QUART DVT phantom and image reader (QUART GmbH, Munich, Germany) - used to measure CNR and MTF.

Analysis

- Standard and ULD image quality parameters were compared in a paired analysis.

Results

Table 1. Dose by phantom type, FOV, and protocol

Protocol	Phantom	volume (ø*h) in mm	Effective Dose in µSv
ULD Low Dose	Adult	100*100	12
ULD Normal			45
Low Dose			60
Normal			189
ULD Low Dose		200*170	18
ULD Normal			51
Low Dose			72
Normal			215
ULD Low Dose	Child	85*85	10
ULD Normal			36
Low Dose			48
Normal			153
ULD Low Dose		200*170	15
ULD Normal			42
Low Dose			74
Normal			175

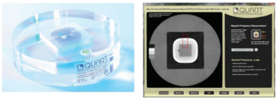


Figure 2. QUART phantom and analysis software display

Table 2. Image quality differences due to protocol and statistical p value of difference

	mean difference	prob > |t|
CNR	0.408	0.56
MTF 10%	0.038	0.56
MTF 50%	0.055	0.47

Conclusion

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, radiation risk becomes a significant public health issue. Therefore, strategies to reduce patient dose, keeping doses "as low as reasonably acceptable" (ALARA) are desirable. An average reduction in dose of 77% was achieved using ULD protocols when compared with standard protocols. While this dose reduction was significant, no statistical reduction in image quality between ULD and standard protocols was seen. This would suggest that patient doses can be reduced without loss of diagnostic quality. Further investigation of the diagnostic efficacy of ULD scans in Orthodontic and Orthognathic surgical treatment planning is indicated.

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"An average reduction in dose of 77% was achieved using ULD protocols when compared in standard protocols. While this dose reduction was significant, no statistical reduction in image quality between ULD and standard protocols was seen."

— JB Ludlow, J. Koivisto

Normal radiation dose

Planmeca Ultra Low Dose™

They compared Planmeca's ULD technology with standard protocols and determined that Planmeca can achieve an average reduction in dose of 77% when compared to standard protocols. They also noted there was no statistical reduction in image quality between the image taken with Planmeca ULD and one taken without. This suggests that patient doses can be reduced to levels equal to, and often less than 2D radiography without loss of diagnostic quality.

This is the game changer and the reason for a paradigm shift in how dentist employ 3D imaging in general dentistry.

We know dentists can make an accurate diagnosis with CBCT imaging 100% of the time and without unnecessary delays. We now have technology that can produce a diagnostically valuable image that delivers the same or less radiation dose compared to traditional 2D radiography. It should therefore be logical that Planmeca CBCT with ULD technology can be used routinely for diagnosis and treatment planning purposes. Even more importantly, this checks both boxes when held up to both the ALARA and ALADA principles.

ALARA ☑

ALADA ☑

Dr. Michael Young, a general practitioner in Michigan has been using CBCT technology in his practice since 2015. Initially, he purchased the technology for implant planning, but then began to uncover the true potential for this technology in everyday dentistry.

"One of the reasons I purchased a Planmeca CBCT unit was the low dose technology," Dr. Young explained. "I called my rep and asked for the dose information on my Planmeca ProMax® 3D Classic. I wanted to see the numbers myself. What I learned really opened my eyes. By using Planmeca's Ultra Low Dose technology, I can take a 5x5 limited view of the area of concern, which delivers the same or low patient radiation compared to the 2D periapical, and we can make an accurate diagnosis right away. This became my '3D PA,' and I follow this imaging protocol when a patient comes in with discomfort. It's been incredible."

Michael Young, DDS

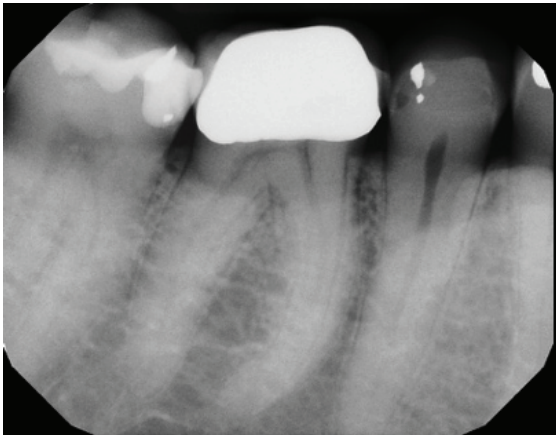
An early adopter of digital dentistry, Dr. Michael Young, operates a private practice in Sterling Heights , MI. He graduated from the University of Michigan School of Dentistry. He is a mentor for the Kois Center for Advanced Dental Learning and is a member of the American Dental Association, Michigan Dental Association, Detroit District Dental Association, Pierre Fauchard Academy, American College of Dentists, International College of Dentists, and American Academy of Oral Systemic Health.

Dr. Michael Young's story

"Whenever a patient presented with pain and a radiograph was warranted to make a diagnosis, we took a 2D periapical X-ray," he explains. "Most of the time, we were not able to determine the source of pain because nothing was obvious on the radiograph. We would tell the patient that we weren't able to make a diagnosis as the signs and symptoms were not clear enough at the moment. Then, we would send the patient home and ask them to return if there was no improvement in their symptoms. Invariably, the patient would return with the same symptoms, and sometimes they were worse. At that point, we would take a 3D CBCT image. In every case, we were able to make a diagnosis from the 3D image alone," recalls Dr. Young.

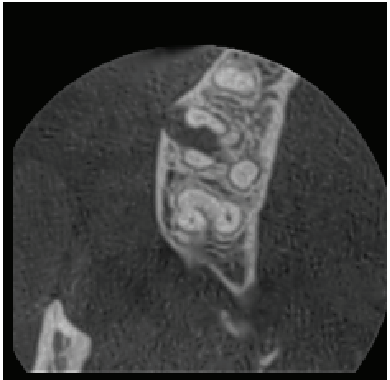
"For example, I had a patient arrived at my office with a chief complaint of pain when chewing on his mandibular right. During the examination, he pointed at tooth #29. As was customary, the dental assistant did some investigating and took a 2D periapical radiograph. The image showed nothing remarkable, and an initial exam was inconclusive. There is a problem, however as the radiograph did not show the apex of #29."

"A low resolution, ULD 3D 5x5 cm image was taken, and sagittal, coronal, and apical screenshots are shown here. **The 5x5 cm volume is able to capture the entire tooth, and even on the low-resolution setting, the radiolucency is obvious, and a diagnosis can be made using the 3D image.**"



"In another example, this patient presented with tenderness in her maxillary right posterior teeth," Dr. Young continued. "She was not sure of the exact tooth but believed it to be a molar."

"Again, the 2D periapical radiograph shows nothing remarkable or obvious. **The ULD 5x5 3D images very clearly show pathology associated with tooth #3, as one can see here with the screenshots of sagittal, coronal, and apical views.** The 3D image enabled me to make a diagnosis at an exposure that is less than the original 2D image taken. These cases and others like it caused a paradigm shift in my practice."



"This scenario played out many times in my practice until it became apparent to me that we would do our patients a great service by taking the 3D image immediately and skip the 2D PA, he explained. "I kept mulling this over in my mind because it contradicts industry guidelines."

"One of the reasons I purchased a Planmeca CBCT unit was the low dose technology," Dr. Young explained. "I called my rep and asked for the dose information on my Planmeca ProMax® 3D Classic. I wanted to see the numbers myself. What I learned really opened my eyes. By using Planmeca's Ultra Low Dose technology, I can take a 5x5 limited view of the area of concern, which is delivers the same or low patient radiation compared to the 2D periapical, and we can make an accurate diagnosis right away. This became my '3D PA,' and I follow this imaging protocol when a patient comes in with discomfort. It's been incredible. There are so many benefits. With an earlier diagnosis, treatment could be provided sooner, resulting in less bony destruction and tooth loss. This paradigm shift from 2D PA to 3D PA is better for our patients, and it's better for our practices because we must be efficient, especially now."

While most CBCT manufacturers tout low dose imaging. None can produce images like Planmeca. In a study conducted by Ludlow and Koivisto, the Planmeca ProMax® 3D Mid produced an image with significant reduction in dose, (77%) with no statistical reduction in image quality between ULD and standard protocols was seen.

"While most CBCT manufacturers tout low dose imaging. None can produce images like Planmeca."

Other manufacturers sacrifice image quality in order to lower effective patient radiation. The resulting image is not diagnostically viable. In a similar study by Ludlow and Walker regarding a competitor system, the report stated, "Significant dose reductions are accompanied by significant reductions in image quality."[6]

CBCT imaging can play an integral role in general dentistry, but only with technology like Planmeca Ultra Low Dose™. With the ability to have diagnostically valuable images at equal to or less than the effective patient dose of 2D images. Those using this technology such as Dr. Young, have embraced the use of CBCT imaging technology every day and wouldn't consider practicing dentistry without it.

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