IDT

making the most of your image™

Image Diagnostic Technology Ltd

53 Windermere Road, London W5 4TJ

Tel: +44 (0)20 8819 9158 www.idtscans.com email: info@idtscans.com

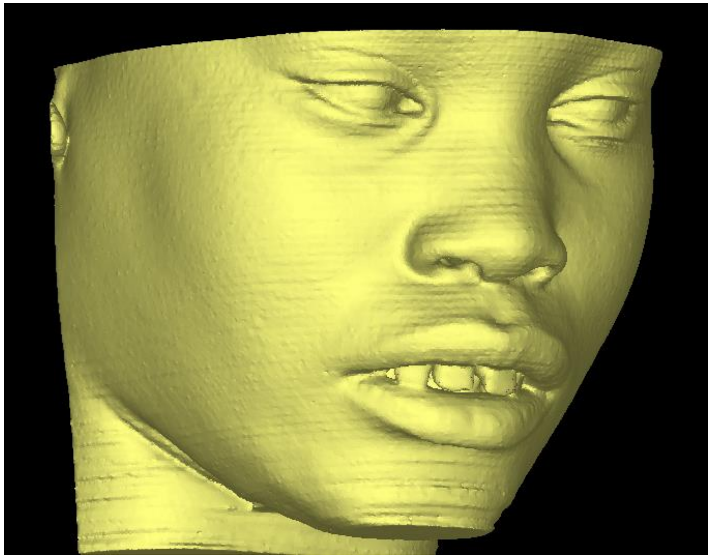
Dental Radiography and Quality Assurance

Anthony Reynolds BA MSc PhD
Registered Clinical Scientist CS03469

Image Diagnostic Technology Ltd.

Who or what is IDT?

Image Diagnostic Technology Ltd aka “IDT Scans”



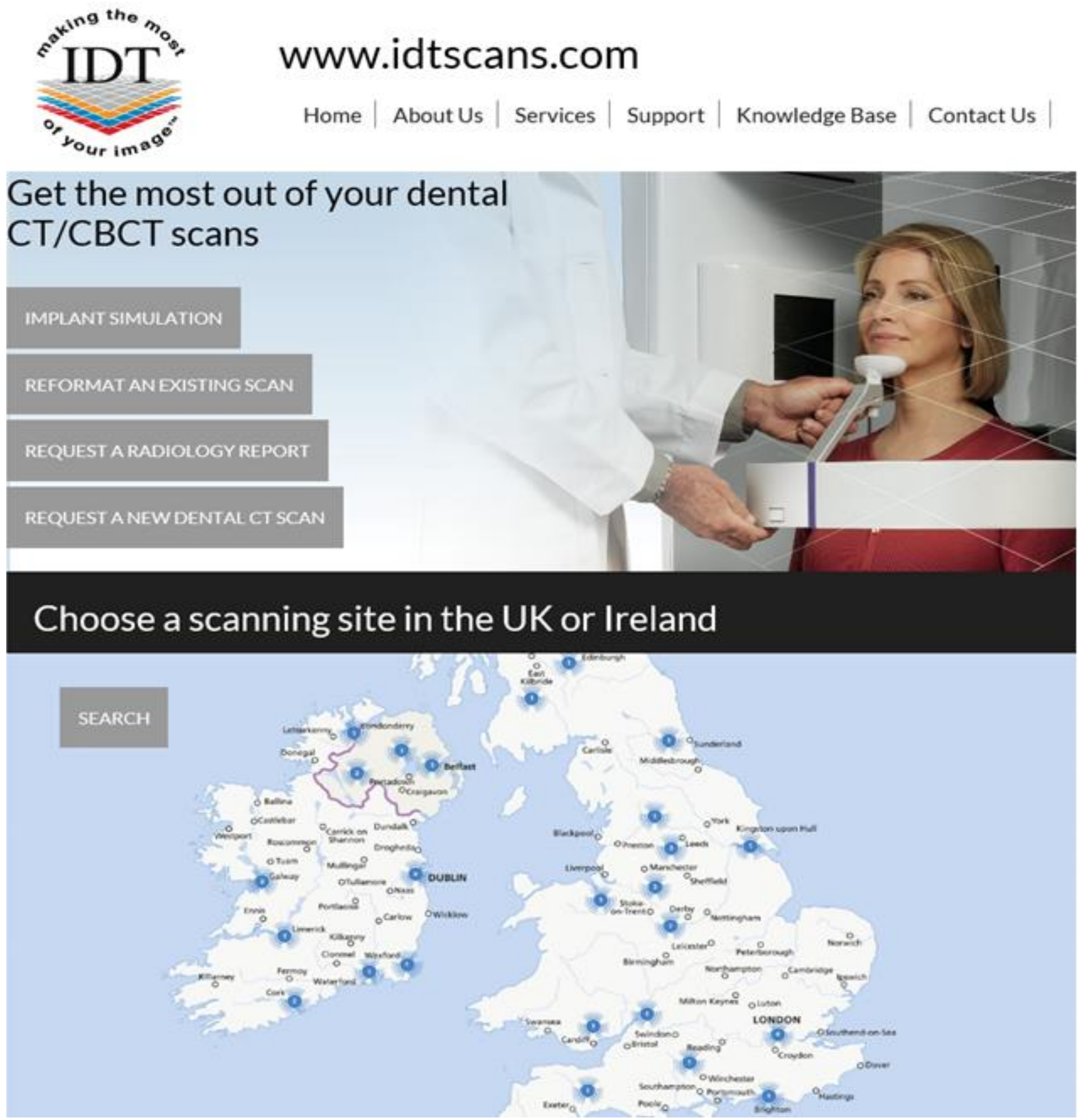
Specialises in:

- **arranging dental CT/CBCT scans**
- **3D processing**
- **radiology reports**
- **implant simulation**
- **3D models**
- **surgical drill guides**

32,000 scans processed since 1991

What can IDT do with my images

- **Prepare datasets for planning implants**
- **Radiology Reports**
- **Treatment Plans**
- **3D Models**
- **Surgical Drill Guides**



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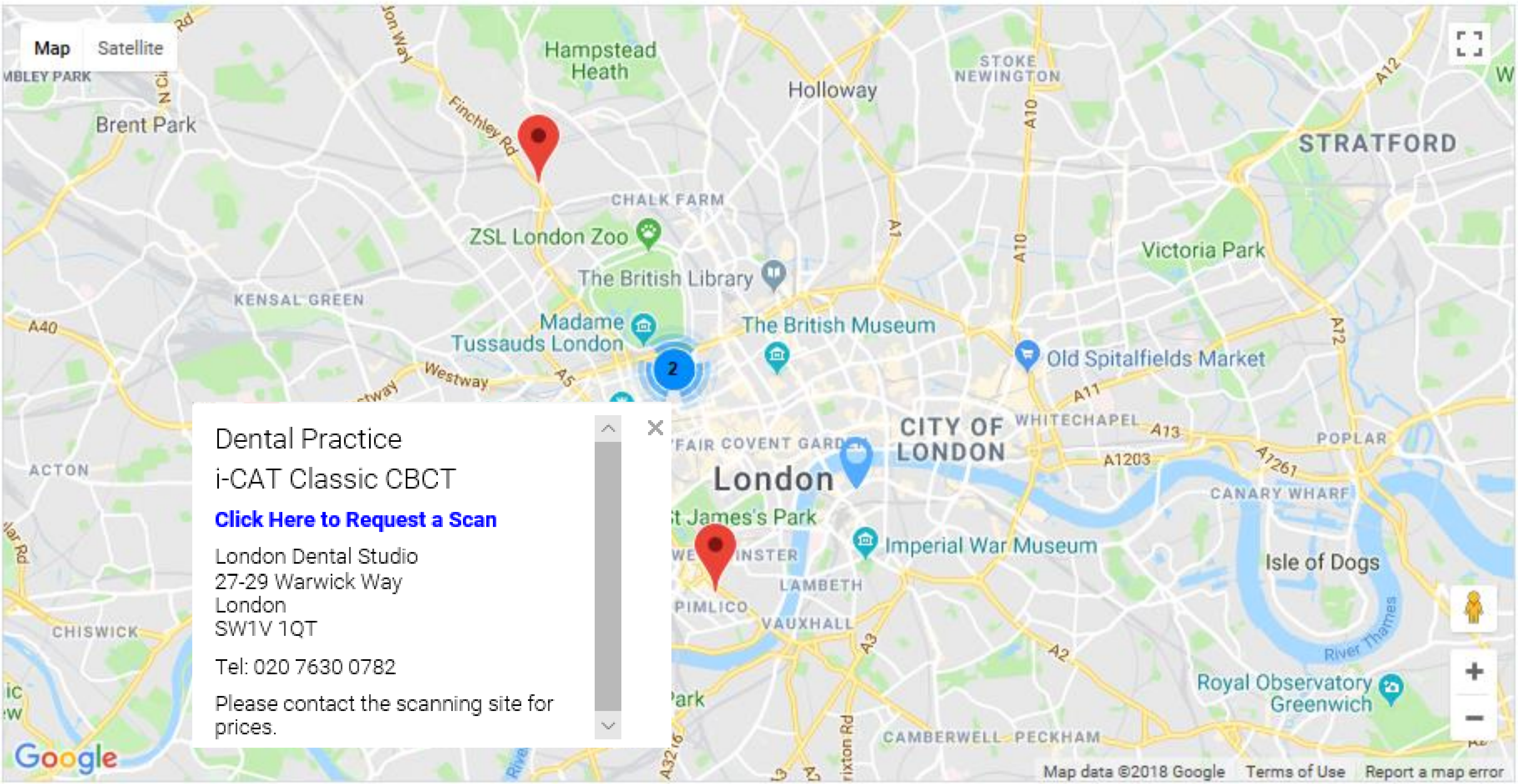
Location Keyword A-Z List

United Kingdom ◉ Ireland ○

SE1 9NN | 5 miles | Search

Found 4 sites. Please click the icons for more information.



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Outline of Lectures

- ✔ Introduction / Disclosures
- Diagnostic Imaging in Dentistry
  - Conventional Radiography
  - CT / CBCT Scans
- Quality Assurance
- Radiation Dose and Risk
- Compliance with the Legislation

What do we use dental imaging for?

Review patient anatomy and pathology

- **diagnostic quality images**
- **at a low radiation dose**

Answer specific clinical questions

- **is caries present**
- **how many teeth are present**
- **quality and quantity of bone**
- **radio-lucencies or radio-opacities**

Imaging for specific dental applications

Planning dental implants

Orthodontics

Endodontics

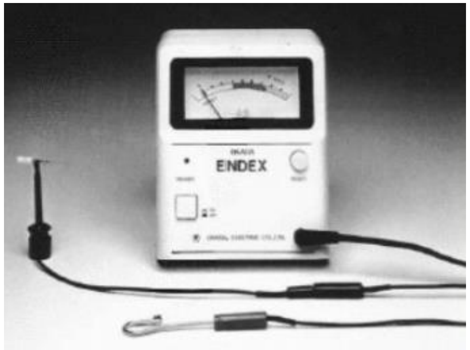
Surgical Planning

What Imaging Modalities are available?

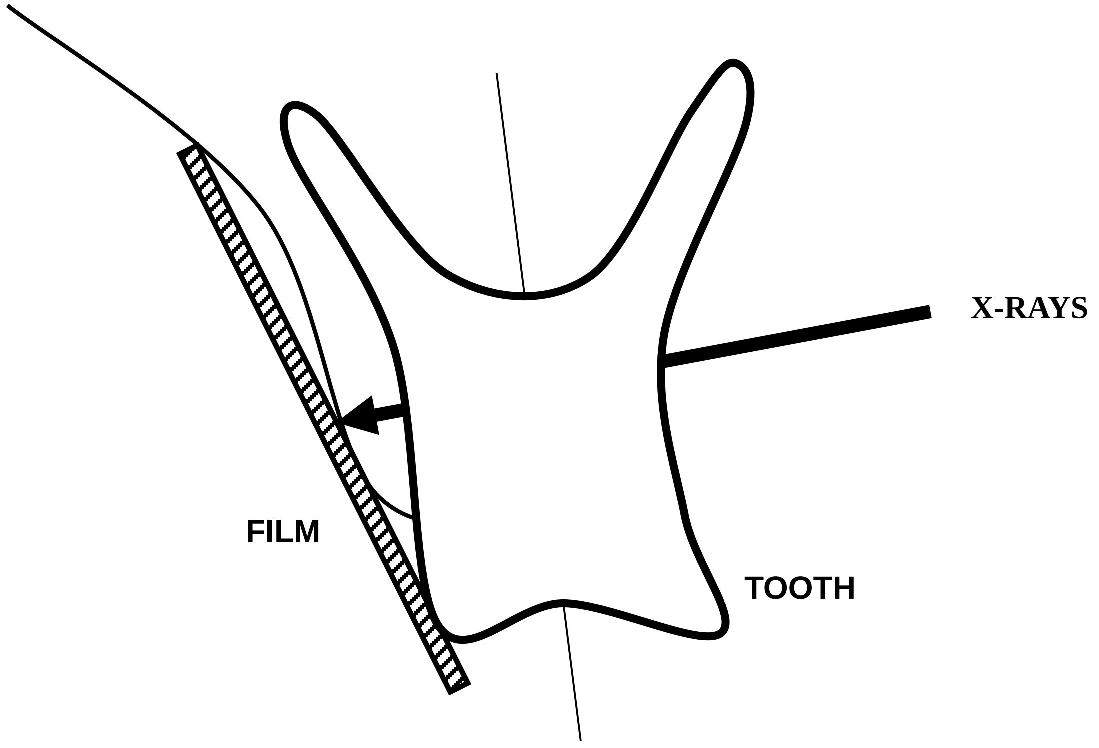
- **Intra-oral radiography**
  - **Periapicals, bitewings, ~~occlusal views~~**
- **Extra-oral radiography**
  - **AP and Lateral cephs**
- **Dental Panoramic Tomography (DPT or OPG)**
- **Cone Beam computed tomography (CBCT)**

Intra-oral Imaging

- + Very high resolution (20 lp/mm)
- + Fast, convenient, low dose
- – Magnification / Distortion
- – No (quantitative) bone quality
- – Distance measurements not reliable



Distortion in intra-orals



Solutions:

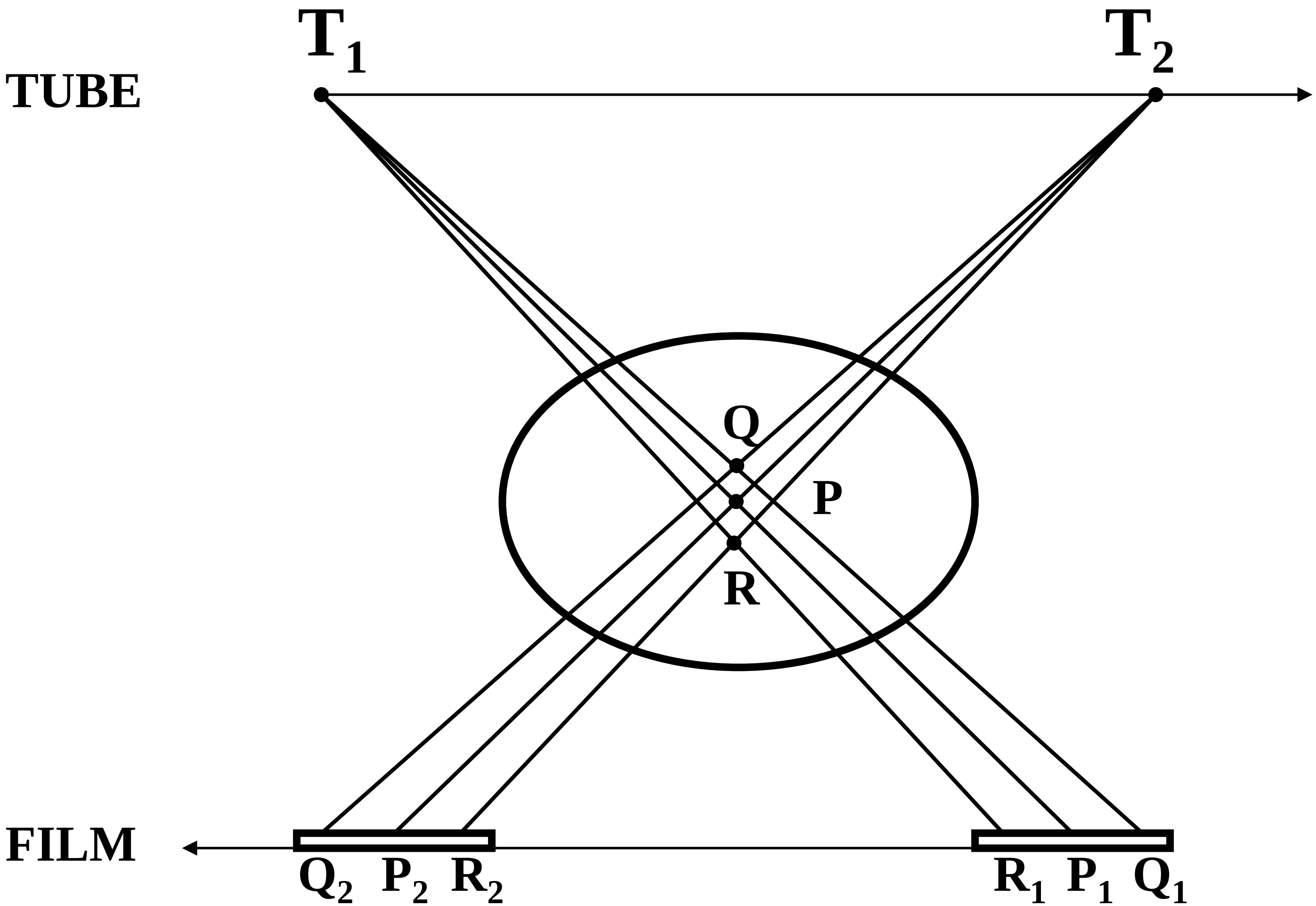
- bisecting angle ✗
- paralleling technique ✓

Extra-oral: Lateral Cephs

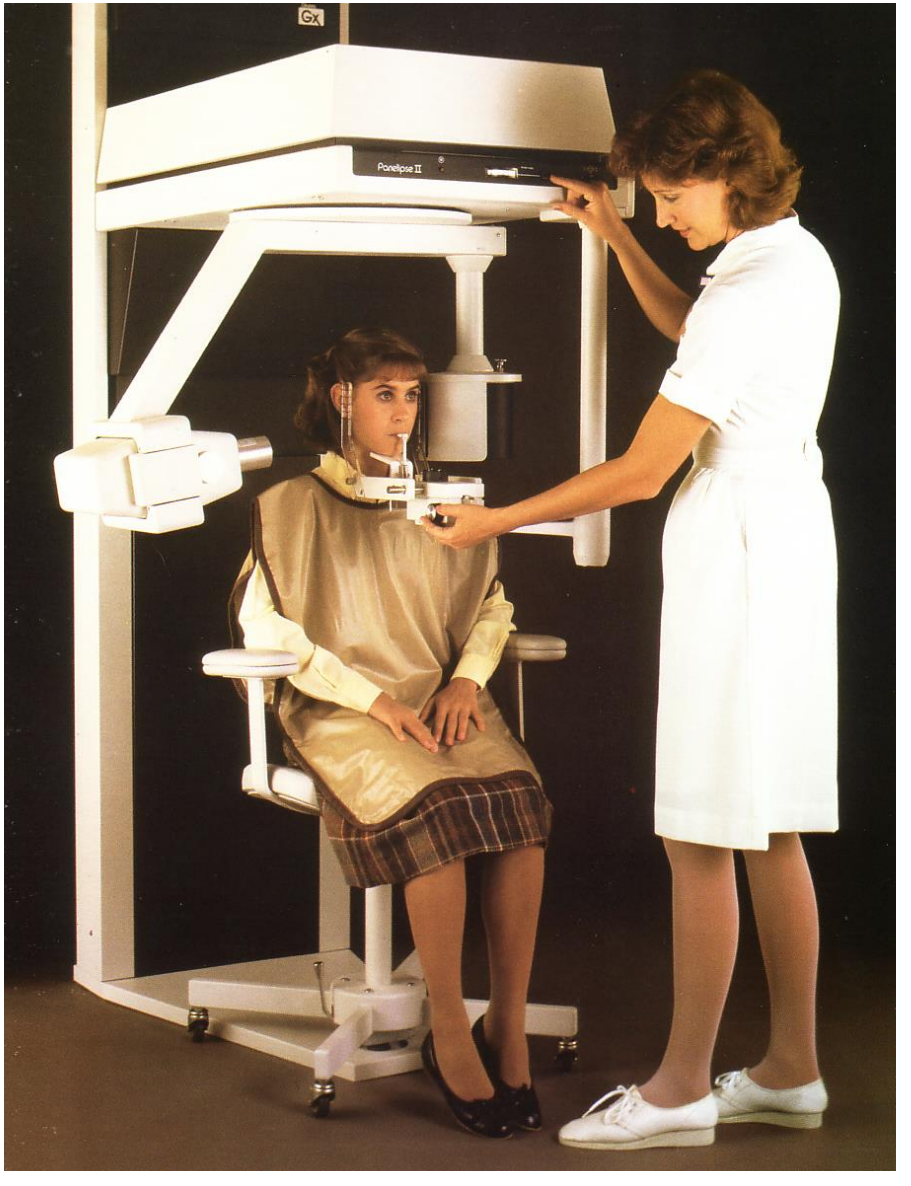
- \+ **Good overview**
- **+ Useful for orthodontics**
- **– Magnification / Distortion**
- **– Distance measurements not reliable**

Conventional Tomography

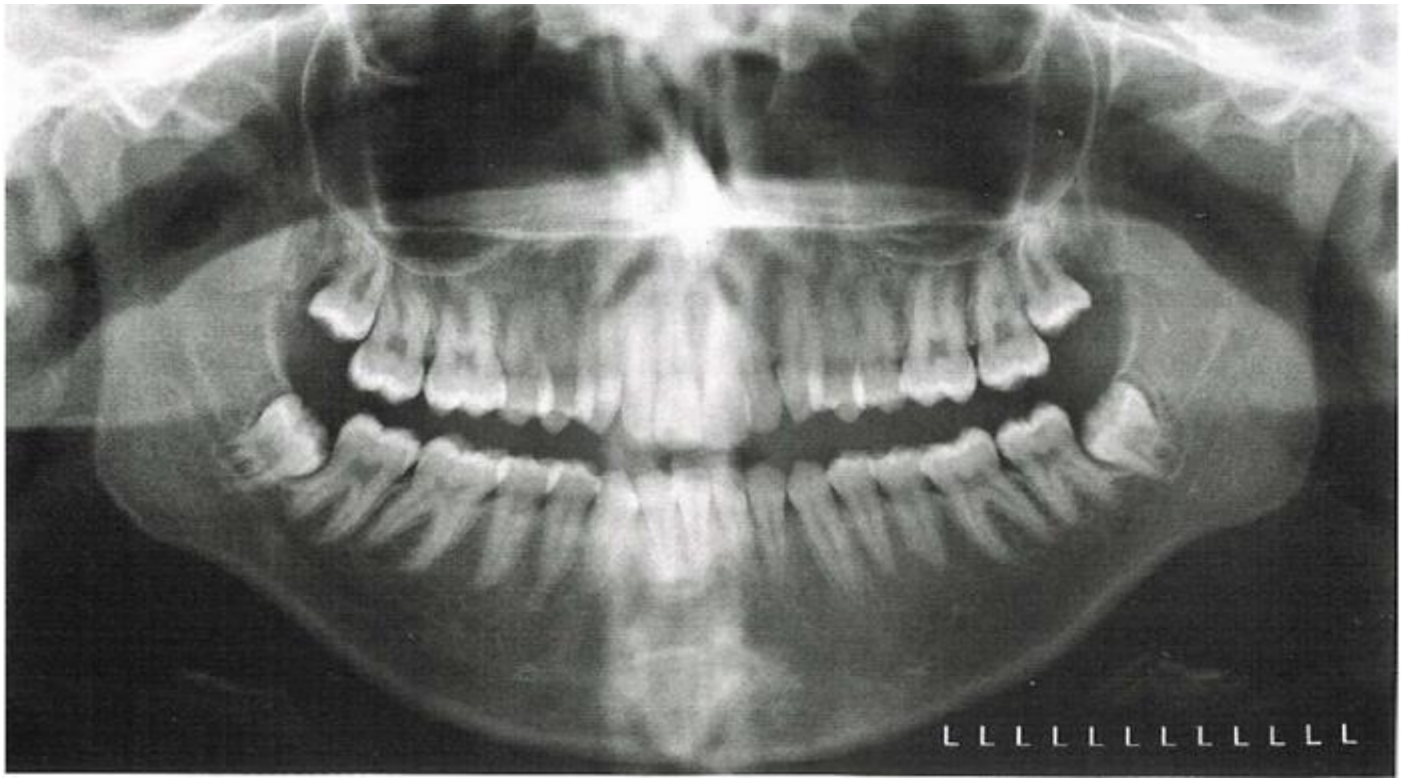
(tomography by blurring)



Dental Panoramic Tomography (DPT)

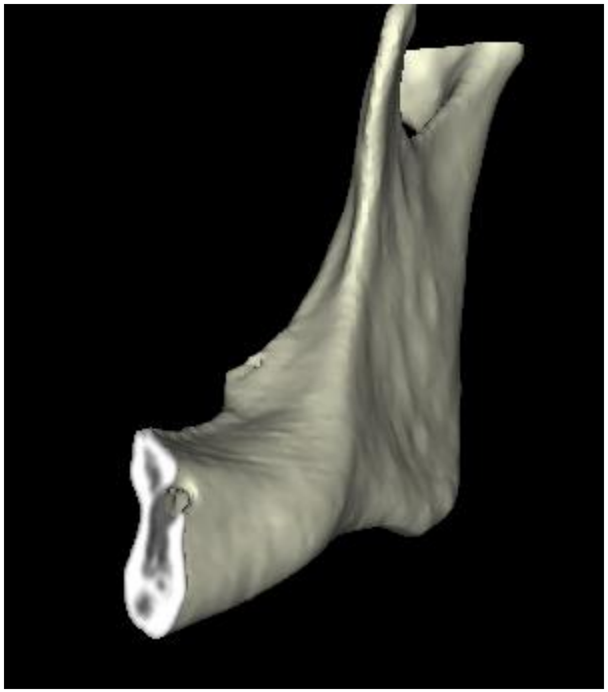


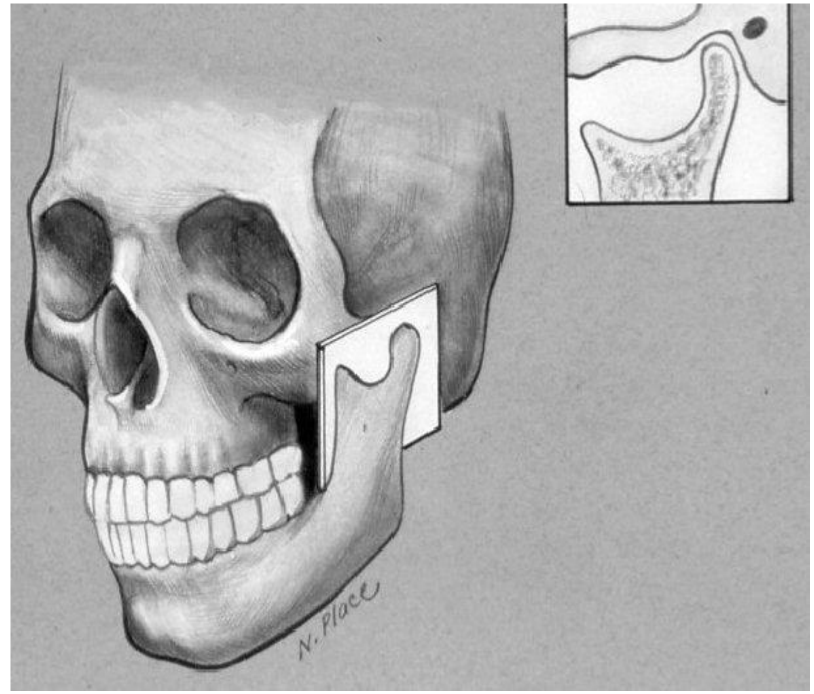
Dental Panoramic Tomography (DPT, OPG, OPT)



- \+ Very good overview
  - \+ Mandibular fractures, unerupted teeth
- \+ Sufficient detail for caries diagnosis
- – Variable Magnification / Distortion
- – Patient positioning is crucial

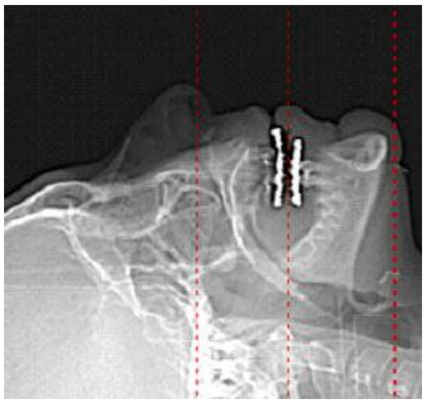
Cross-Sectional Imaging





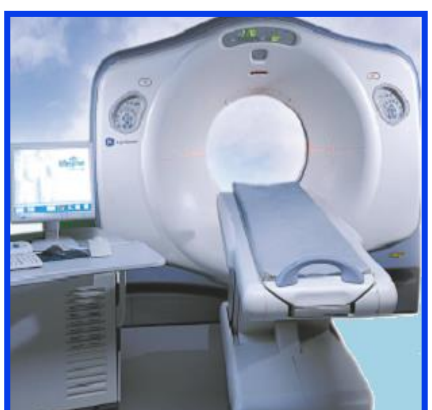
- ~~Linear Tomography~~
- ~~Complex Motion Tomography (CMT)~~
- ~~Ultrasound~~
- ~~Magnetic Resonance Imaging (MRI)~~
- Computed Tomography ~~(CT~~ or CBCT)

Dental (CB)CT Scans



The dentoalveolar region has high natural contrast

So we can get away with
- high resolution images
- low radiation dose

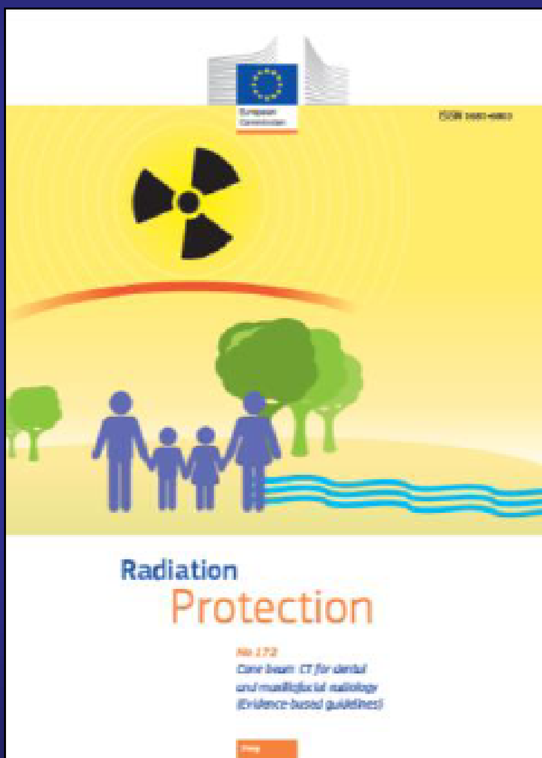


We can reduce the dose and get away with images that would not be acceptable for a medical CT scan.

- **CBCT is useful for:**
  - **planning dental implants**
  - **maxillofacial surgery**
  - **cleft palate assessment**
  - **TMJ and airway analysis**
  - **impacted, supernumerary and abnormal teeth**
  - **root canals, root fractures etc**
  - **periapical disease**

- **CBCT is not good for:**
  - **dental caries**
  - **soft tissue tumours**

Systematic Review of Indications for CBCT



The SEDENTEXCT project (2008-2011)

4.18: Where CBCT images include the teeth, care should be taken to check for periapical disease when performing a clinical evaluation (report).

GP

4.19: CBCT is not indicated as a standard method for demonstration of root canal anatomy.

GP

4.20: Limited volume, high resolution CBCT may be indicated, for selected cases where conventional intraoral radiographs provide information on root canal anatomy which is equivocal or inadequate for planning treatment, most probably in multi-rooted teeth.

GP

4.21: Limited volume, high resolution CBCT may be indicated for selected cases when planning surgical endodontic procedures. The decision should be based upon potential complicating factors, such as the proximity of important anatomical structures.

GP

4.22: Limited volume, high resolution CBCT may be indicated in selected cases of suspected, or established, inflammatory root resorption or internal resorption, where three-dimensional information is likely to alter the management or prognosis of the tooth.

D

4.33: Limited volume, high resolution CBCT may be justifiable for selected cases, where endodontic treatment is complicated by concurrent factors, such as resorption lesions, combined periodontal/endodontic lesions, perforations and atypical pulp anatomy.

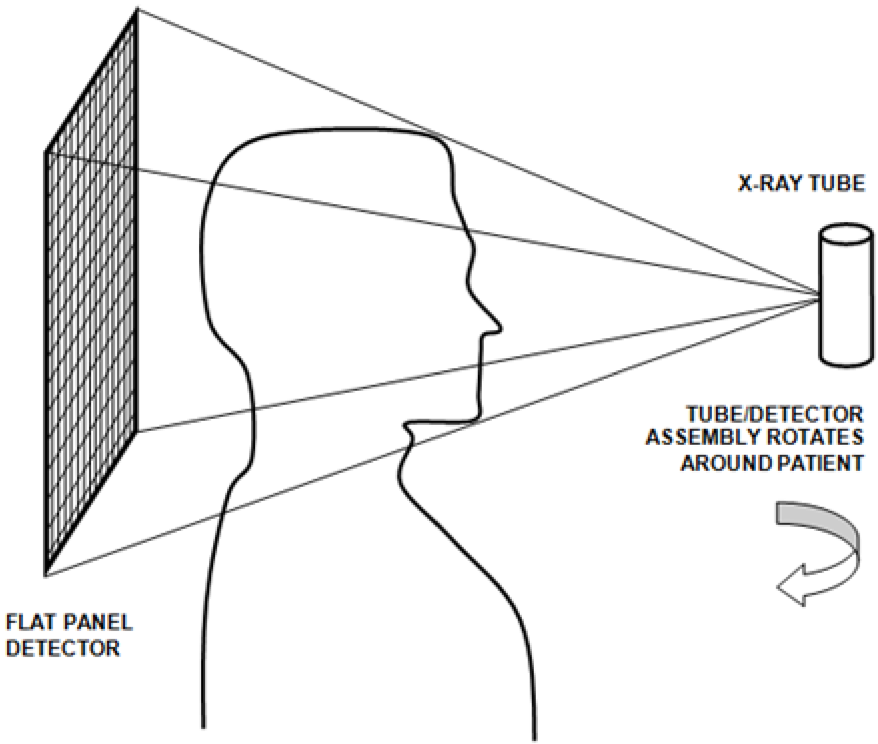
C

4.34: Limited volume, high resolution CBCT is indicated in the assessment of dental trauma (suspected root fracture) in selected cases, where conventional intraoral radiographs provide inadequate information for treatment planning.

B

Prof Keith Horner

Cone Beam CT (CBCT) Scanner



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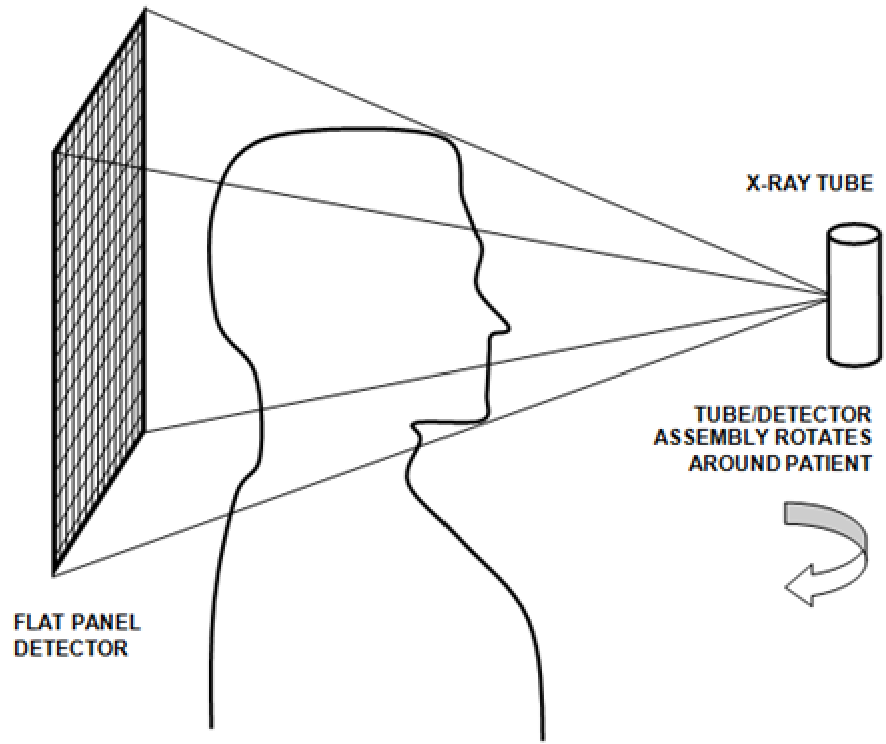
Cone Beam CT (CBCT) Scanner



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ELSEVIER
SAUNDERS

(Review Paper)

THE DENTAL CLINICS OF NORTH AMERICA

Dent Clin N Am 52 (2008) 707–730

What is Cone-Beam CT and How Does it Work?

William C. Scarfe, BDS, FRACDS, MS[a,*],
Allan G. Farman, BDS, PhD, DSc, MBA[b]

[a] *Department of Surgical/Hospital Dentistry, University of Louisville School of Dentistry, Room 222G, 501 South Preston Street, Louisville, KY 40292, USA*
[b] *Department of Surgical/Hospital Dentistry, University of Louisville School of Dentistry, Room 222C, 501 South Preston Street, Louisville, KY 40292, USA*

Int. J. Oral Maxillofac. Surg. 2009; 38: 609–625
doi:10.1016/j.ijom.2009.02.028, available online at http://www.sciencedirect.com

International Journal of
Oral & Maxillofacial Surgery

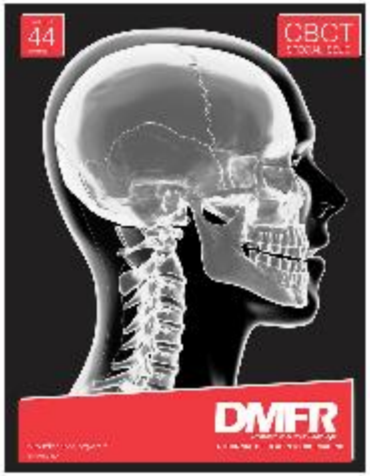
Invited Review Paper

Imaging

Cone-beam computerized tomography (CBCT) imaging of the oral and maxillofacial region: A systematic review of the literature

W. De Vos[1], **J. Casselman**[2,3], **G. R. J. Swennen**[1,3]

[1]Division of Maxillo-Facial Surgery, Department of Surgery, General Hospital St-Jan Bruges, Ruddershove 10, 8000 Bruges, Belgium; [2]Department of Radiology and Medical Imaging, General Hospital St-Jan Bruges, Ruddershove 10, 8000 Bruges, Belgium; [3]3-D Facial Imaging Research Group, (3-D FIRG), GH St-Jan, Bruges and Radboud University, Nijmegen, 3-D FIRG, Ruddershove 10, 8000 Bruges, Belgium



DentoMaxilloFacial Radiology

VOLUME 44, ISSUE 1, 2015

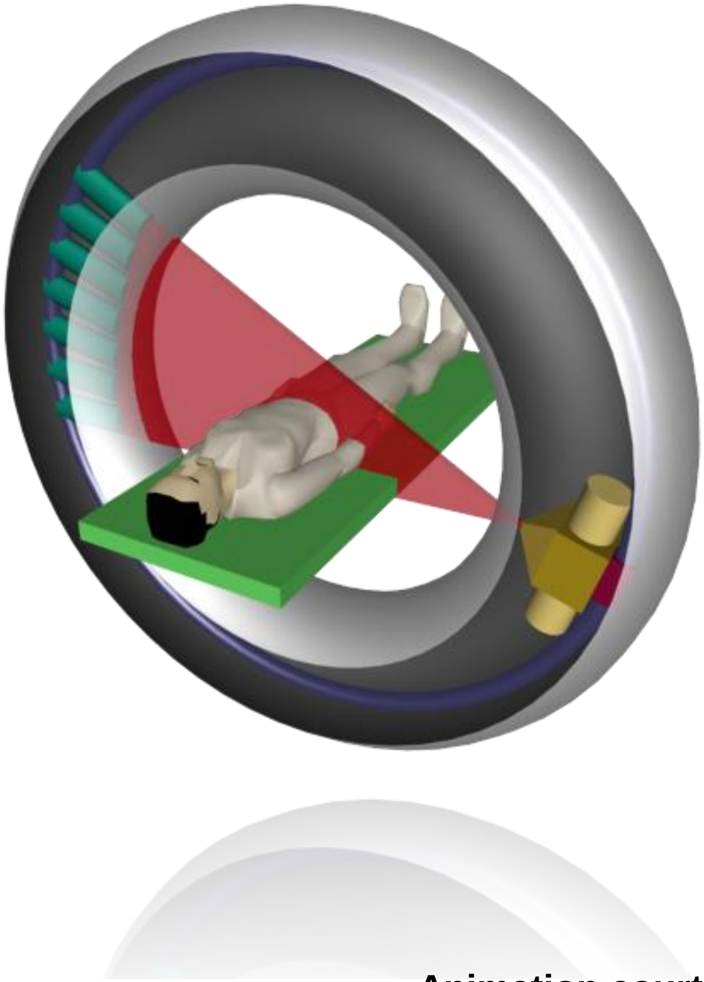
CBCT Special Issue

how CT works…

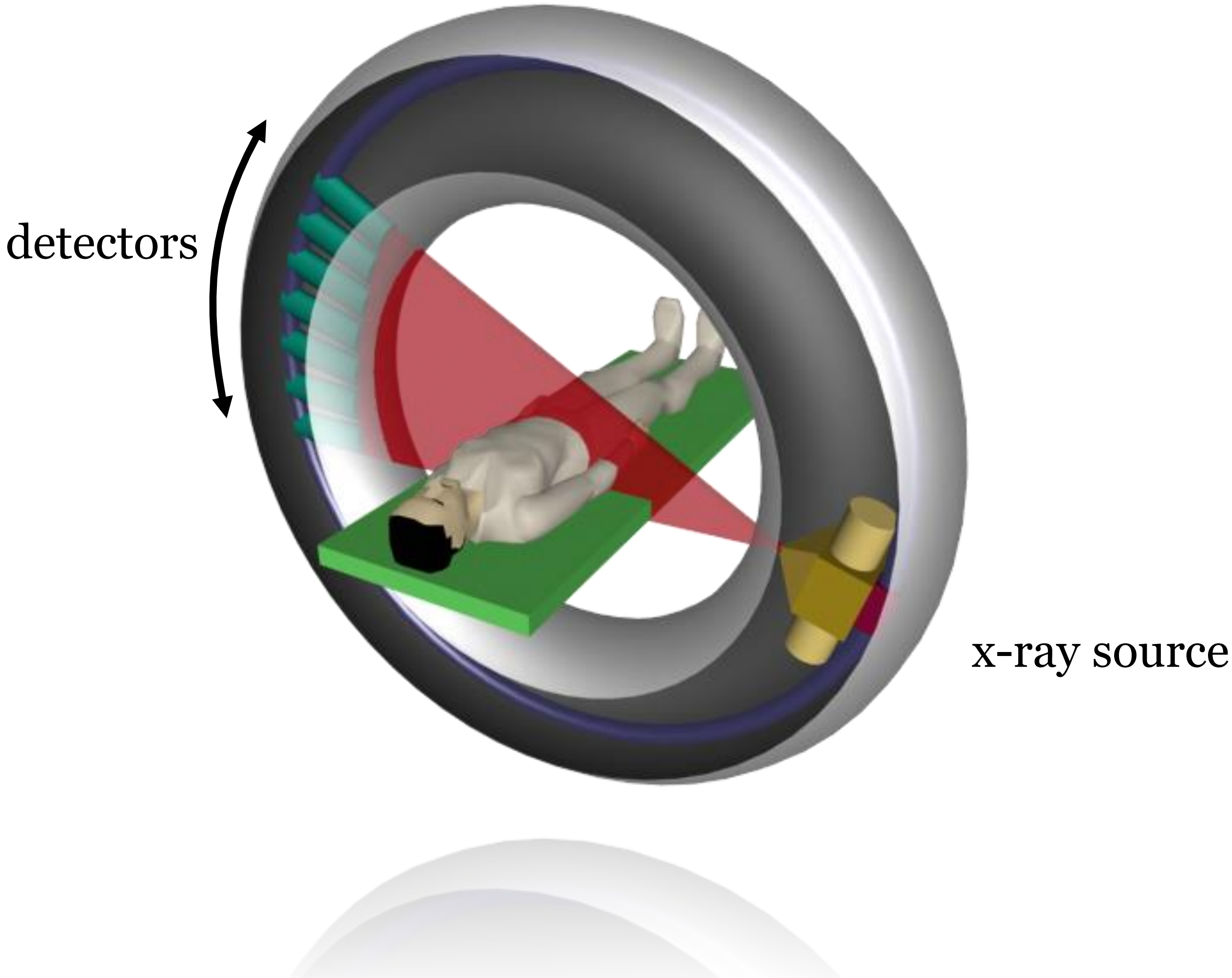
Godfrey Hounsfield

Allan Cormack

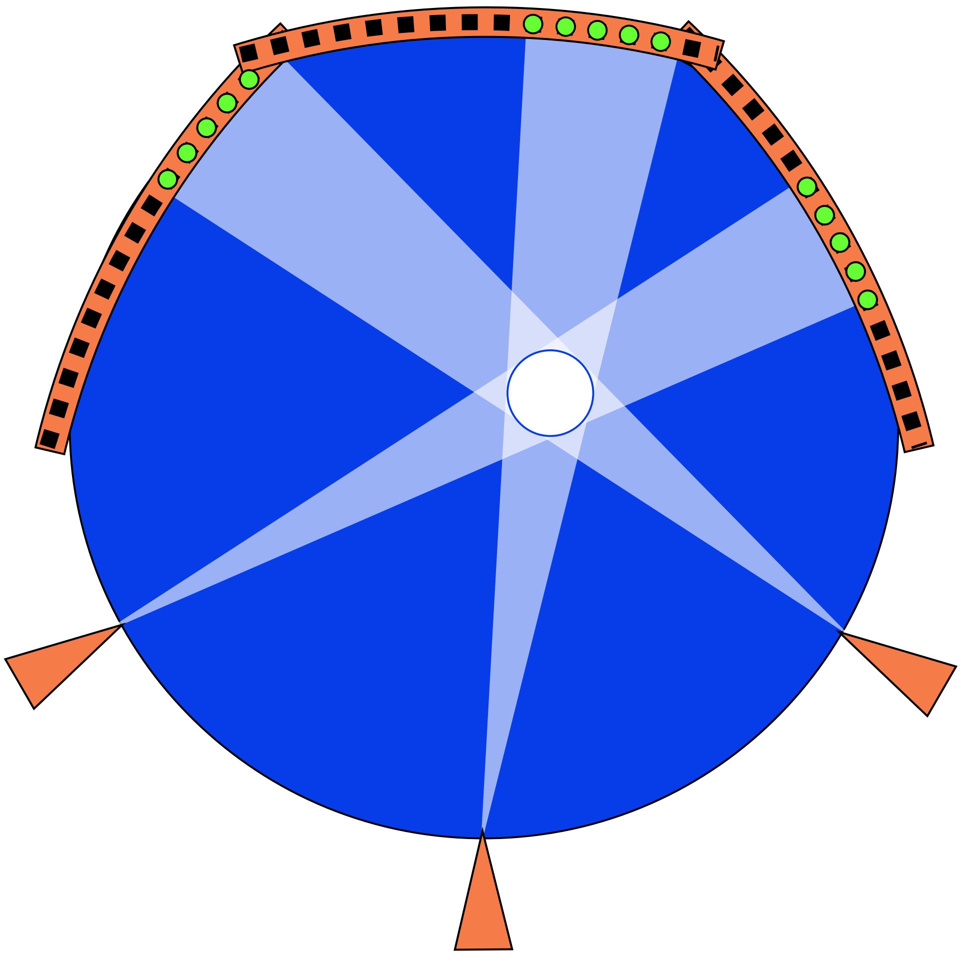
Nobel prize in Medicine, 1979



Animation courtesy of Demetrios J. Halazonetis
www.dhal.com


detectors
x-ray source

reconstruction



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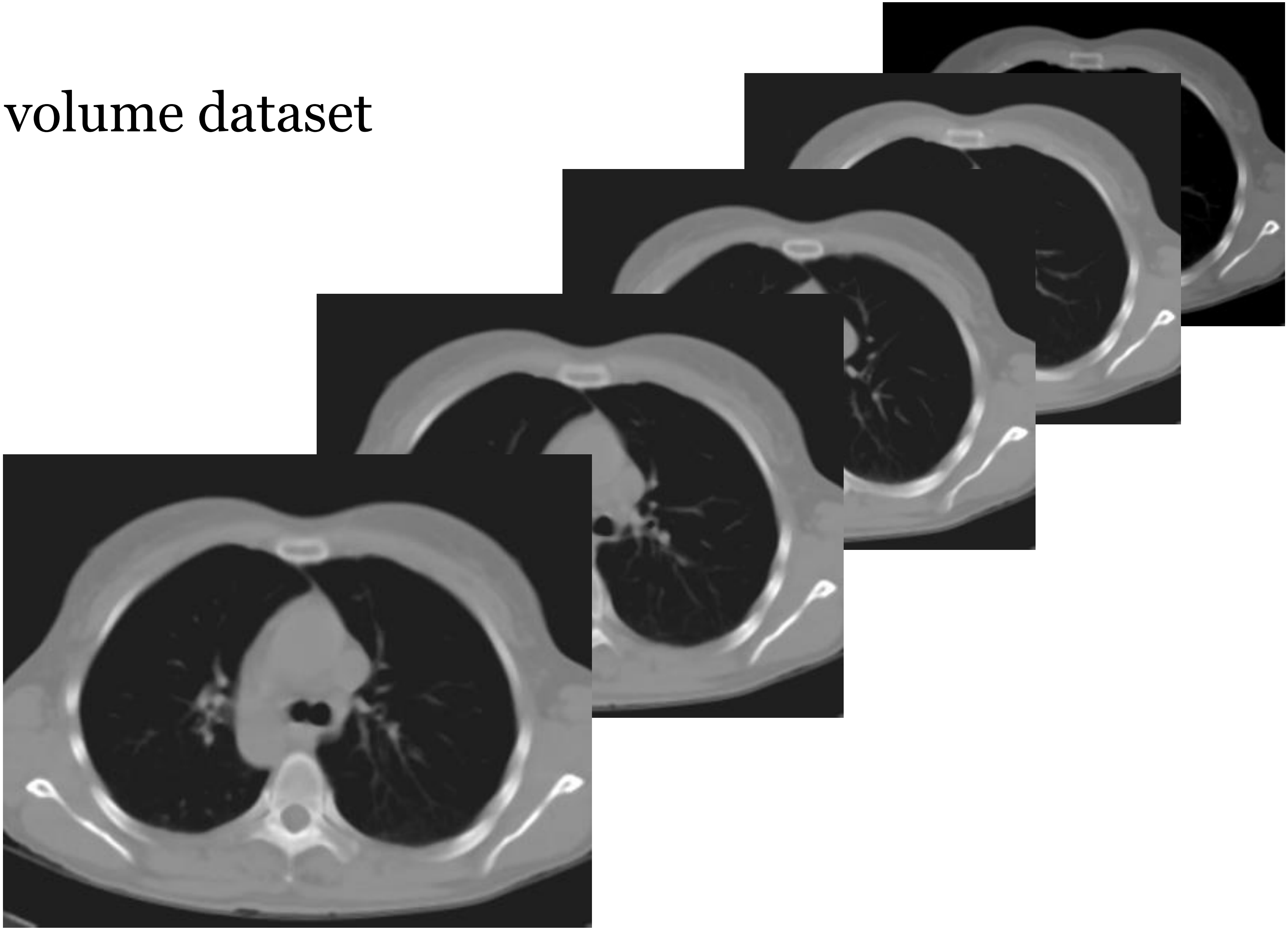
Demetrios J. Halazonetis

volume dataset



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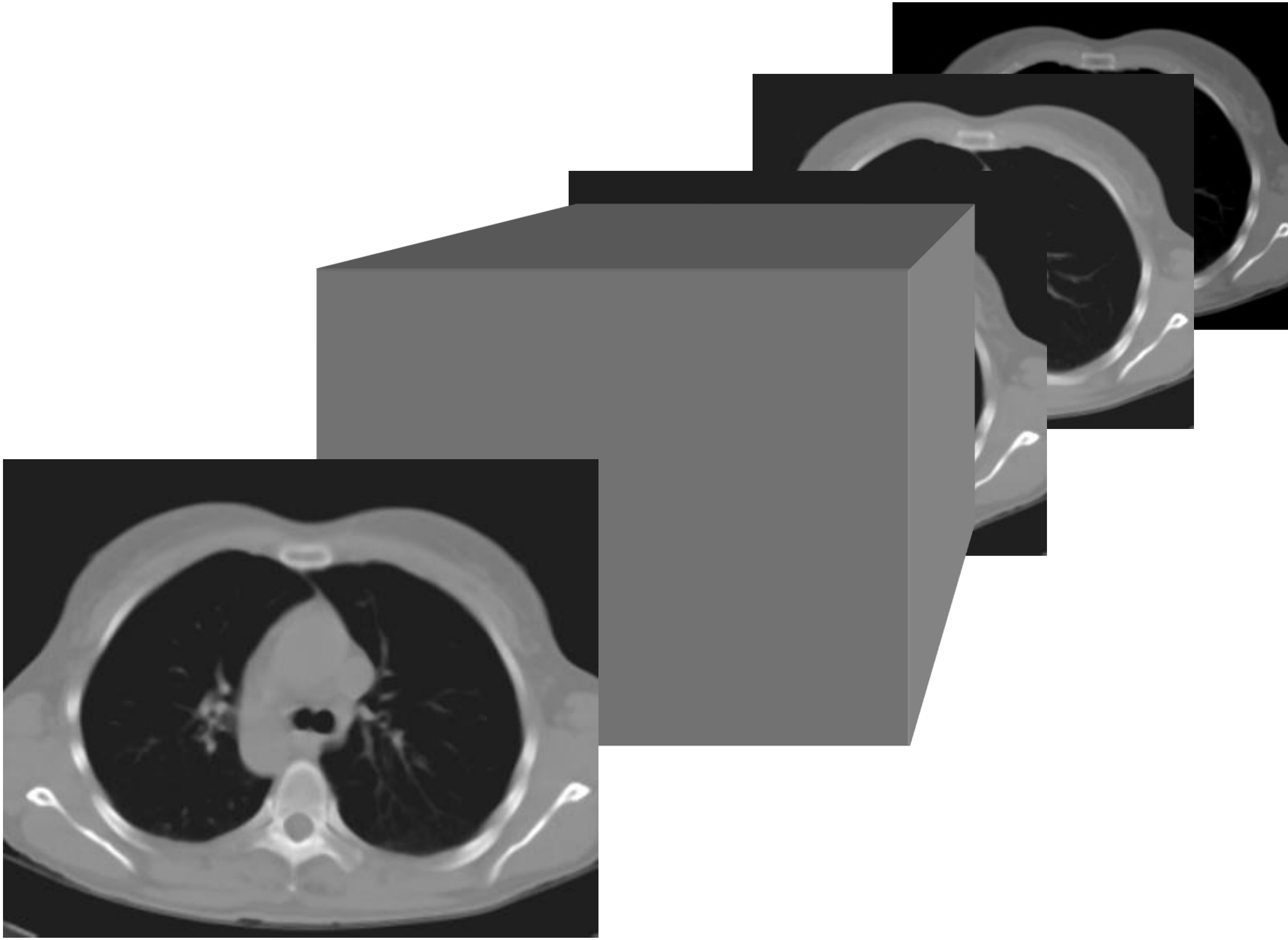

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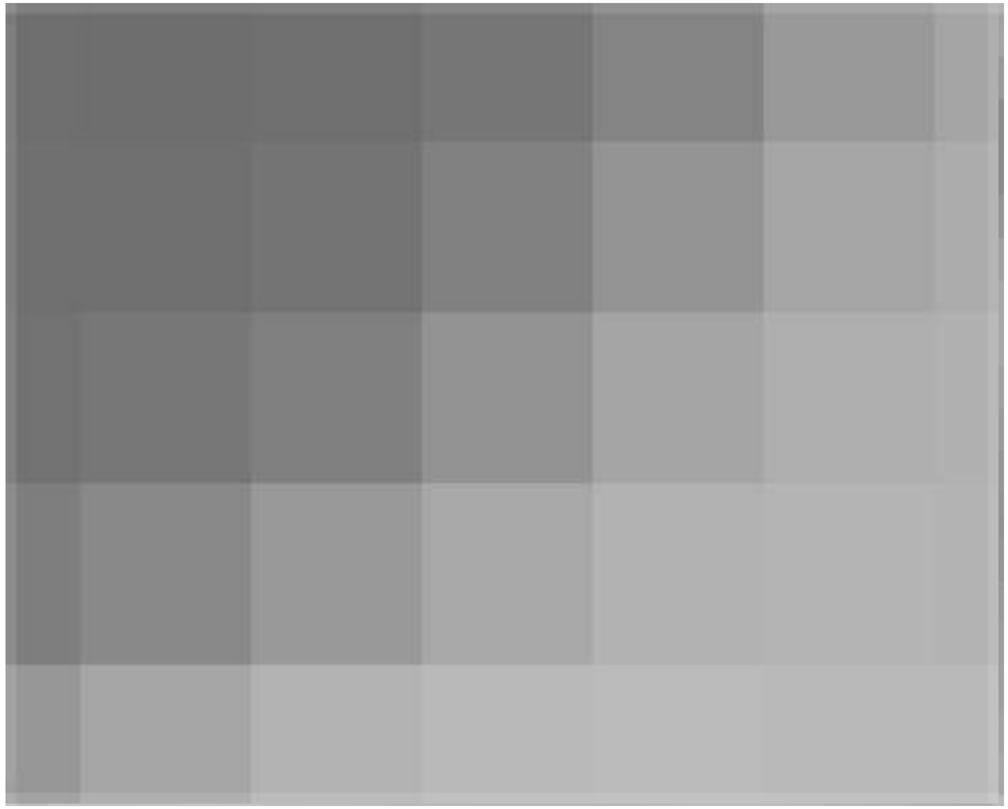

**Animation courtesy of
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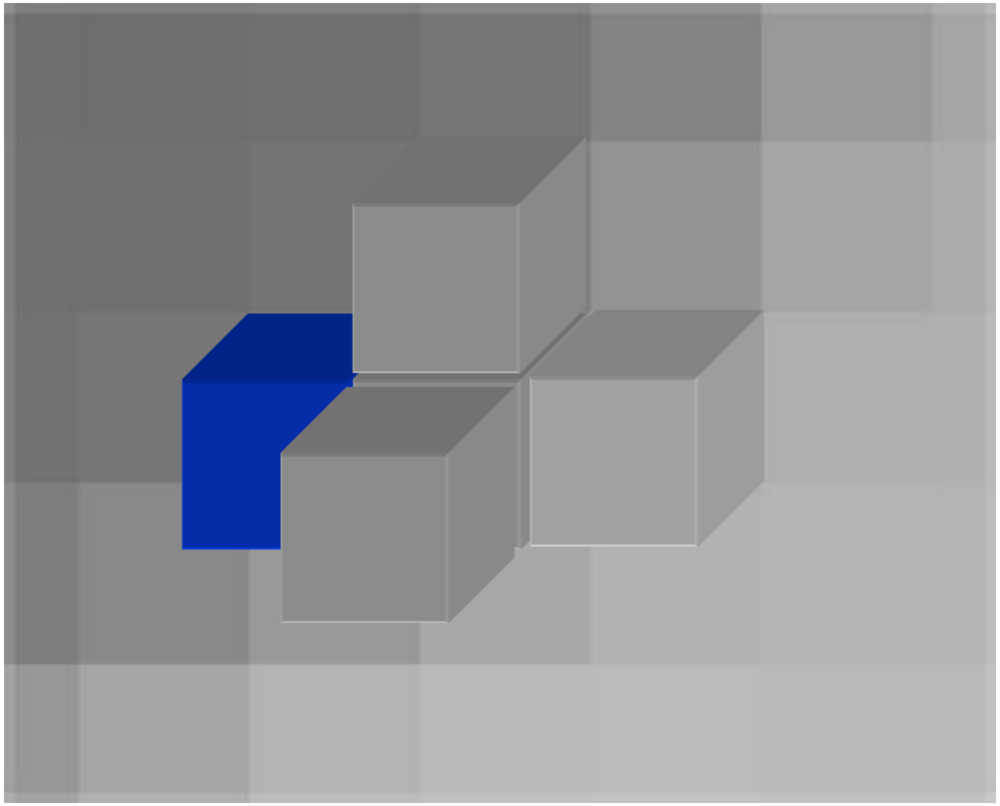
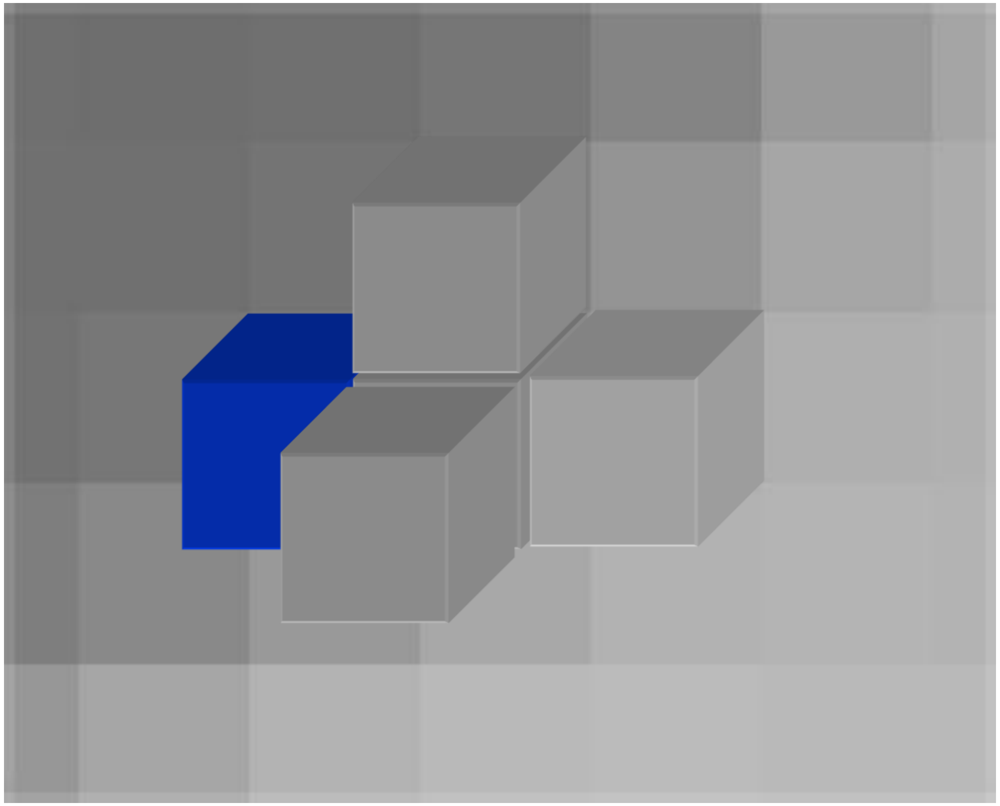


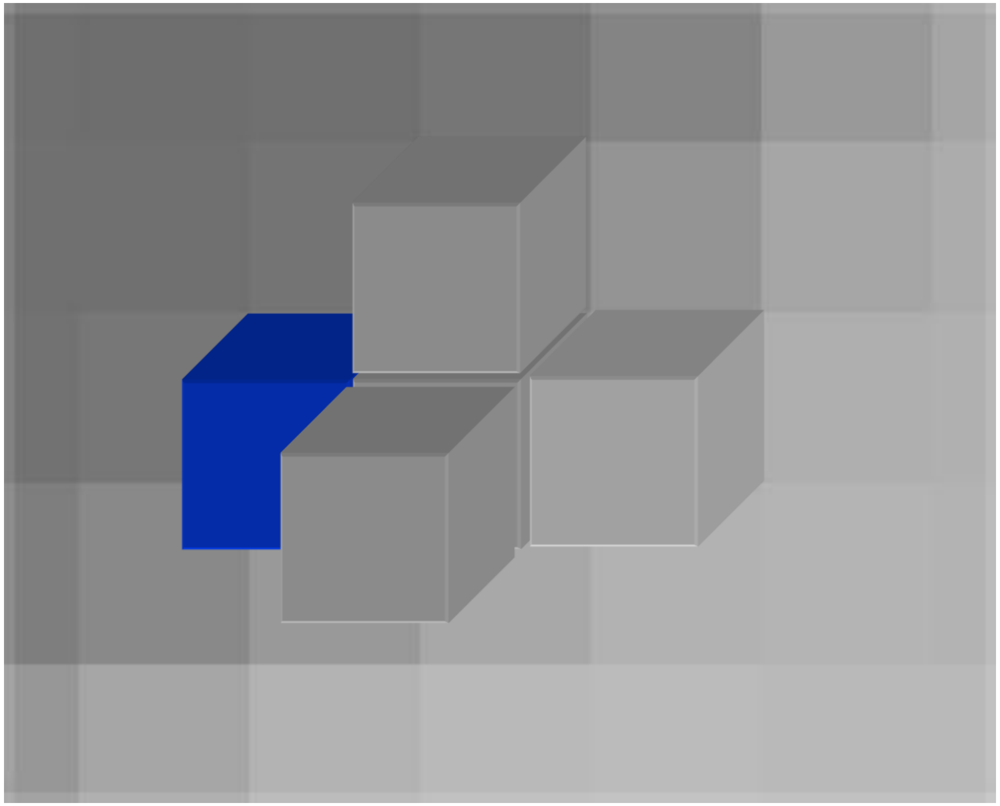
Animation courtesy of
Demetrios J. Halazonetis

Voxels (**Vo**lume **el**ements)



Animation courtesy of
Demetrios J. Halazonetis

Voxels (**Vo**lume **el**ements)

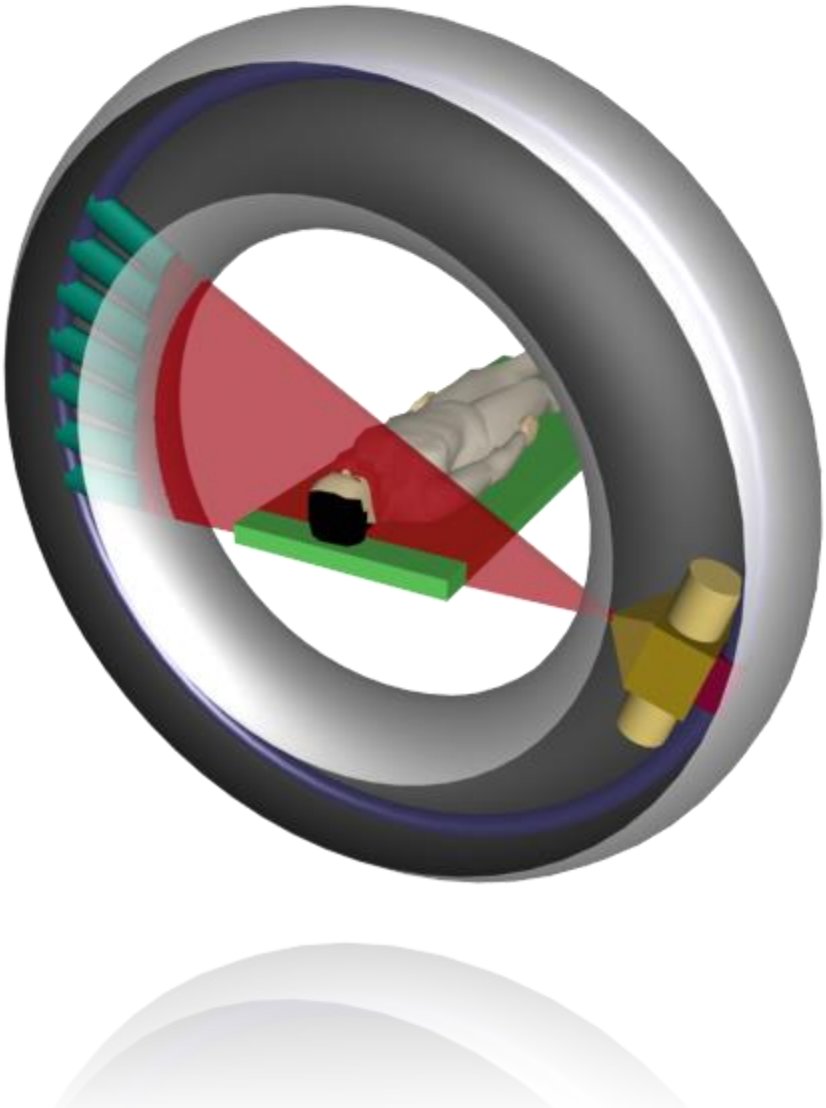


density:
0 - 4095

512 x 512 x 400 slices ≈ 100 million voxels (200 Mb)

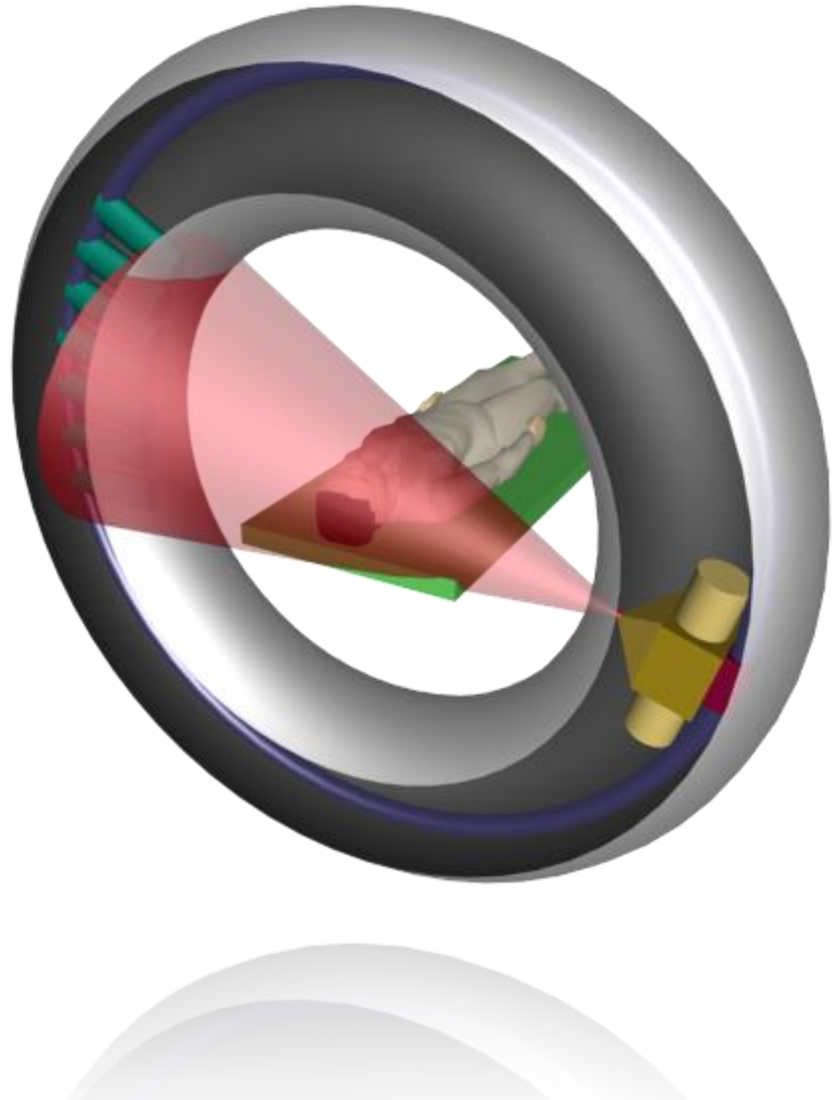
Animation courtesy of Demetrios J. Halazonetis

cone-beam CT (CBCT)



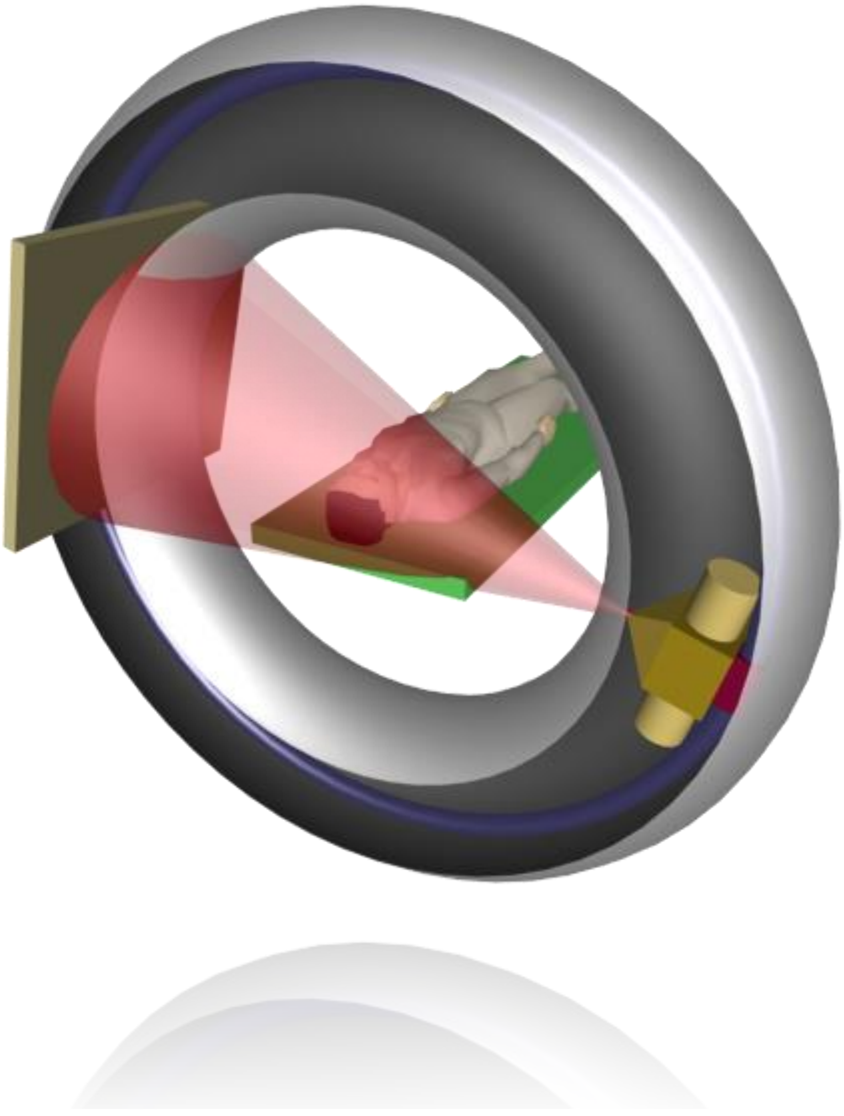
Animation courtesy of Demetrios J. Halazonetis

cone-beam CT (CBCT)



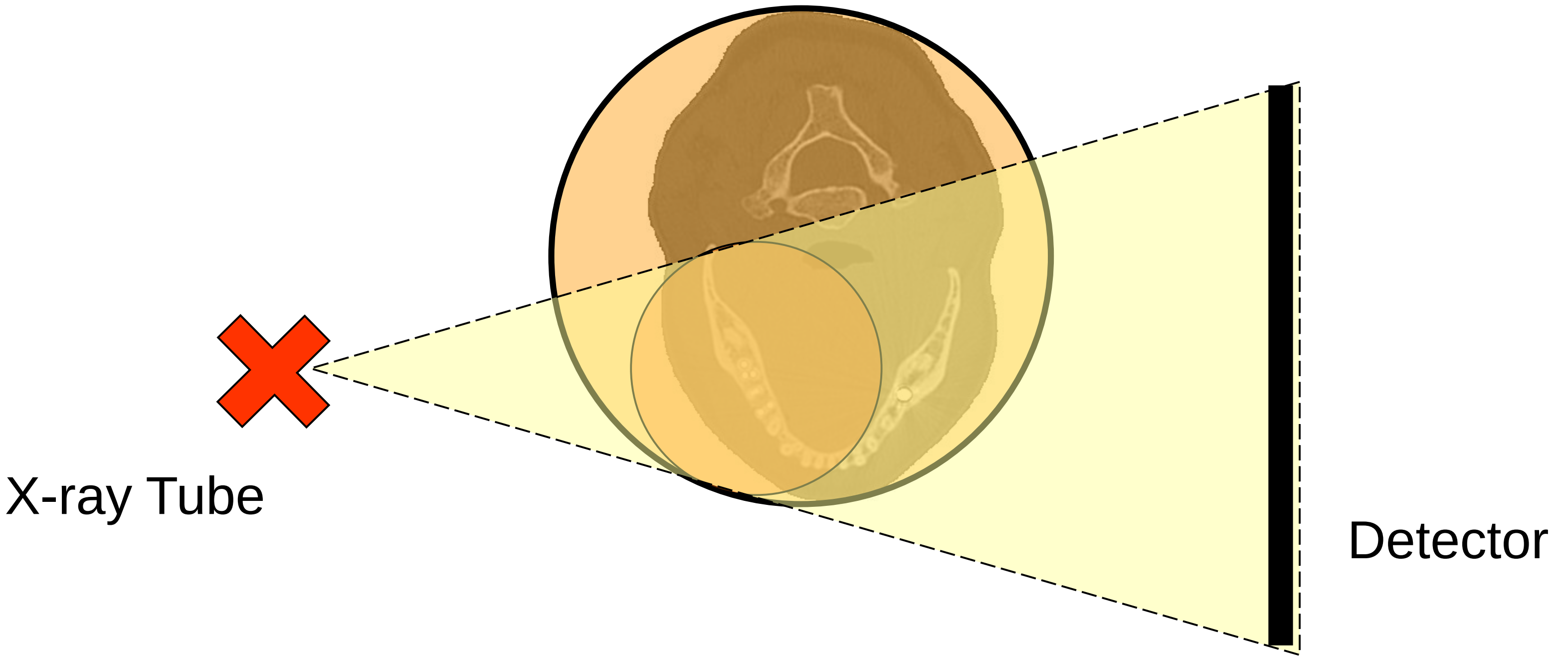
Animation courtesy of Demetrios J. Halazonetis

cone-beam CT
(CBCT)



Animation courtesy of Demetrios J. Halazonetis

cone-beam CT (CBCT)



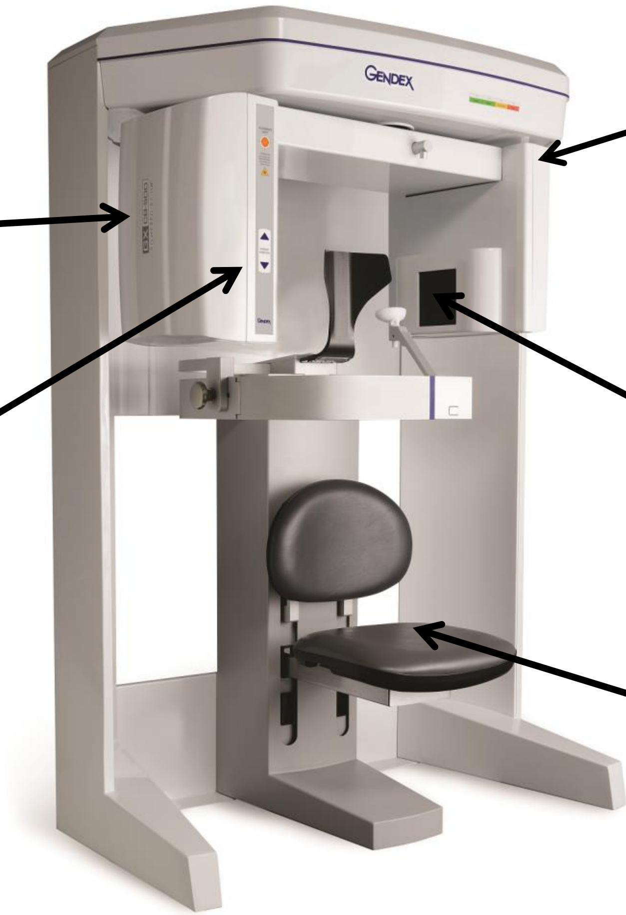
GENDEX Imaging Excellence Since 1893

CB-500 CBCT Scanner

pulsed x-ray tube

adjustable collimator
4 to 8.6 cm height
8.6 or 15.6 cm width

Around £90K



fast scan times
4.8s to 23s

low dose
typical Mx 35µSv
typical Mn 60µSv

large detector
8cm x 8cm

adjustable chair

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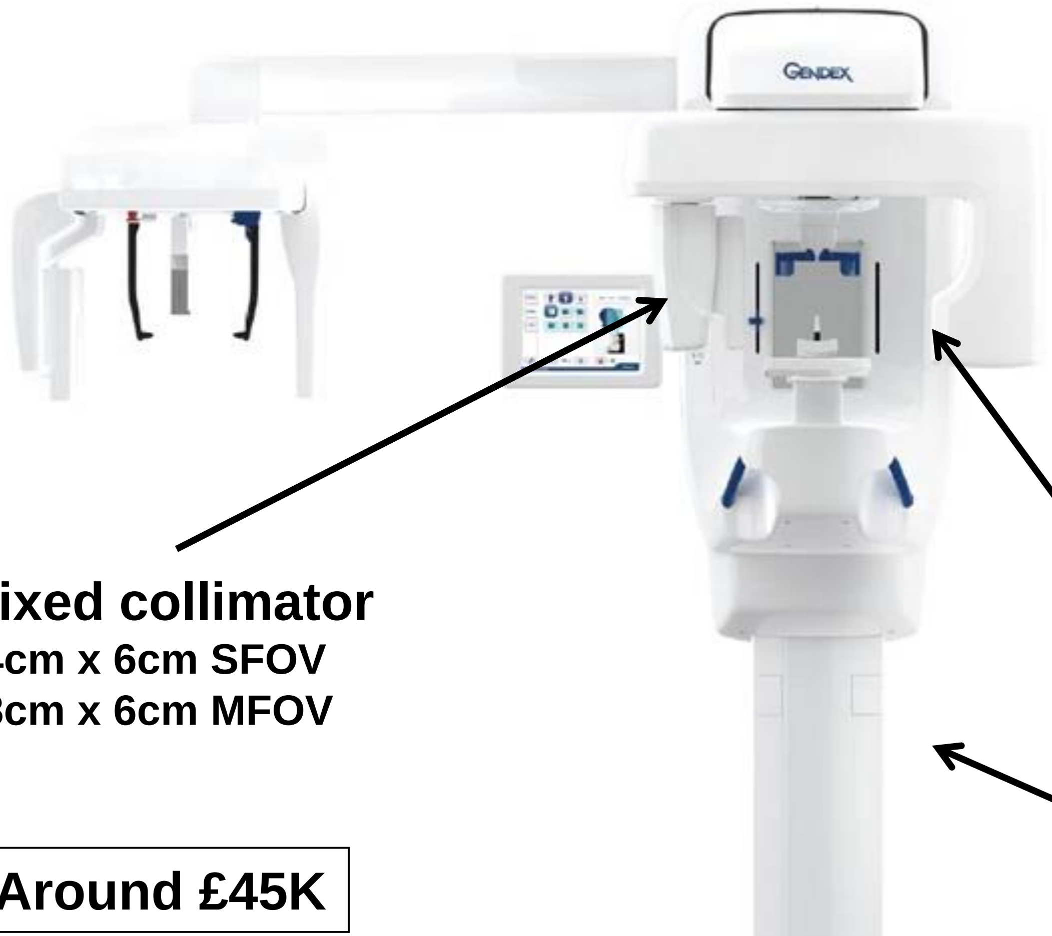
GENDEX
Imaging Excellence Since 1893

DP-700 CBCT Scanner



variable mA
fixed scan times
11s for SFOV
45s for MFOV

medium dose
typical Mx 60µSv
typical Mn 100µSv

fixed collimator
4cm x 6cm SFOV
8cm x 6cm MFOV

small detector

no chair

Around £45K

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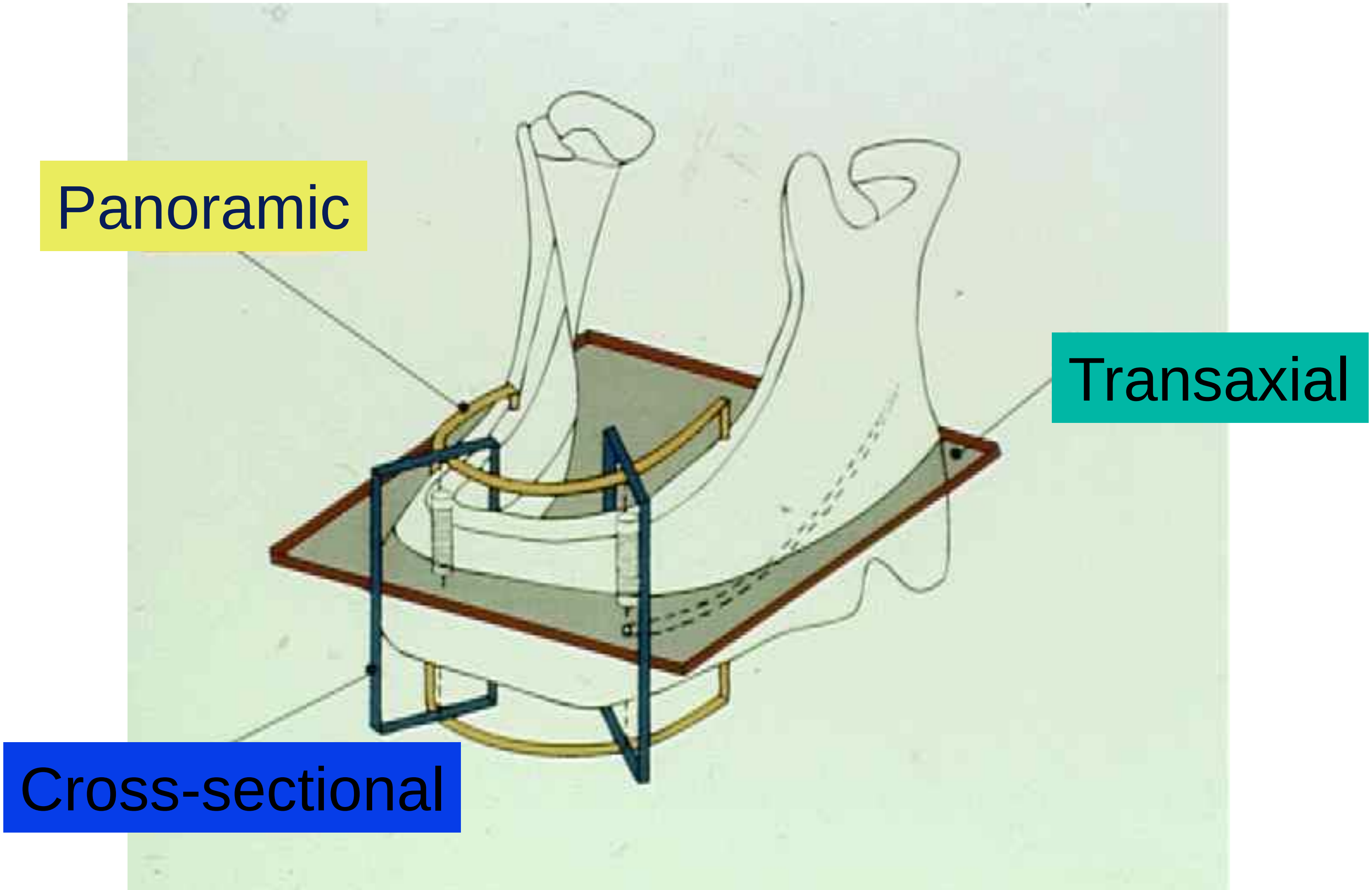
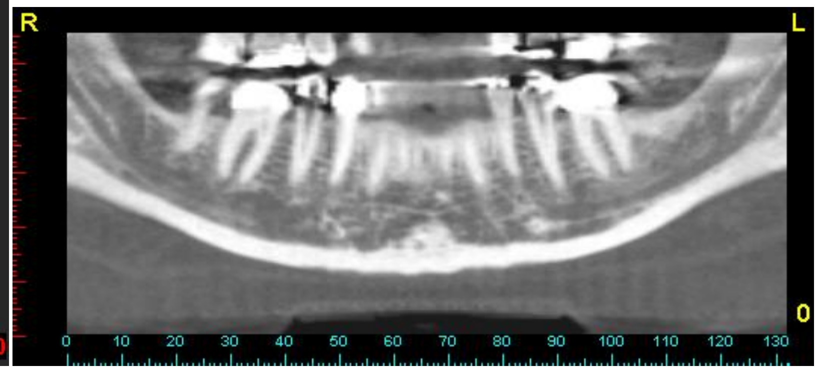
Basic CBCT images



Basic CBCT images

Axials



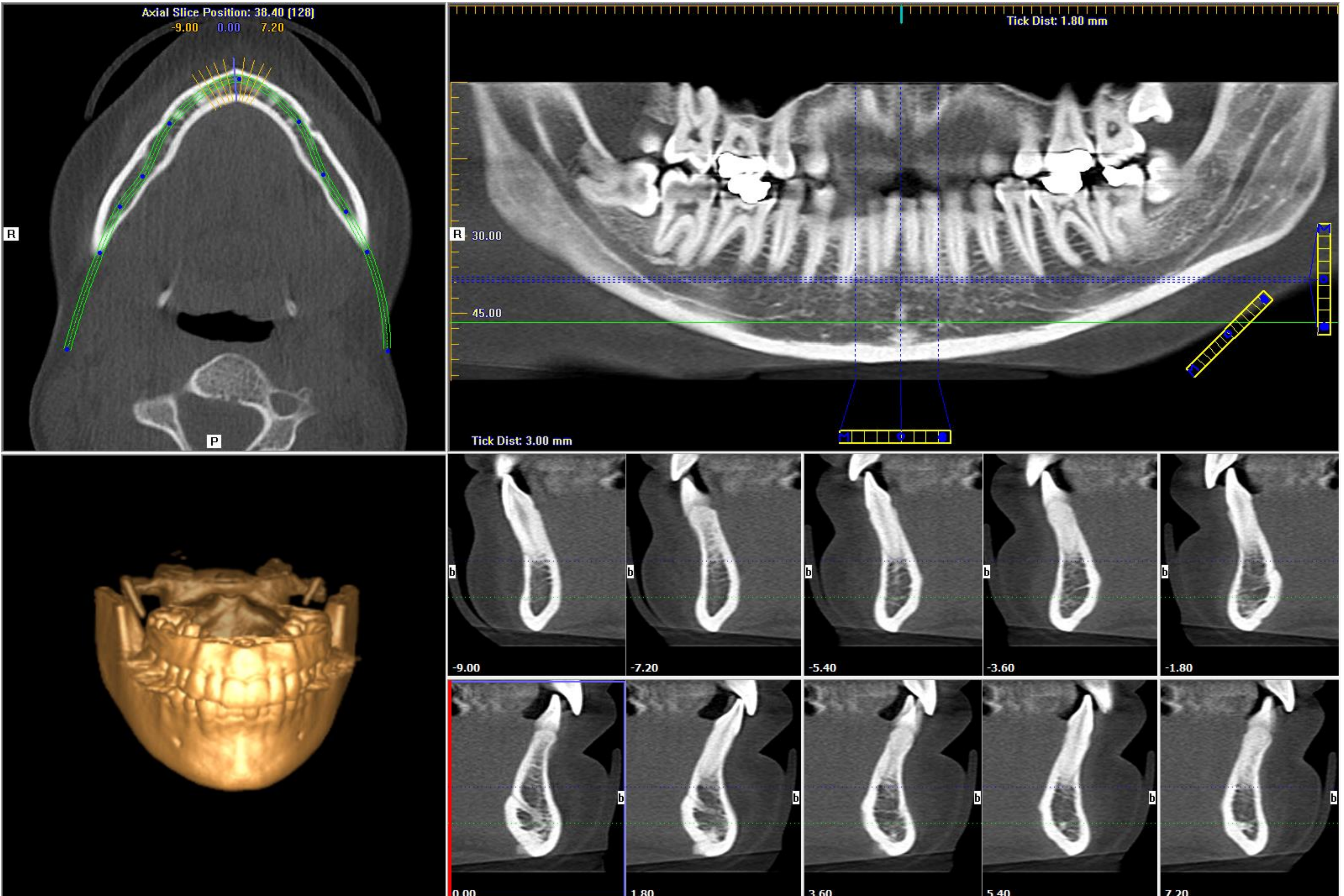
Panoramics

Cross Sections

Sagittal

Coronal

i-CATVision™


Axial Slice Position: 38.40 (128)
-9.00 0.00 7.20
R
P
Tick Dist: 1.80 mm
R
30.00
45.00
Tick Dist: 3.00 mm
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-5.40
-3.60
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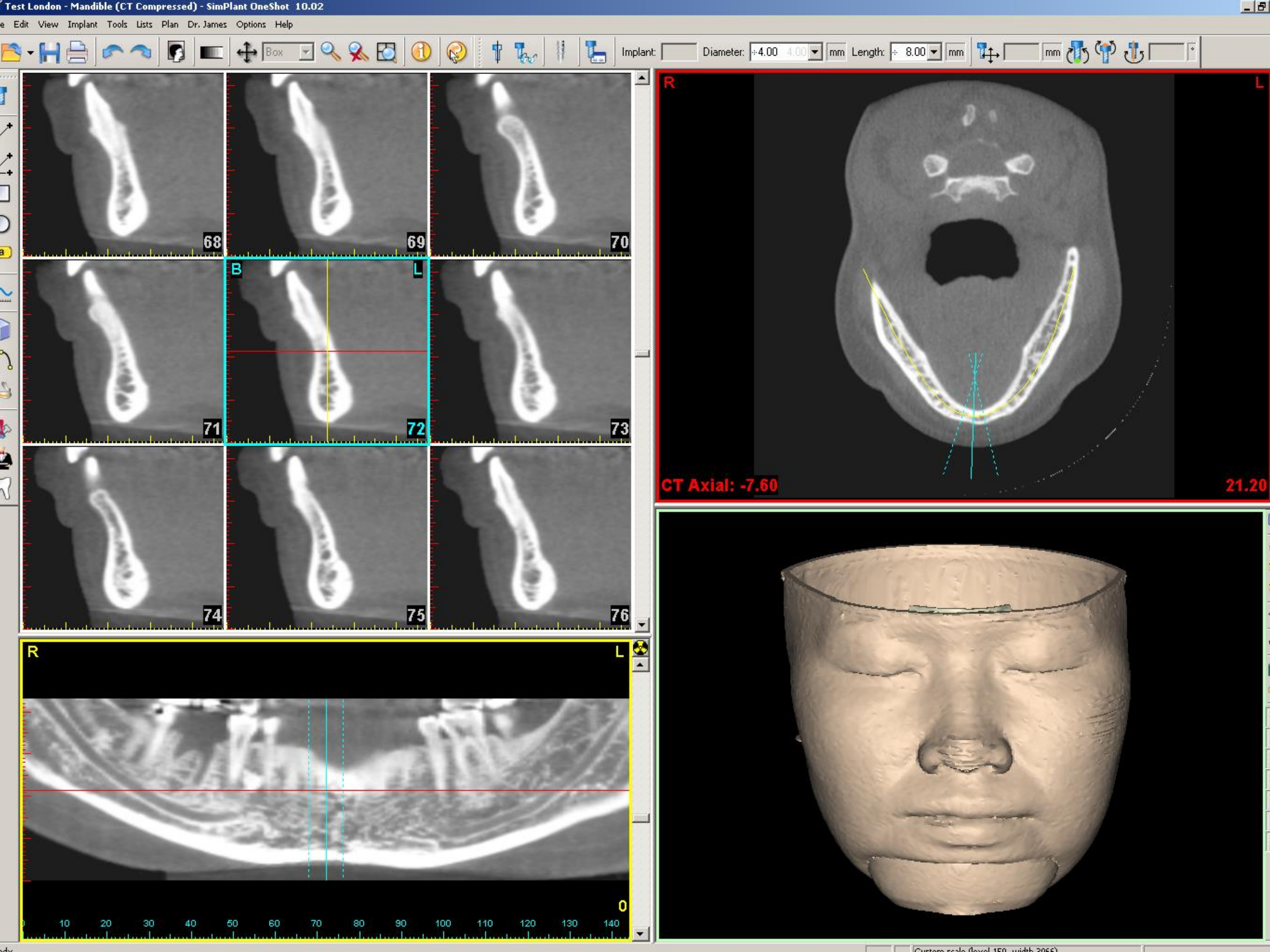

Test London - Mandible (CT Compressed) - SimPlant OneShot 10.02
Edit View Implant Tools Lists Plan Dr. James Options Help
Box
Implant:
Diameter: 4.00
mm
Length: 8.00
mm
mm
68
69
70
B
L
71
72
73
74
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76
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CT Axial: -7.60
21.20
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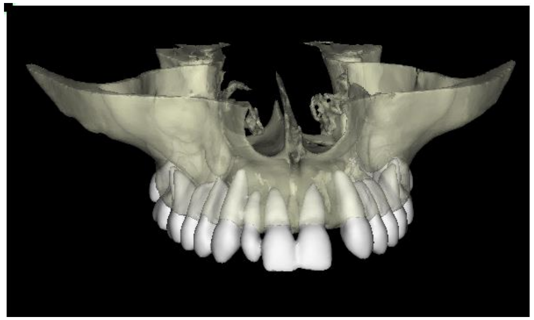
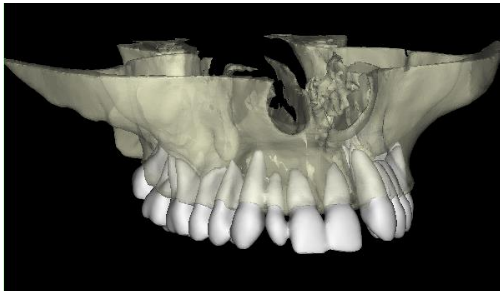
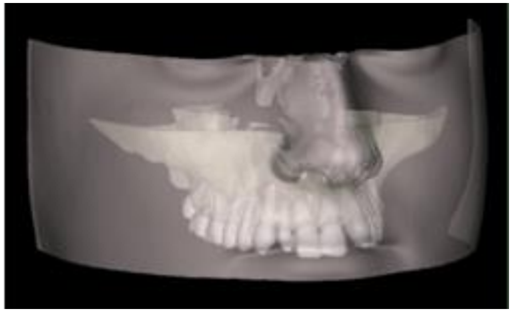
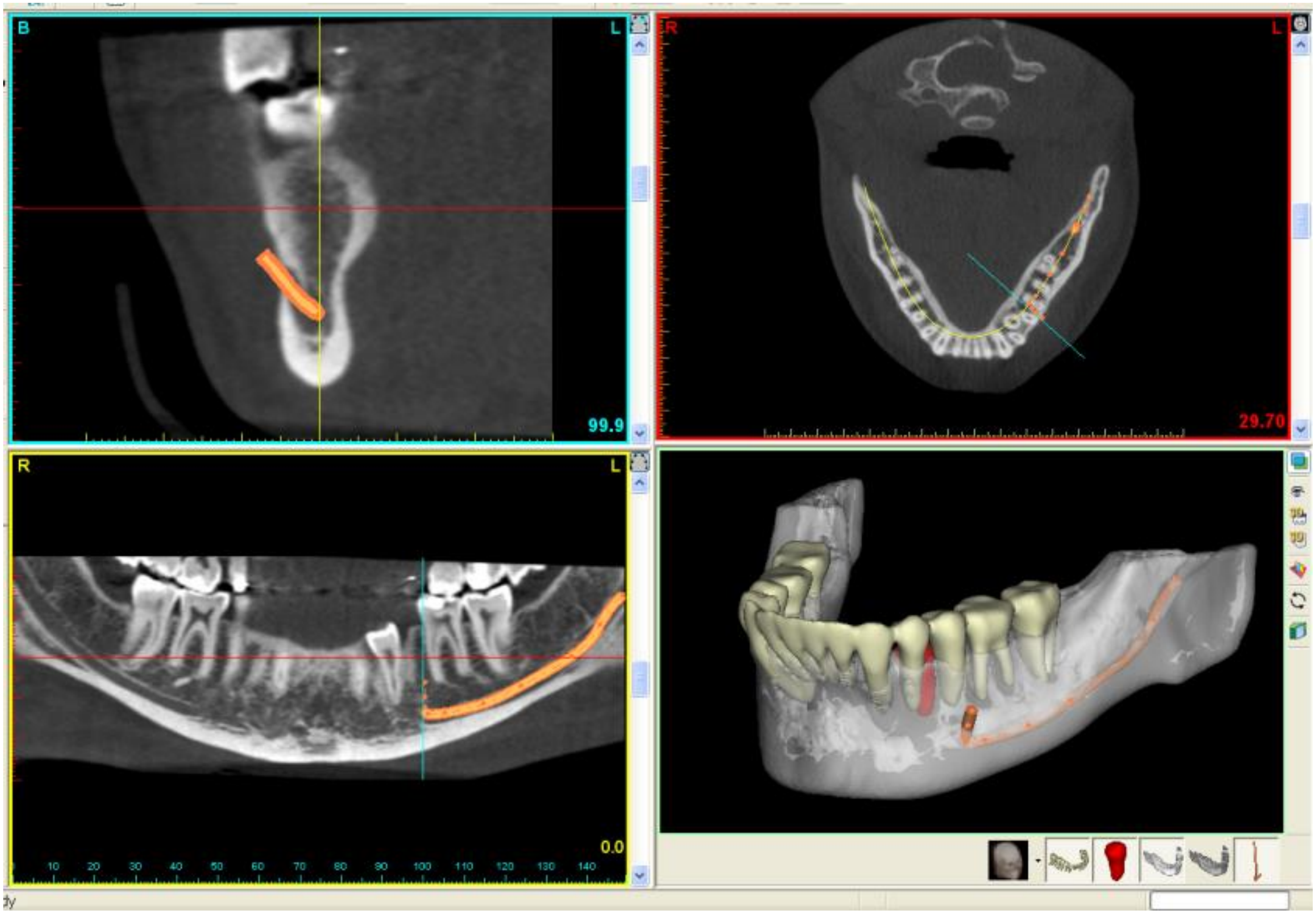
10 20 30 40 50 60 70 80 90 100 110 120 130 140

Segmentation









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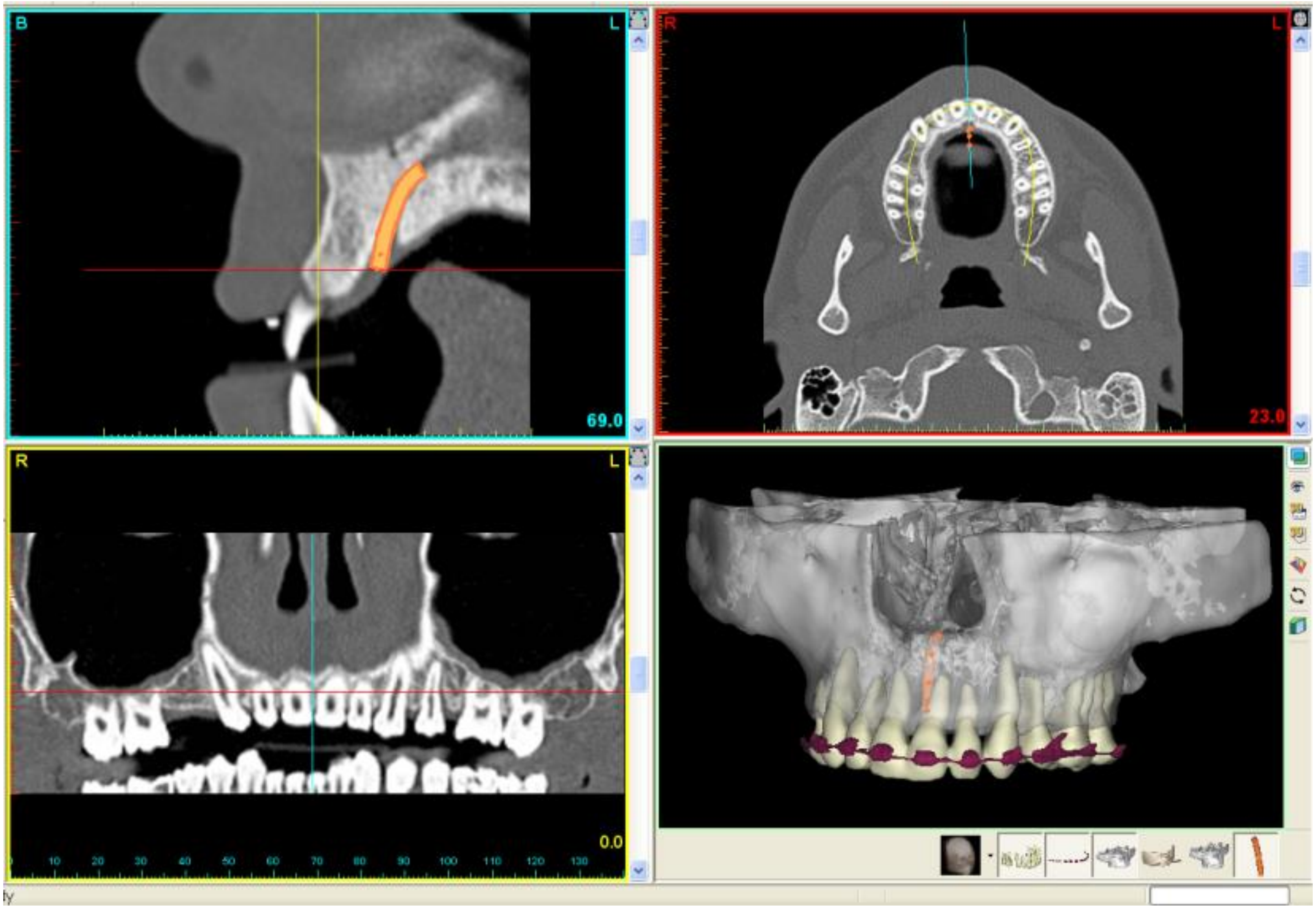
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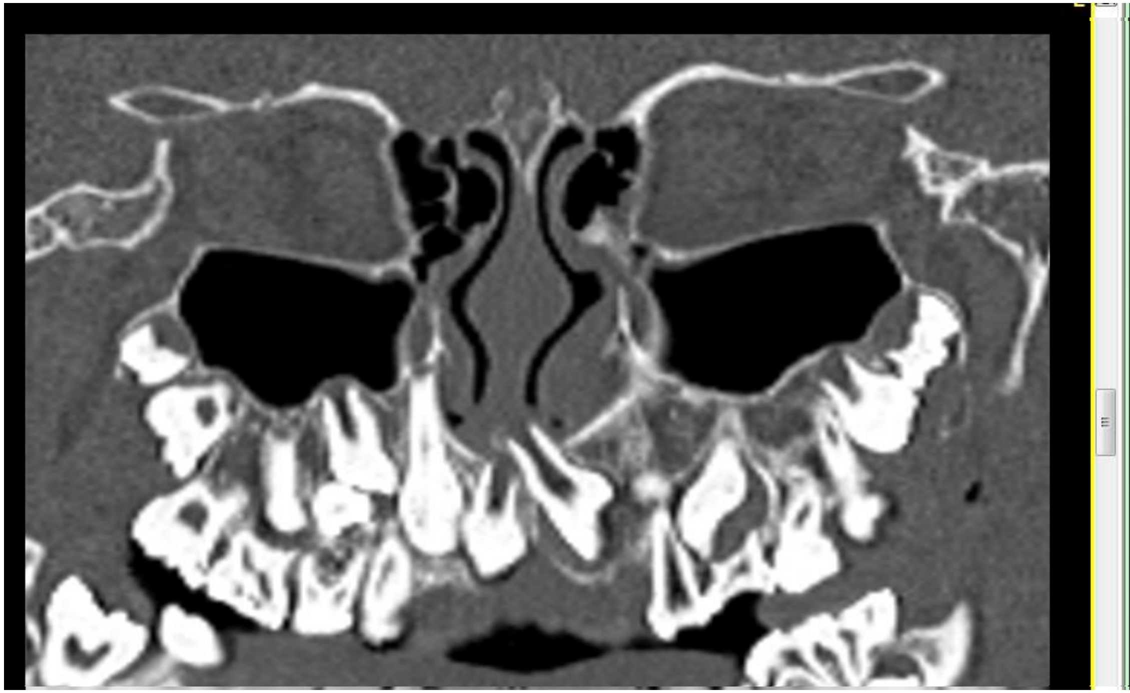
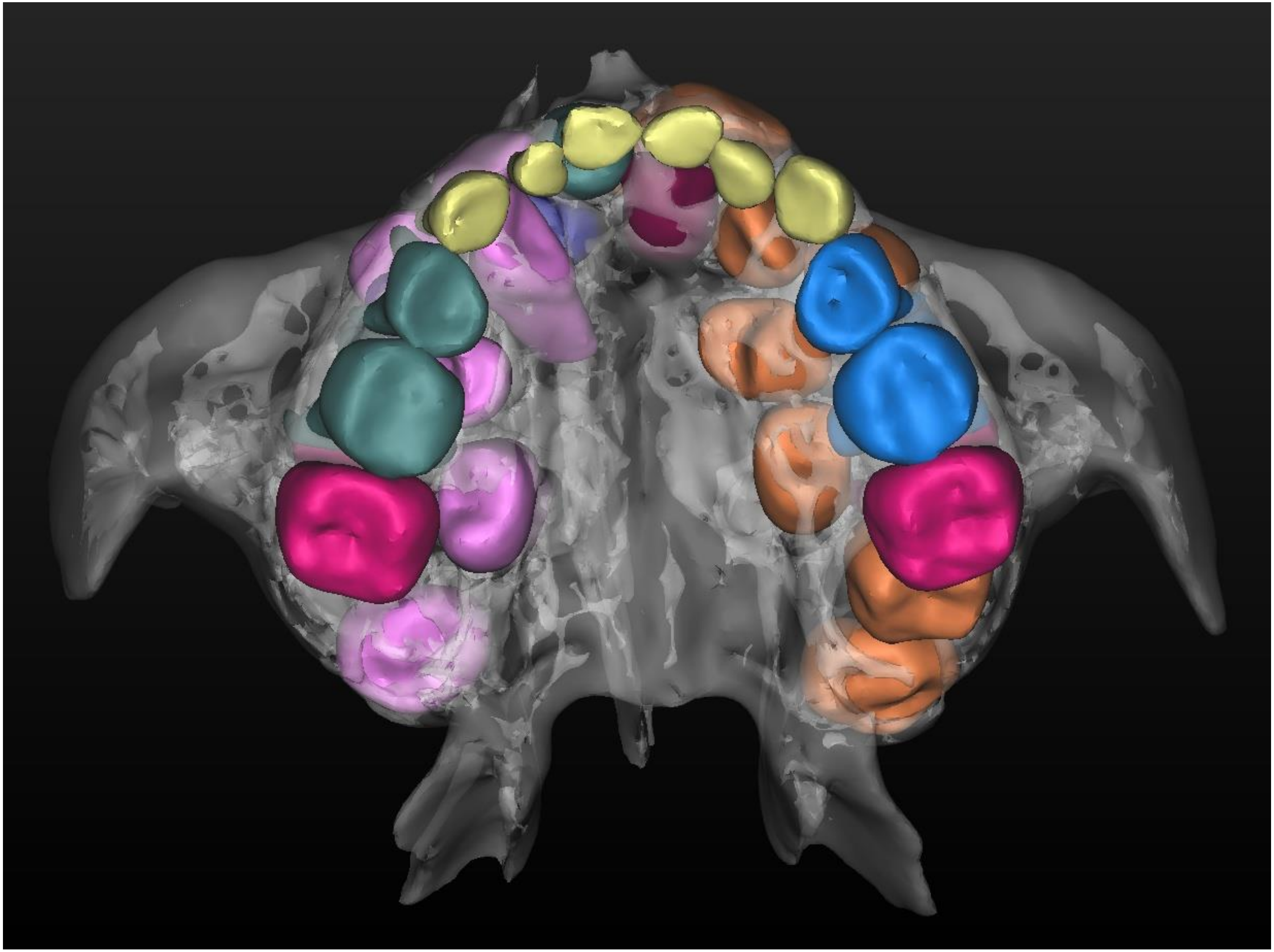
120
130

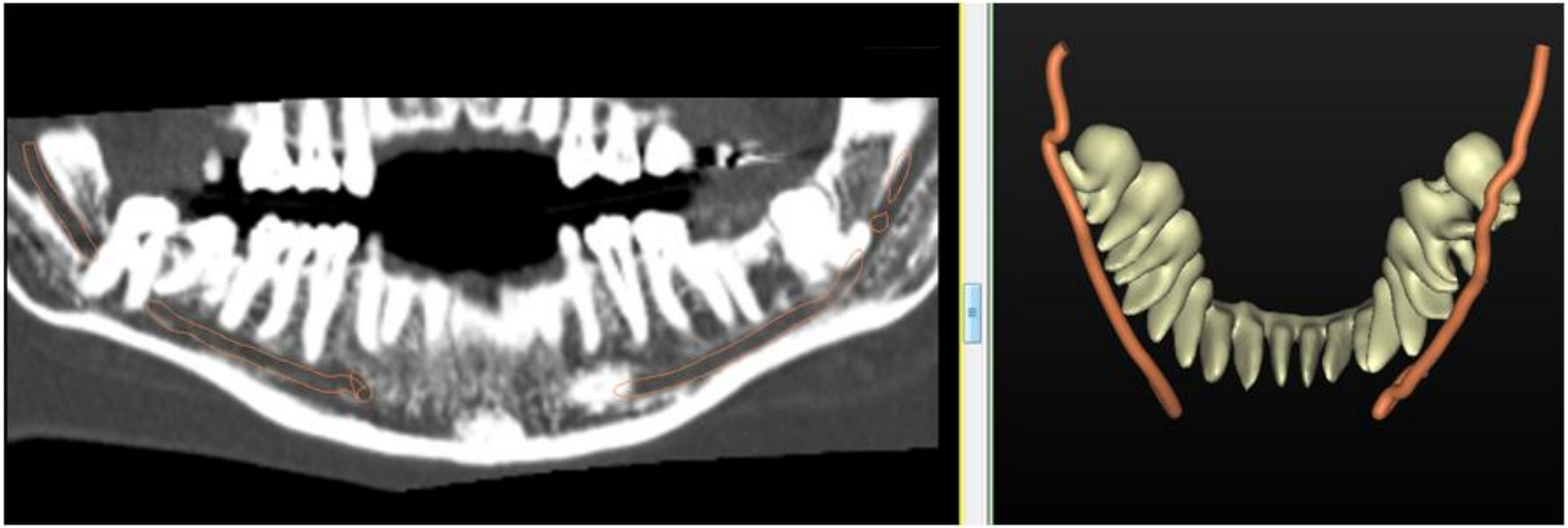
Hyperdontia



Courtesy of Nicolette Schroeder

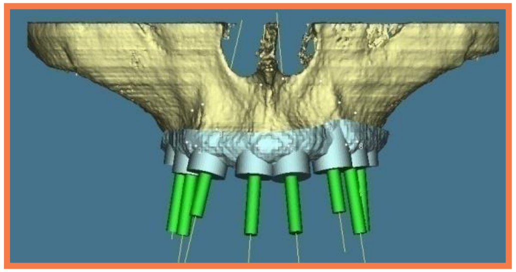


Third Molars

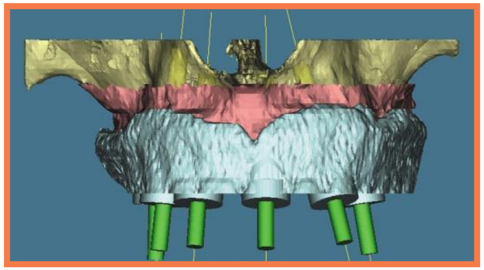


Courtesy of Barry Dace

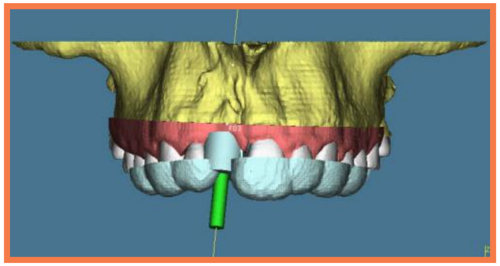
Implants: *Make Your Own Surgical Drill Guide*



Bone



Mucosa



Teeth

Bone Supported Guides:

- Bone crest must be clearly visible in the CBCT images and ≥ 3cm long

Mucosa Supported Guides:

- Patient must be scanned with a radio-opaque scanning stent in place

Tooth Supported Guides:

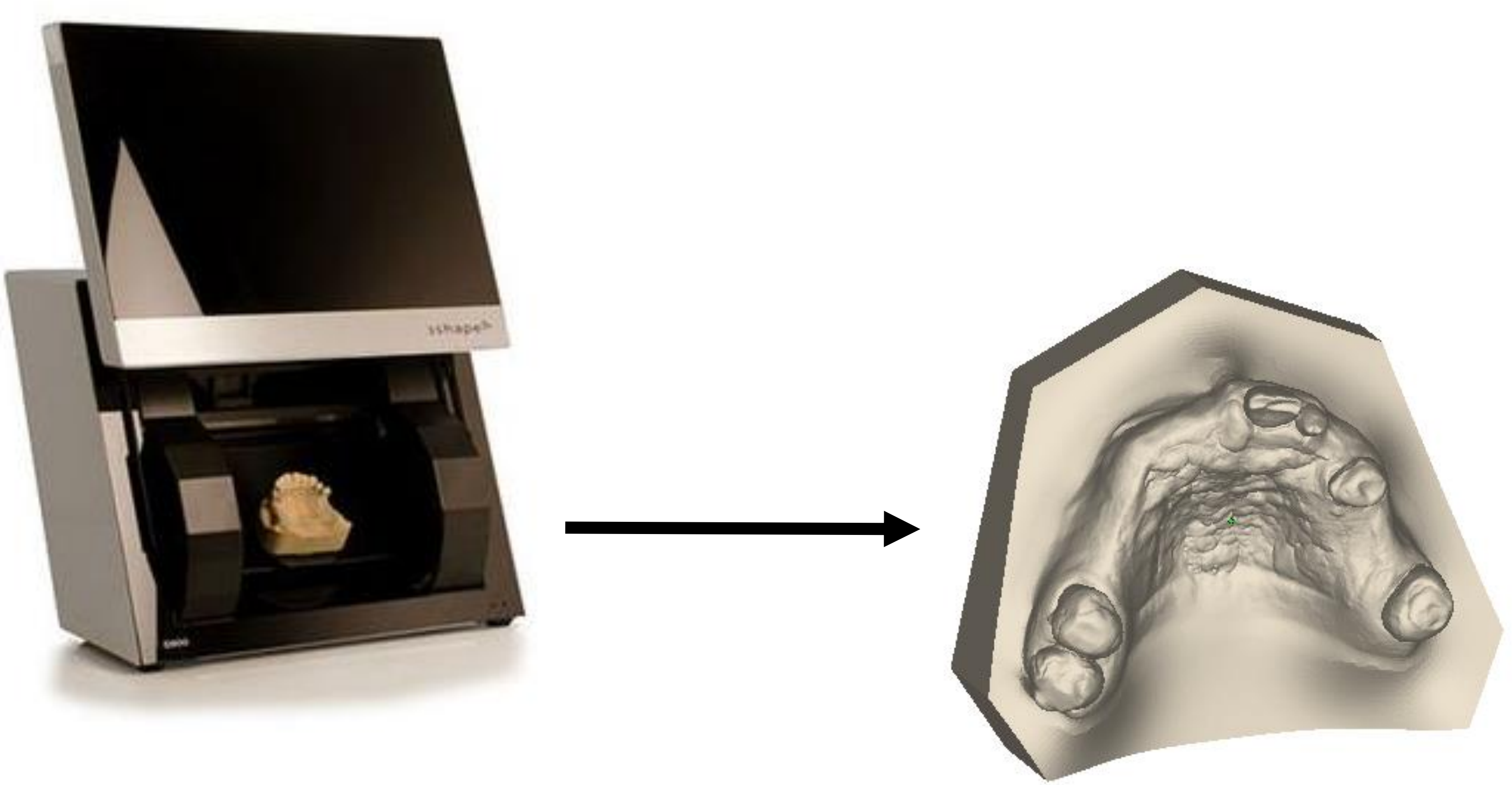
- Tips of teeth must be clearly visible in the CBCT images
- A recent and accurate plaster cast will be required

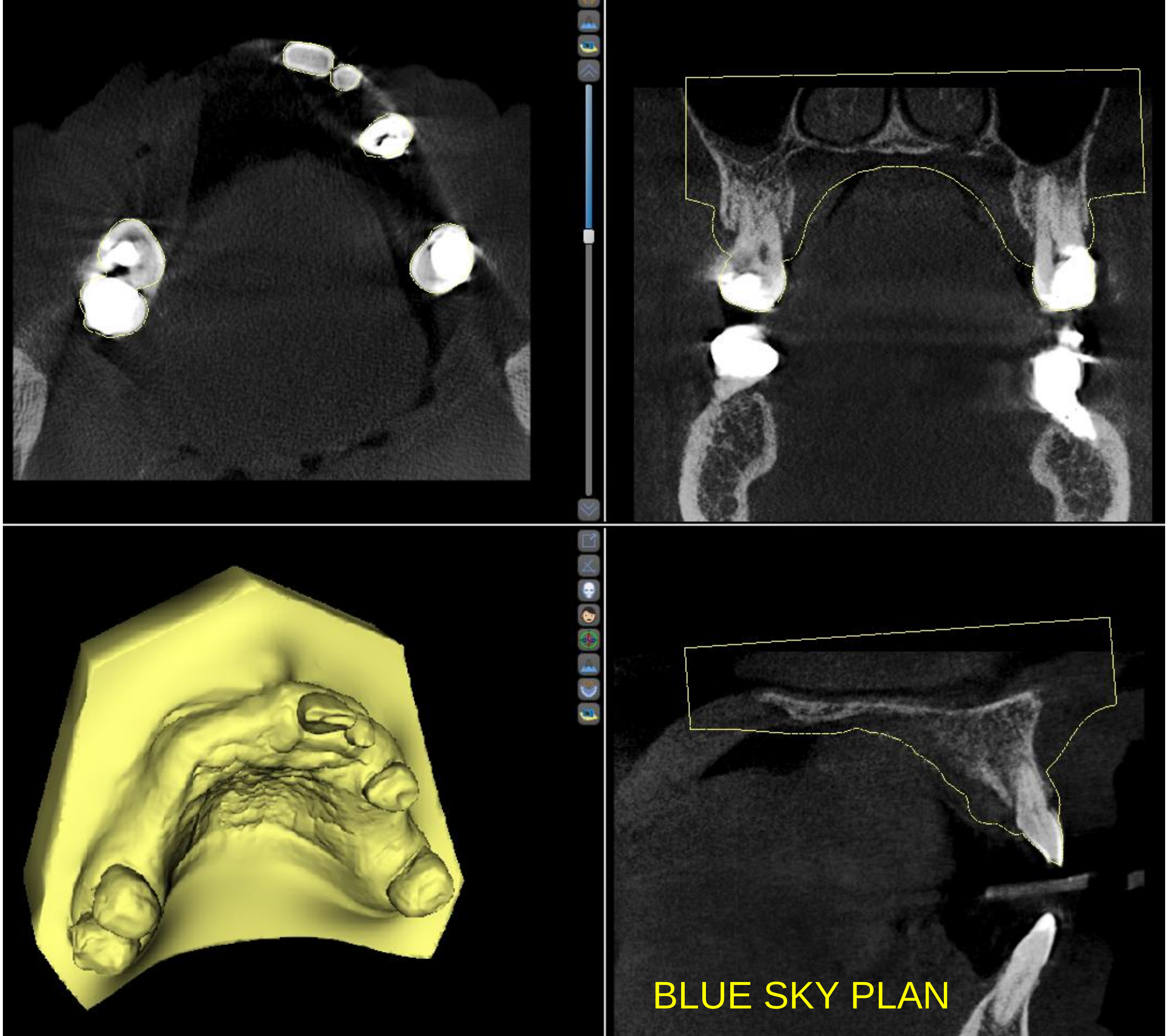
Need to think about the Guide before you request the CBCT Scan!

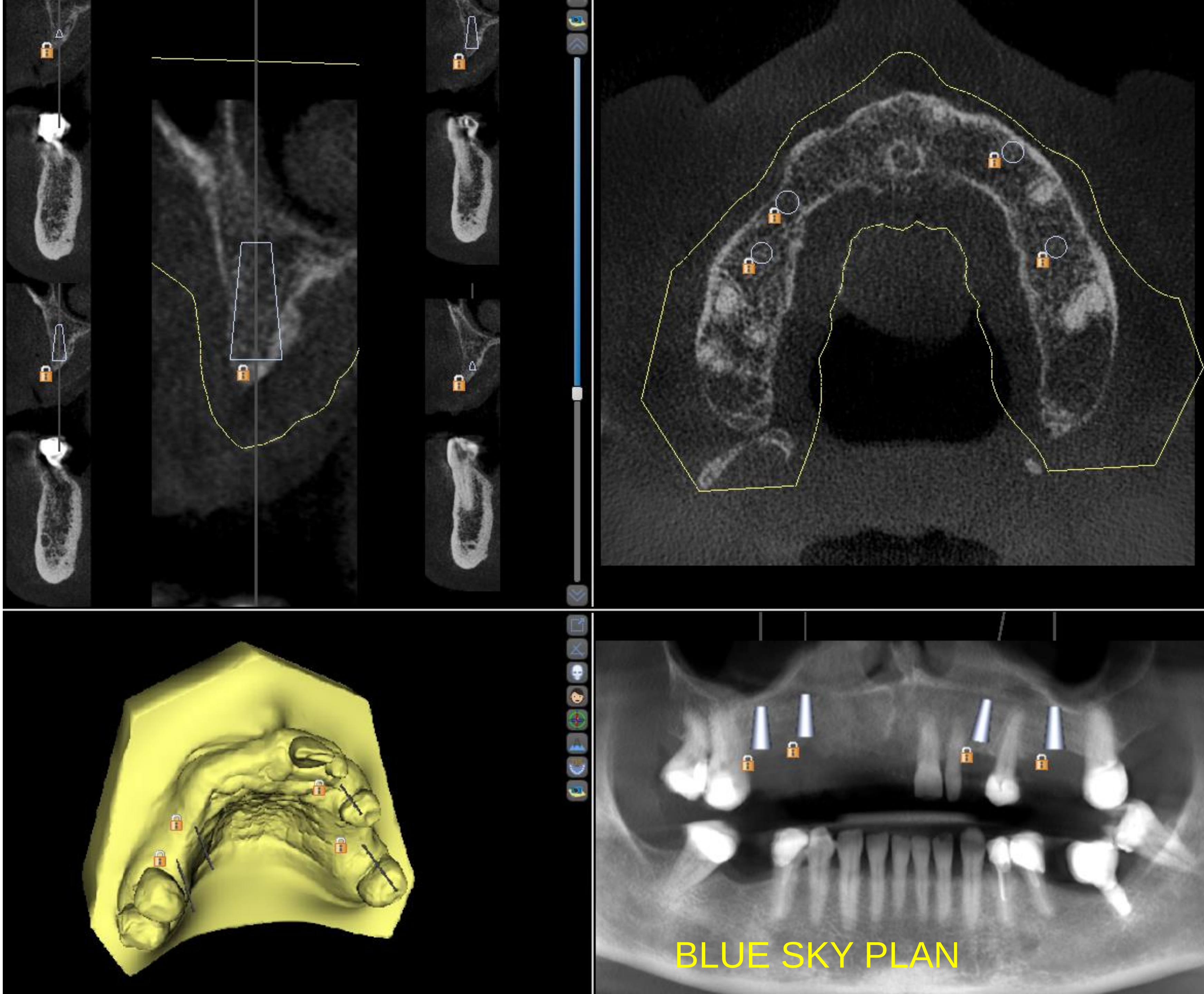
Tooth Supported Guides

- **Drill Guide will be supported on patient's existing teeth**
- **Need a recent and accurate impression or plaster cast**
- **Optical (laser) scan of plaster cast**
- **Import optical scan into the implant planning software**
- **Guide will be designed to fit the plaster cast.**

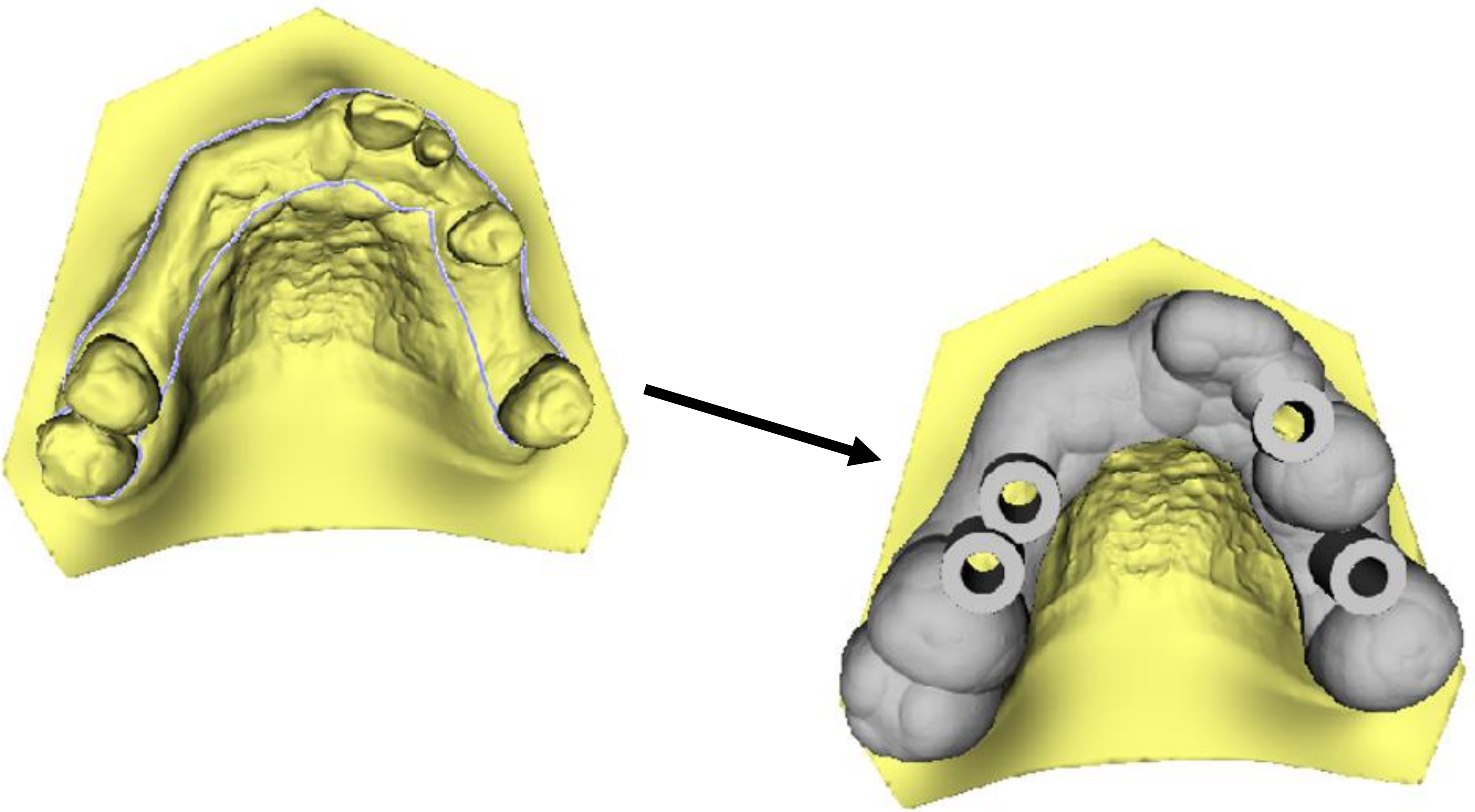
Optical Scan of Plaster Cast




BLUE SKY PLAN


BLUE SKY PLAN

Design the Guide



Print it on a 3D Printer

Outline of Lectures

- ✓ Introduction / Disclosures
- ✓ Diagnostic Imaging in Dentistry
  - Conventional Radiography
  - CT / CBCT Scans
- Quality Assurance
- Radiation Dose and Risk
- Compliance with the Legislation

What is Quality Assurance?

An on-going audit of the entire imaging process from start to finish, to make sure we are getting the best possible image quality at the lowest practical radiation dose.

Why Quality Assurance?

- **Ensure images are produced under the most favourable conditions**
- **Cost and time savings from fewer repeats**
- **Regulatory compliance**
  - **QA is a requirement under IR(ME)R 2017 (used to be a requirement under IRR 99)**

Quality Assurance (QA) versus Quality Control (QC)

- **Quality Assurance is process oriented**
  - **makes sure you are doing the right things, in the right way**
- **Quality Control is equipment oriented**
  - **makes sure the equipment is performing as you expected.**

Quality Control

- **Regular testing of equipment**
  - **detect malfunctions**
  - **assess image quality and radiation dose**

- **Ensure it produces consistent images**
  - **acceptable image quality**
  - **low radiation dose**
  - **as good as new!   (within acceptable limits)**

Quality Control Program

- **QC tests should be written down**
- **Make them the responsibility of a named individual**
- **Simple tests can be done by the person who takes the x-rays**
- **More complicated tests require a physicist or engineer.**

If you have a Darkroom …

(applies also to Daylight Loaders)

Need to look at:

- **Film storage**
- **Safe light levels**
- **Film processing**
- **Chemicals**
- **Temperature**
- **Cleaning**

Coin Test

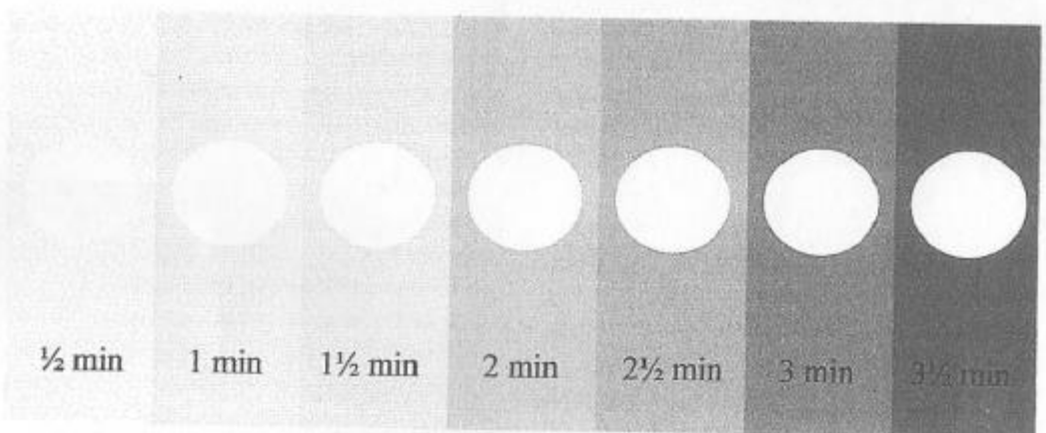


Fig. 18.7 A simulated coin test result. The film, with seven coins on it, has been gradually uncovered every 30 seconds. Th coin-covered part of the film remains white while the surrounding film is blackened or fogged. The longer the film is expos to the safelight the darker it becomes. (Kindly provided by Mr N. Drage.)

When should QC tests be performed?

- **Before first clinical use**
- **At regular intervals (every few months)**
- **After a major repair.**

Critical Examination

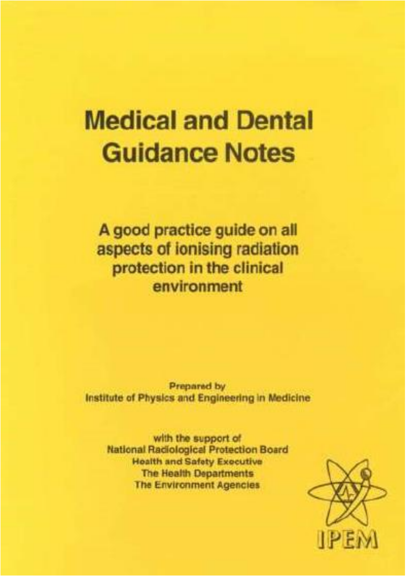
- Must be performed before first use or after a major repair
- Evaluation of safety features
- Responsibility of the installer/repairer
- Performed by engineer or physicist
- Evaluation of shielding and radiation protection
- Evaluation of warning signals
- Evaluation of exposure controls
- Acceptable functioning of cut-out switches etc
- Report should be kept with equipment records.

Acceptance Testing

- **Ensures equipment meets its specifications**
- **Responsibility of the purchaser**
- **Performed by Radiation Protection Advisor (RPA) or Medical Physics Expert (MPE)**
- **Provides a baseline for Quality Control tests.**

Routine QC Tests

- Monthly tests can be performed by the Operator
- Annual tests should be performed by RPA or MPE
- Follow manufacturer's instructions for QC tests
- See also Medical and Dental Guidance Notes (2002)



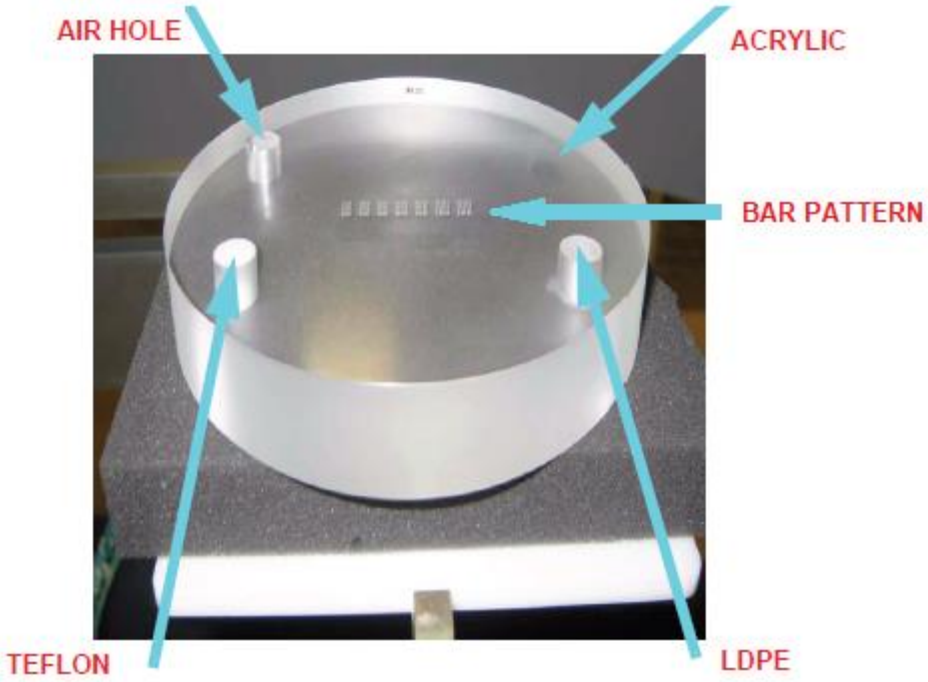
£20 from Institute of Physics and Engineering in Medicine (IPEM)

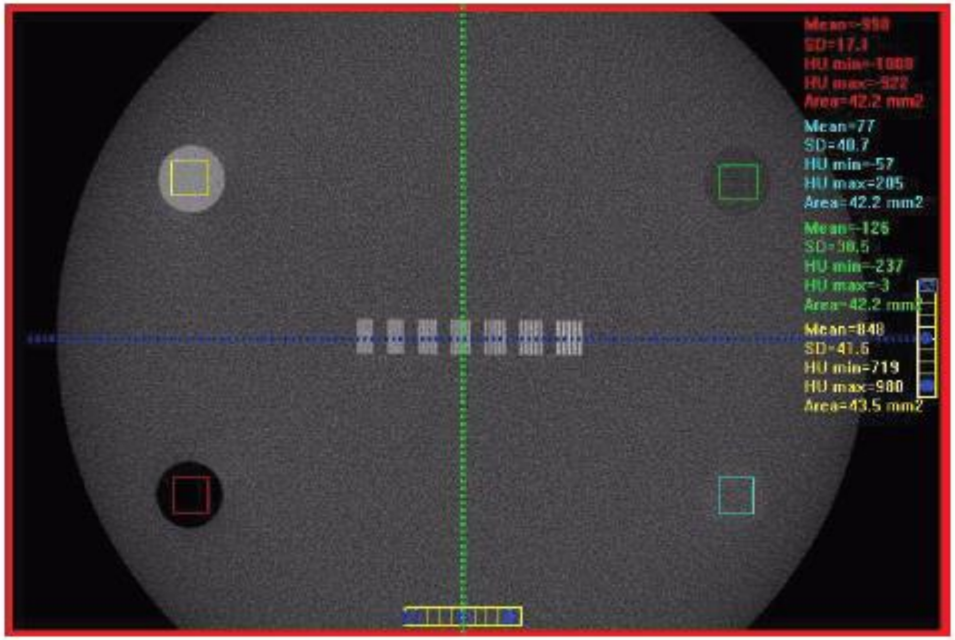
https://www.ipem.ac.uk/ScientificJournalsPublications/MedicalandDentalGuidanceNotes.aspx

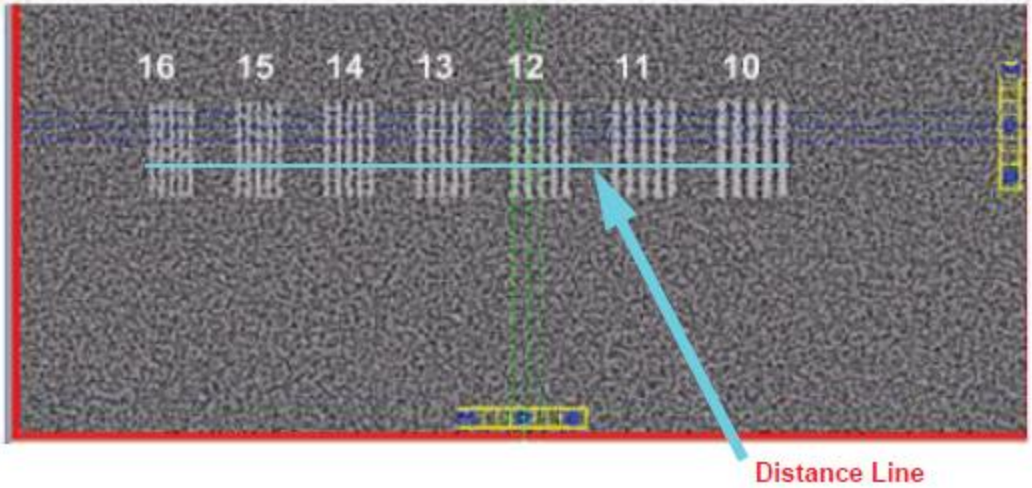
Monthly Tests

example: i-CAT 17-19 CBCT Scanner

- **Scan the supplied QC phantom using the recommended settings**
- **Follow the manufacturer's instructions to measure density of inserts and number of line pairs visible**
- **Measure the distance to check geometrical accuracy**




Mean=-990
SD=17.1
HU min=-1000
HU max=-922
Area=42.2 mm2
Mean=77
SD=40.7
HU min=-57
HU max=205
Area=42.2 mm2
Mean=-126
SD=38.5
HU min=-237
HU max=-3
Area=42.2 mm2
Mean=848
SD=41.6
HU min=719
HU max=980
Area=43.5 mm2


16
15
14
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12
11
10
Distance Line

Recommended Annual Tests

- Usually performed by RPA or MPE
- Is radiation output within specs?
- Is tube voltage (kVp) within specs?
- Tube Current (mA) accuracy
- Timer (s) accuracy
- Half value layer
- Tube leakage
- Focal spot size
- Collimation accuracy
- Tube stability & mechanical safety

Quality Assurance Program

- **Takes a holistic approach**
  - **choosing equipment**
  - **installing and testing equipment**
  - **training staff**
  - **acquiring images**
  - **viewing images**
  - **storing images**
  - **reject analysis**

Choosing Dental X-ray Equipment

- **Should be designed to meet European standards (CE Marking)**
- **Must meet requirements of Medicines and Healthcare Products Regulatory Agency in the UK (Health Products Regulatory Authority in Ireland)**
- **Manufacturers must provide adequate information on use, testing and maintenance.**

Medical Device Alert

Ref: MDA/2012/046 Issued: 16 July 2012 at 15:30

Device

Non CE-marked portable dental X-ray units.

Including the Tianjie Dental 'Falcon'.

Problem

Testing by the Health Protection Agency (HPA) has revealed that the Tianjie Dental Falcon device lacks sufficient shielding in the X-ray tube, which could give rise to high patient doses and under typical high radiographic workloads result in operator doses in excess of the Ionising Radiation Regulations 1999 annual dose limits. This could give rise to adverse health effects caused by radiation.

The Tianjie Dental Falcon is not CE-marked as a medical device.

Action by

Dentists, Medical Physics Departments

Action

- Identify and stop using this and similar non CE-marked devices.
- Replace the device with a suitable CE-marked alternative.
- Be aware of the NRPB (HPA) Guidance Notes for Dental Practitioners on the Safe Use of X-Ray Equipment or the Medical & Dental Guidance Notes published by IPEM.
- Be aware of the general requirement to consult a suitable radiation protection adviser with regard to the use of X-ray equipment.
- Be aware of MHRA advice on the use of non-CE marked devices.
- Report any suspected devices to MHRA Adverse Incident Centre.

CAS deadlines

Action underway: 23 July 2012

Action complete: 06 August 2012

Contact

Manufacturer
Lin Lin
Zhengzhou Tianjie Electronic Equipment Co

Tel: +86 371 67934274
Fax: +86 371 67375396

website:
http://www.tianjiedental.com/contact.html

Before taking radiographs

- **Is the radiograph necessary?**
- **Is adequate clinical information available?**
- **Do we understand the referrer's objectives?**

Before taking radiographs

- **Do we have the correct patient?**
  - **Name**
  - **Address**
  - **Date of Birth**
  - **Pregnancy status**
- **Exposing the wrong patient is automatically notifiable to Care Quality Commission (CQC)**
- **Check the problem area with the patient before the exposure.**

Guidance on investigation and notification of medical exposures much greater than intended.

16 January 2017

Table 1 – Examples of unintended medical exposures that require notification

All Modalities	**When to notify (what constitutes an exposure much greater than intended)**
Wrong patient exposed	All cases – regardless of dose
Wrong examination including incorrect body part or modality.	When the total exposure is at least 20 times greater than the intended dose.
Low dose examinations, where the intended dose is less than 0.5mSv, to include DEXA, skull, dentition, chest, in-vitro nuclear medicine	

Google for "MGTI Guidance"

Radiographic Technique

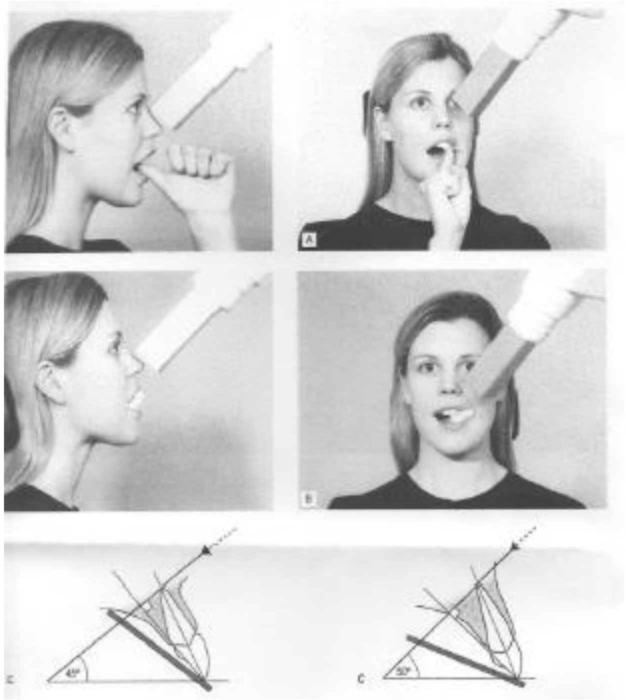
- **Record who received what training when**

- **Intra-oral technique**
  - **Use of film holders and beam aiming devices**

- **DPT technique**
  - **Correct patient positioning**
  - **Patient immobilisation**
  - **Use of light beams**

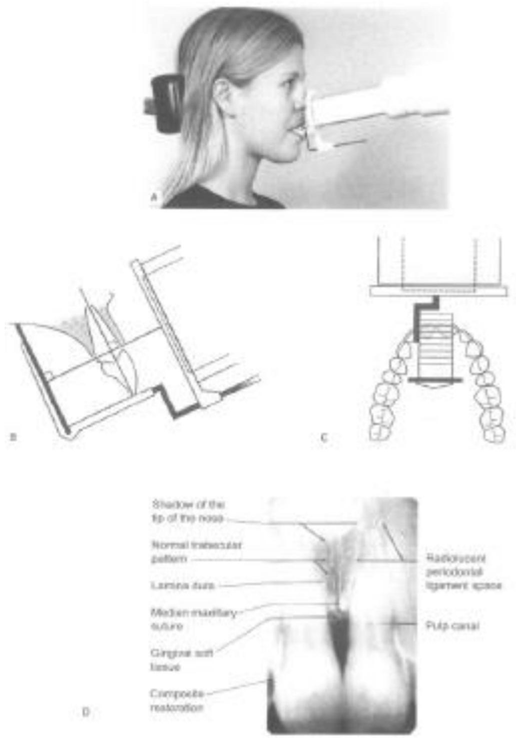
Bisecting Angle Technique

- **Not the technique of choice**
- **Only use when paralleling technique cannot be used**
  - **e.g. small mouthed patient**
  - **patient cannot tolerate film holder**
- **Images can be elongated or distorted**



Paralleling Technique

- **Beam aiming device must be used**
- **Film holder must be far enough into mouth to ensure film is parallel to the tooth**
- **Magnification but no distortion (provided it is performed correctly)**



OPG/DPT

Dental Panoramic Tomogram (DPT) aka Orthopantogram (OPG or OPT)

- **Patient Positioning**
  - **head and neck straight**
  - **shoulder clearance**
  - **bite block between central incisors**
  - **follow infection control protocol.**

- **Light beams**
  - **mid sagittal**
  - **frankfort plane**
  - **AP (canine line) position.**

Correct Orientation of Cassette

- Tube side facing the patient
- Arrow aligned with arrow on the machine
- Label with L and R markers

Cassette Care

- **Clean cassettes once a month**
- **Check for scratches or marks**
- **Check for light leaks (e.g. hinges)**
- **Check film/screen contact as poor contact may cause blurring.**

Acquiring the Image

- **Use appropriate settings**
  - **refer to chart for Adult / Child**

- **Observe patient during exposure**
  - **no patient movement**
  - **not in distress**

Digital Radiography

Two types:

- **CMOS or CCD detector**
- **Photostimulable Phosphor Plate (PSPP)**

CCD/CMOS Digital imaging

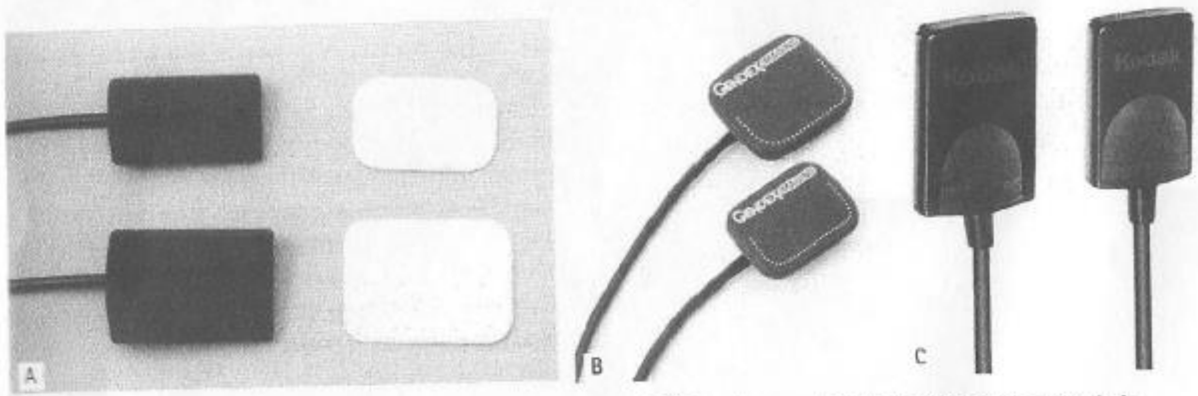


Fig. 6.14 Examples of modern solid-state sensors. A Planmeca dixi^2 ® and conventional film packets to show their comparative size. B Gendex Visualix® (kindly provided by Mr R. France). C Kodak RVG 6000.

PSPP Digital imaging

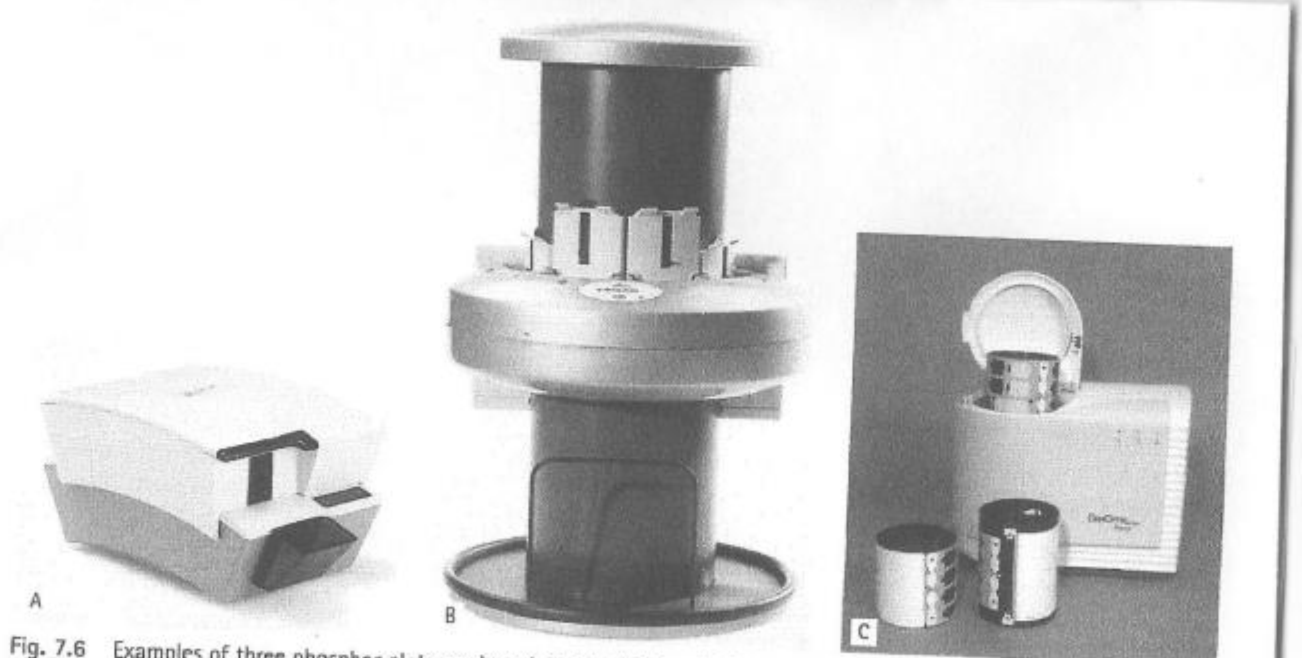


Fig. 7.6 Examples of three phosphor plate readers. A Soredex's Digora® Optime (intraoral), B Durr's Vistascan and C Gendex® DenOptix™.

Digital QA

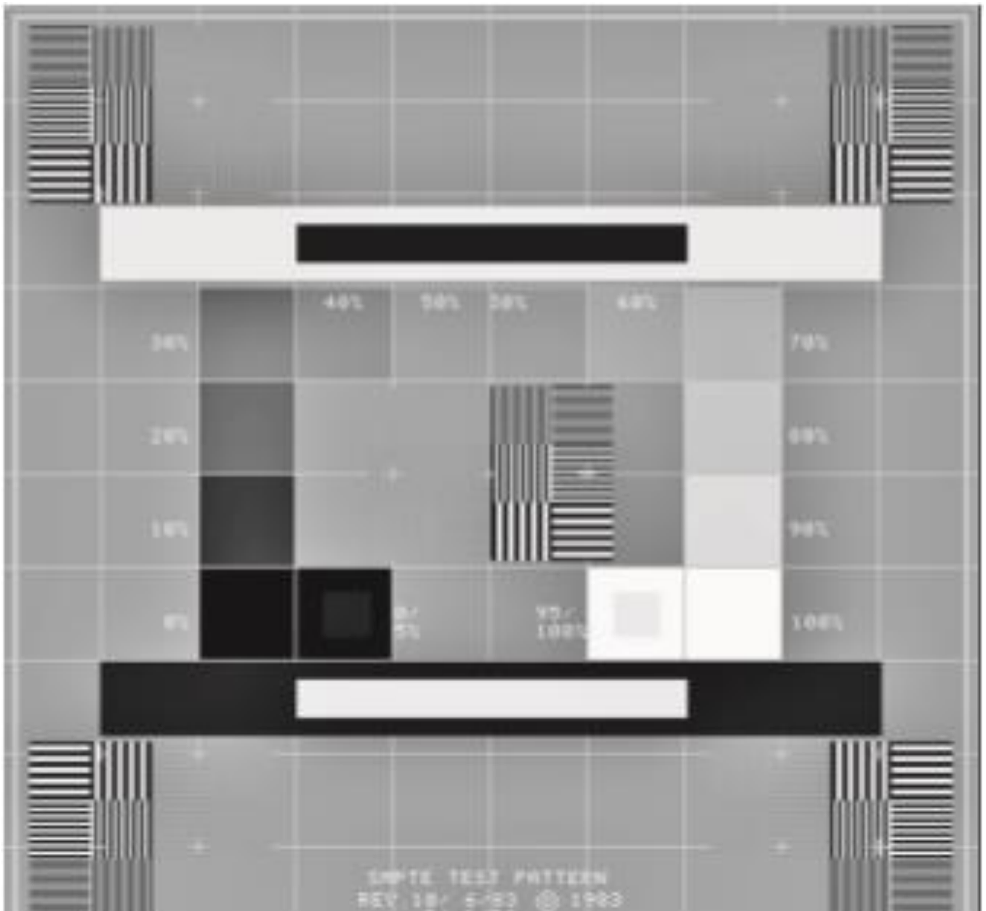
- **CCD/CMOS sensors should be inspected monthly for damage**
- **PSPP sensors should be cleaned and inspected monthly for dirt, scratches or bends**
- **Test objects can be x-rayed to check for geometrical accuracy.**

Viewing Conditions

- **Radiographs should be viewed on a viewing box**
- **Digital images should be viewed on a calibrated monitor**
- **Room lights should be dimmed.**

SMPTE Test Pattern

(Society of Motion Picture and Television Engineers)



Reject Analysis

- **Studies have shown that up to 50% of dental x-rays are of poor standard.**
- **Assign (subjective) image quality ratings to rejected images**
- **Analyse the results.**

Triage based on Image Quality

1. **Excellent**
   - **No errors of positioning, exposure or processing**
   - **Should be 70% or more in this category**

2. **Acceptable**
   - **Some errors but still diagnostic**
   - **Not more than 20% in this category**

3. **Unacceptable**
   - **Unusable, must be repeated**
   - **Not more than 10% in this category**

Rejected radiographs

Grade 3 (unacceptable) radiographs should be examined to look for trends:

- **Operator**
- **Date taken**
- **Nature of deficiency**
- **Cause of deficiency**
- **Number of repeat radiographs.**

Thank you !

Any questions?

Outline of Lectures

- ✔ **Introduction / Disclosures**
- ✔ **Diagnostic Imaging in Dentistry**
  - **Conventional Radiography**
  - **CT / CBCT Scans**
- ✔ **Quality Assurance**
- **Radiation Dose and Risk**
- **Compliance with the Legislation**

Radiation Dose and Risk

Anthony Reynolds BA MSc PhD
Registered Clinical Scientist CS03469

Image Diagnostic Technology Ltd.

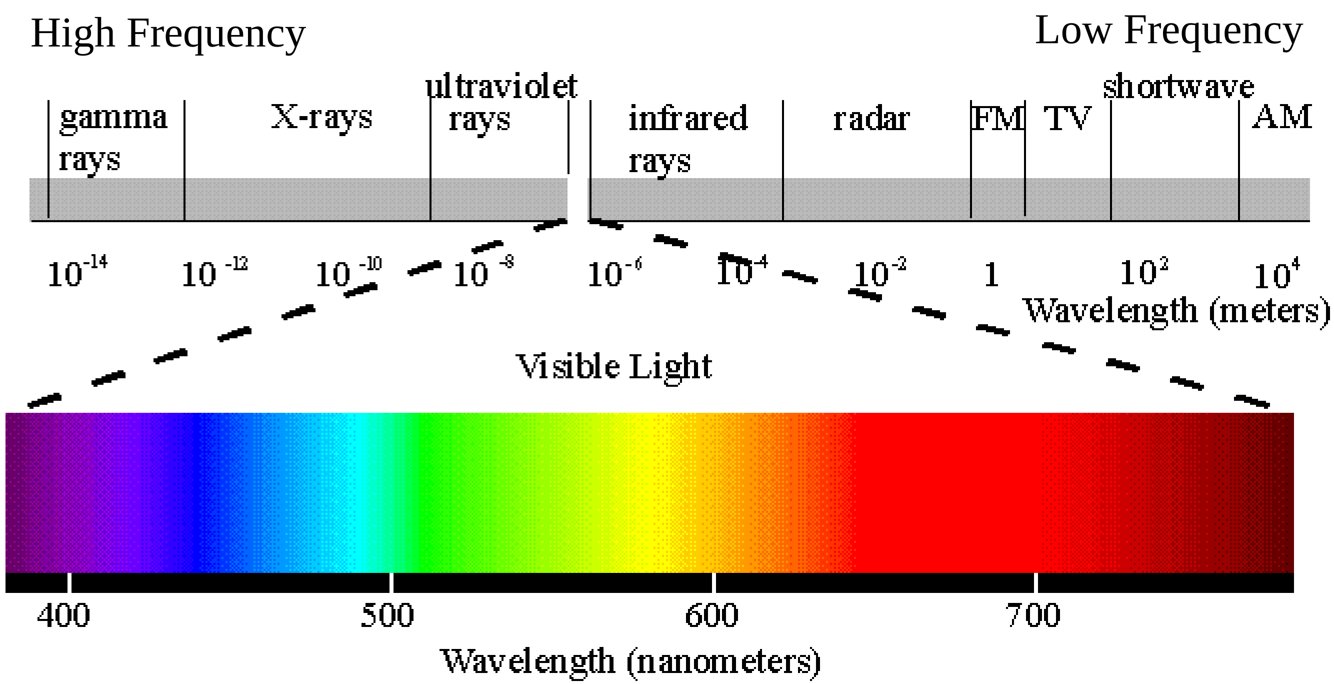
Topics

- **What is radiation?**
- **Sources of radiation**
- **Is radiation harmful?**
- **How can I estimate the risk?**

What is Radiation?

- **Energy travelling through space**
- **Sunshine is a familiar example**
  - **A small amount is beneficial**
  - **Too much can be harmful**

The Electro-Magnetic Spectrum

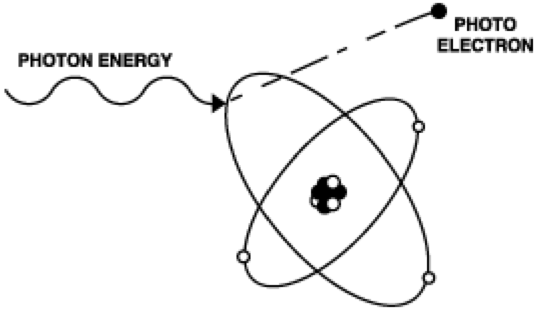


from **http://www.yorku.ca/eye/spectru.htm**

Energy depends on the frequency $E = h\nu$

Gamma Rays and X-Rays

- **Referred to as "Ionising Radiation"**
- **Can disrupt atoms and turn them into positive and negative ions**
- **This can cause damage at molecular level.**

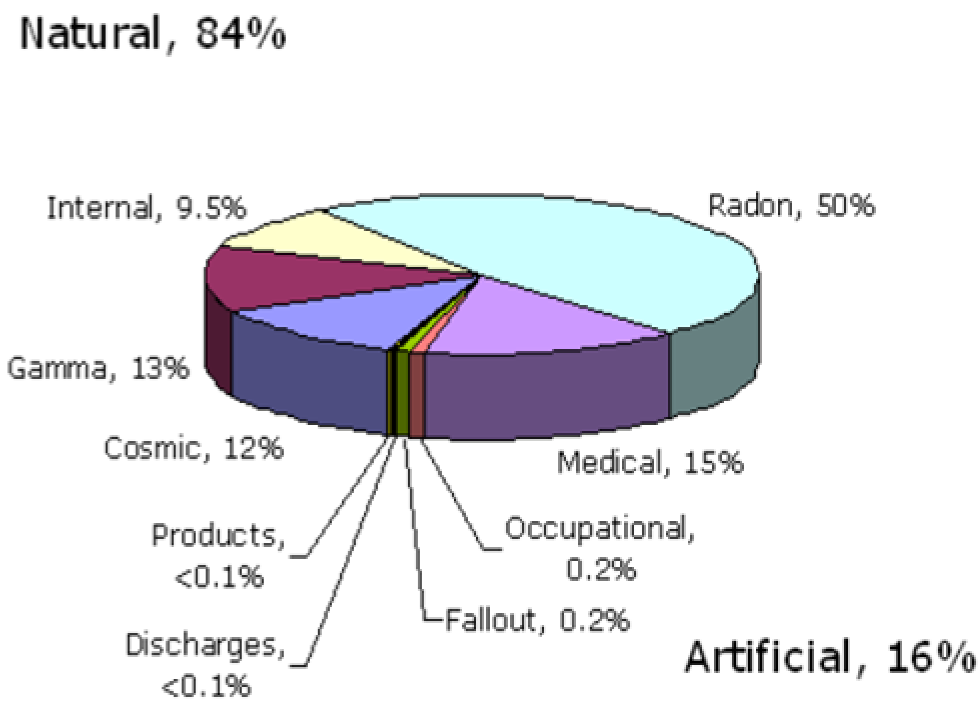


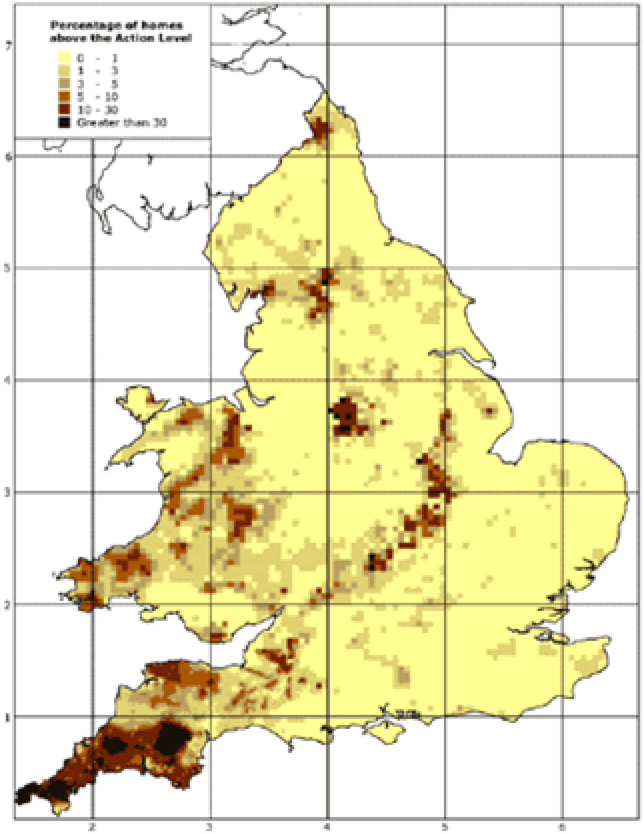
Sources of Ionising Radiation

1. Environmental (e.g. Radon)
2. Cosmic Rays
3. Radioactive Isotopes
   - inside or outside the body
   - natural or man-made
4. Medical and Dental x-rays

The first 3 make up “Background Radiation”
The first 4 make up “Per-Capita Dose”.

Per-Capita Dose in the UK

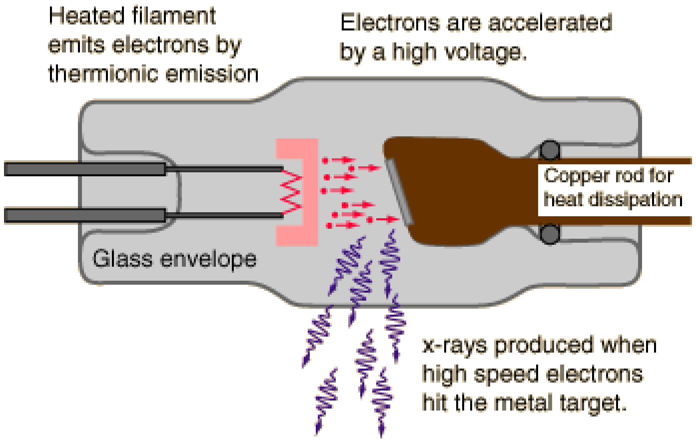




Background Radiation 2.2mSv
Medical and Dental 0.5mSv
Average Per-Capita Dose 2.7mSv per person per year

X-Ray Tubes

- **Vacuum Tube**
  - **High Voltage (60 to 120 kVp)**
  - **Low Current (1 to 100 mA)**
  - **12 KiloWatts of Power !!**
  - **Mostly appears as heat but about 1% appears as x-rays.**



Advantage of X-Ray Tubes

- **Produce an intense stream of x-ray photons from a small focal spot**
- **When the tube is switched off, there is no more radiation**
- **A “Controlled Area” only exists while the power is on.**
- **X-ray tubes cannot induce radioactivity in other objects (or people).**

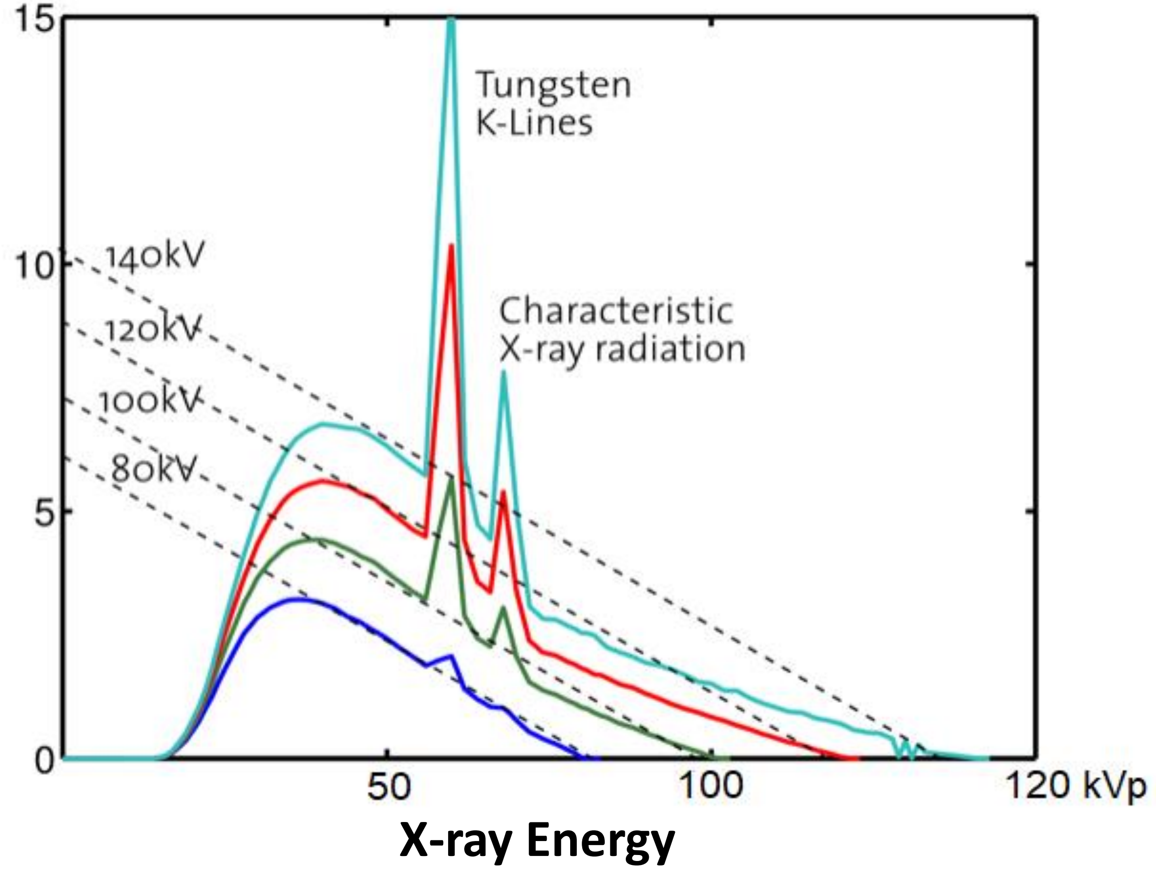
X-Ray Spectrum

Dental x-ray tubes operate in the range 60 to 120 kVp

Bremsstrahlung **produces x-ray photons with a range of energies**

Characteristic Radiation **produces discrete lines indicative of the target material**

Filtration removes the least energetic x-ray photons.

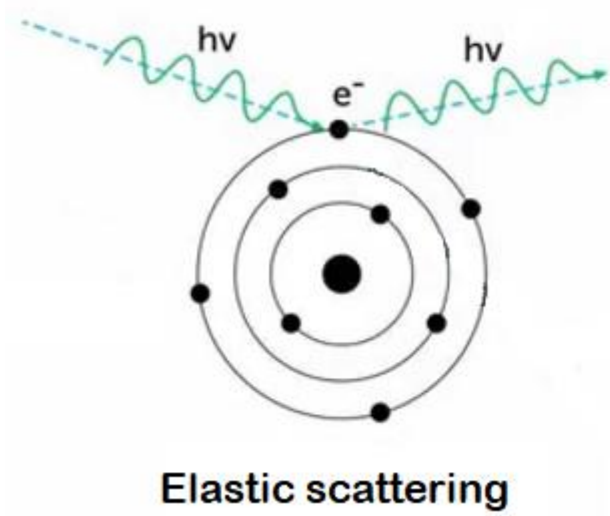


Absorption/Attenuation of X-Rays

At diagnostic energies (60 to 120 keV) x-rays lose their energy by interacting with electrons.

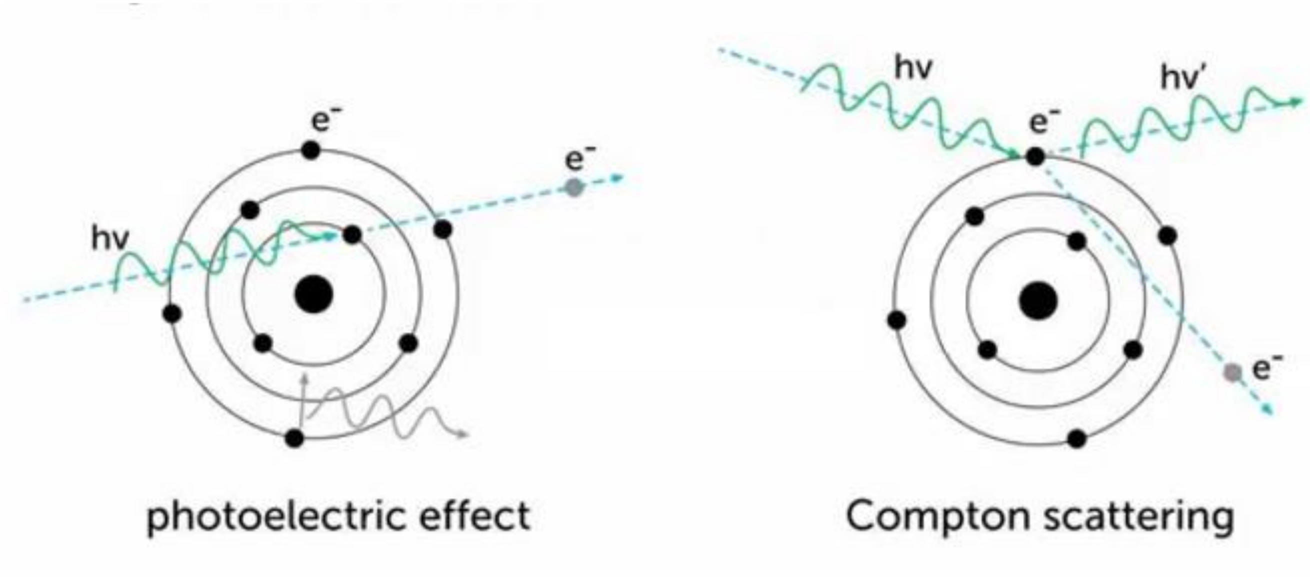
- **For energies up to about 70 keV the photoelectric effect is the most important**
- **Coherent scattering also occurs at energies up to about 70 keV**
- **For energies greater than about 70 keV Compton scattering is the most important.**

Coherent (aka Rayleigh or Elastic) Scattering



Coherent scattering **– low-energy electrons are unable to eject an electron. Instead they "bounce off" the electron and continue in a different direction, without any loss in energy.**

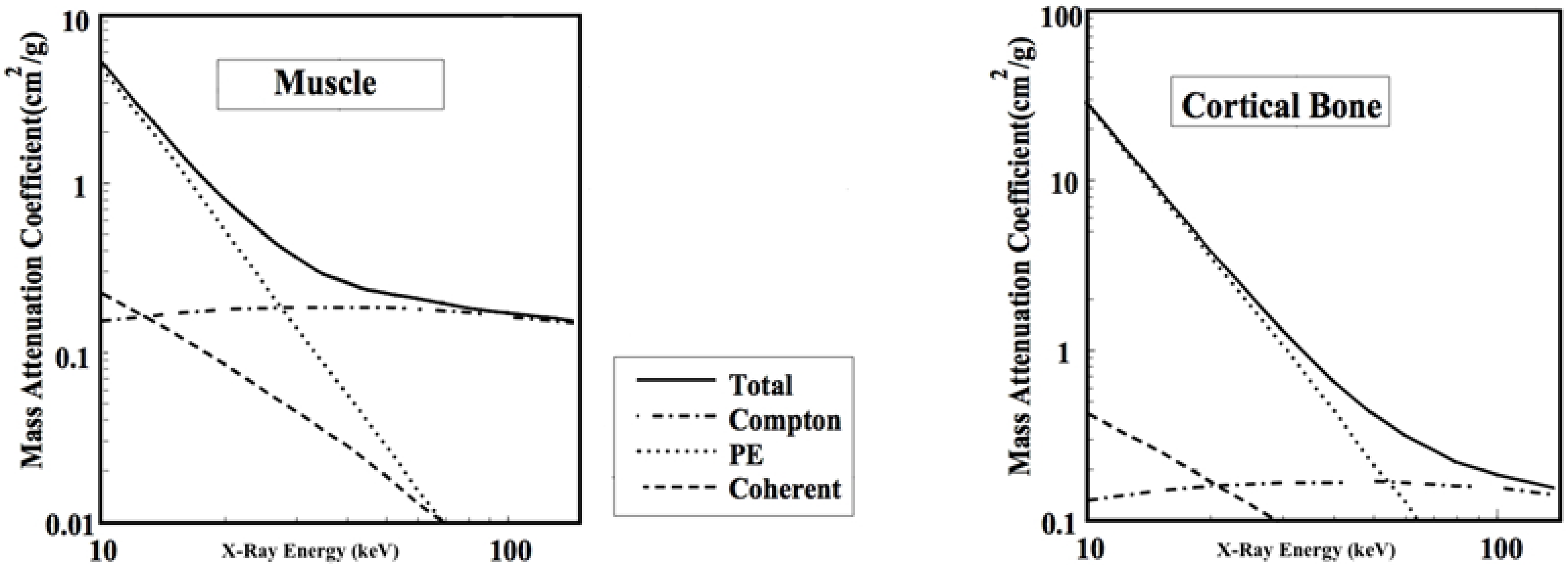
Photoelectric and Compton effects



Photoelectric – x-ray loses all of its energy by ejecting a K-shell electron. X-ray is halted but an outer shell electron may drop into the K-shell with the emission of Characteristic Radiation.

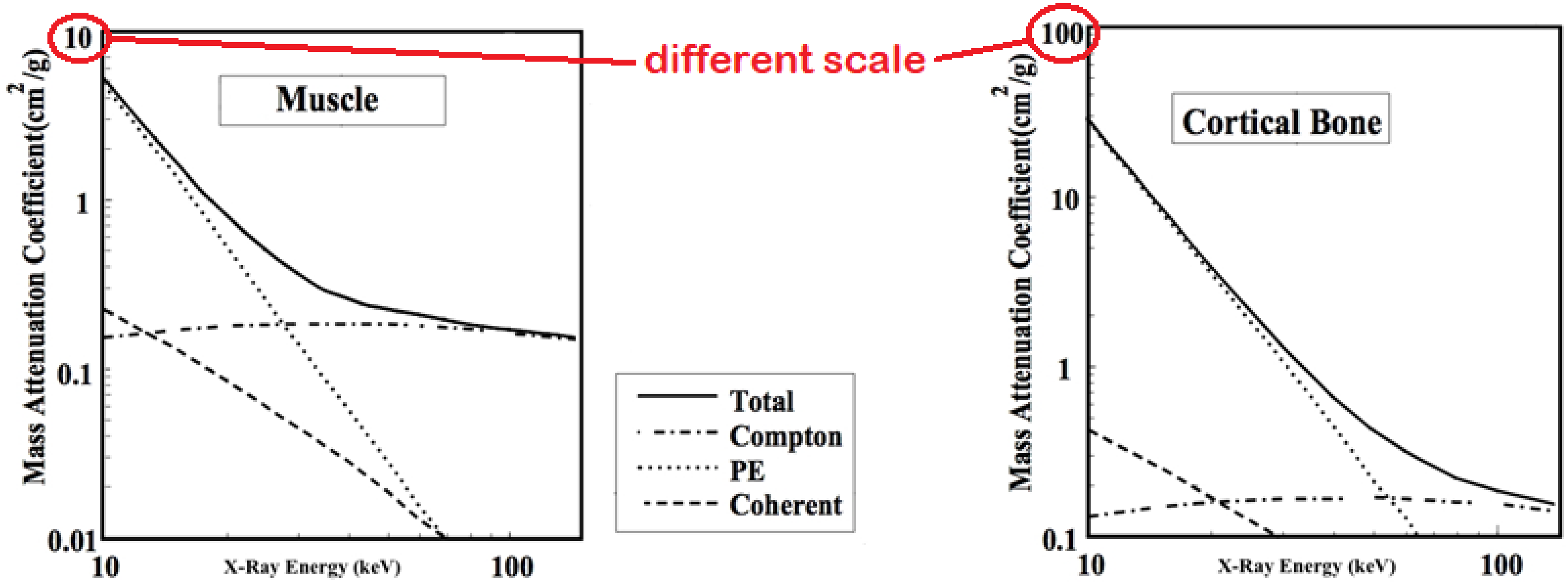
Compton – x-ray loses some of its energy by ejecting an outer shell electron. X-ray continues at a lower energy and in a different direction.

Energy and Tissue Dependence



- Differences in x-ray absorption are perceived as contrast between Bone and Muscle in the images.
- Lower energies produce more contrast at the expense of more patient dose.
- Optimum is around 90 kVp for CBCT.

Energy and Tissue Dependence



- Differences in x-ray absorption are perceived as contrast between Bone and Muscle in the images.
- Lower energies produce more contrast at the expense of more patient dose.
- Optimum is around 90 kVp for CBCT.

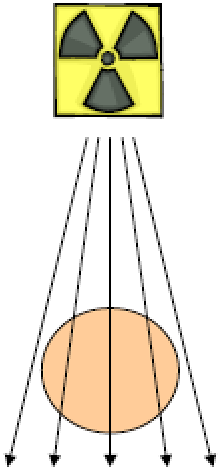
What happens to the energy?

- **The energy lost by the x-rays is imparted to the tissue !**

Absorbed Dose

- Absorbed Dose (D)

$$D = \frac{\varepsilon}{m} (Gy)$$



- ε = energy imparted (J) Joules
- m = Mass of tissue (kg)

- **Unit = (Gy) Gray**
- 1 Gy = 1 J/kg

Equivalent Dose

- Organ Equivalent Dose (H_T)

$$H_T = w_R D_{T,R}$$

- D_T = absorbed dose to organ T
- w_R = radiation weighting factor
  w_R = 1 for x-rays

- **Unit = (Sv) Sievert**

Radiation Type	w_R
Photons (X-rays, γ)	1
Electrons and muons	1
Protons and charged pions	2
Alpha particles, fission fragments, heavy ions	20
Neutrons	Continuous Function of energy

Also known as "Organ Dose" or "Local Dose"

Effective Dose

- Effective Dose (E)

$$E = \sum_T H_T w_T$$

- H_T = Organ Equivalent Dose
- w_T = Tissue weighting factor

- **Unit = (Sv) Sievert**
- Effective Dose is proportional to risk of fatal cancer

Tissue / Organ	w_T
Bone marrow (red)	0.12
Colon	0.12
Lung	0.12
Stomach	0.12
Breast	0.12
Gonads	0.08
Bladder	0.04
Liver	0.04
Oesophagus	0.04
Thyroid	0.04
Brain	0.01
Salivary Glands	0.01
Skin	0.01
Bone surface	0.01
Remainder	0.12

From ICRP 103

Often referred to simply as "The Dose"

Annals of the ICRP

PUBLICATION 103

The 2007 Recommendations of the International Commission on Radiological Protection

Editor
J. VALENTIN

PUBLISHED FOR

The International Commission on Radiological Protection

by

ELSEVIER

Topics

- **What is radiation?**
- **Sources of radiation**
- **Is radiation harmful?**
- **How can I estimate the risk?**


ЧОРНОБИЛЬ

26 April 1986

14 June 2017


TERRA-P
1.35
µSv/h
OPERATIONAL MODES
GAMMA DOSE RATE
1
ALARM CLOCK
GAMMA DOSE
TIME
Solo

Dose Rate at Chernobyl (2017)

- **200m from the reactor**
- **1.35 microSievert per hour**

Background Dose Rate in the UK (Average)

- **0.25 microSievert per hour**

Flight from the UK to Chernobyl

- **3 hours x 2.5 μSv/hr = 7.5 μSv**

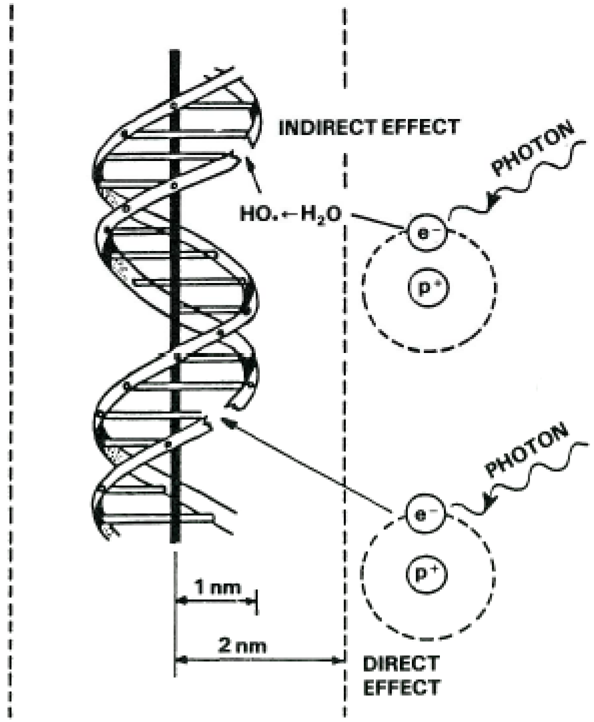
Dental x-ray (intraoral)

- **1 microSievert**

CBCT scan (both jaws)

- **100 microSievert**

Biological Effects of Radiation



Indirect Effects (~70%)

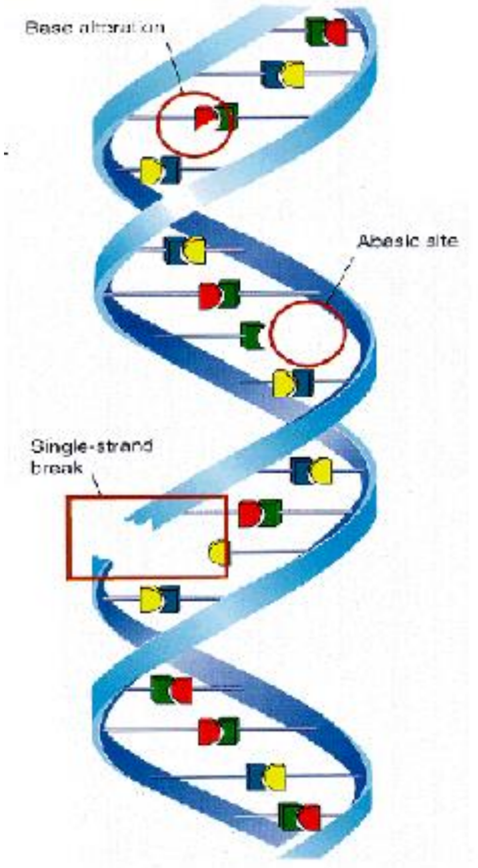
Ionisation of water creating highly reactive oxygen species ('free radicals') which can break bonds in DNA by chemical reactions

Direct Effects (~30%)

Chemical bonds of DNA (or other molecule) broken by ionising interaction with radiation

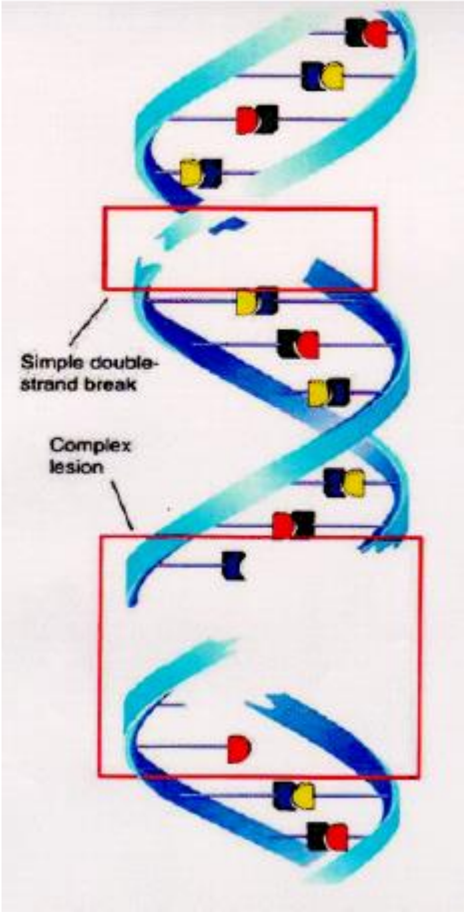
DNA Damage - Simple

- **Most likely damage is single strand break**
- **Occur spontaneously all the time**
- **~100% successfully repairable**
- **Occurs ~1000x more frequently from cellular processes than from background radiation.**



DNA Damage - Complex

- **With radiation there is a greater frequency of more complex breaks**
- **Double strand breaks may not be repaired successfully**
- **Successful repair more difficult at higher dose rates.**



Deterministic and Stochastic effects

Deterministic Effects are reproducible

- severity of the effect increases with the dose
- not observed below a threshold dose of about 500mSv

Stochastic Effects are random

- the risk (not the severity) increases with the dose
- known to occur above 20mSv or so
- below about 20mSv we don’t know if they occur or not

Hereditary Effects are random (stochastic) but the incidence in humans is very low.

Deterministic Effects

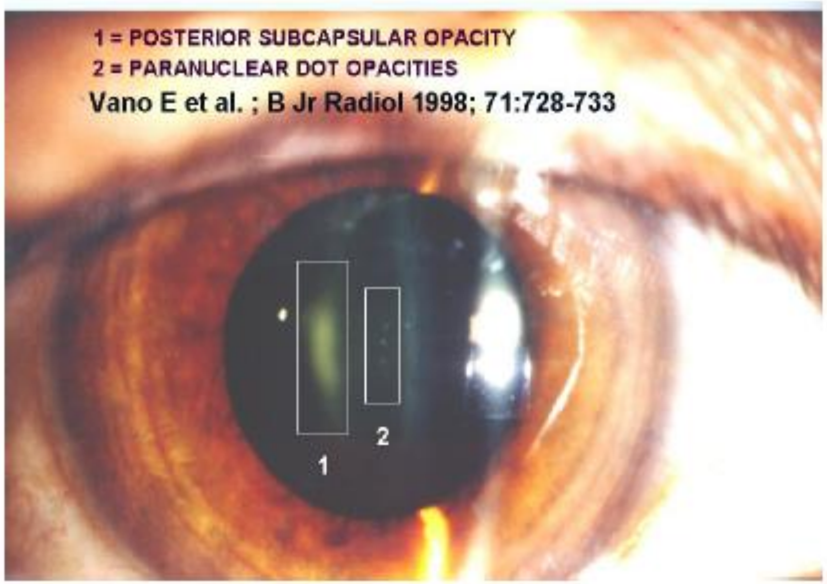
For a high dose of radiation received over a short period of time, it is just about certain that the following effects will occur:

- **radiation sickness: 1-2Gy (whole body dose)**
- **skin erythema: 2-5Gy (local dose)**
- **sterility: 2-3Gy (local dose)**
- **hair loss: 2-5Gy (local dose)**
- **death: 3-5Gy (whole body dose)**

We should never see any of these effects in a dental practice!

Deterministic Effects in Radiation Workers

Dentist (1980s)



Interventional Radiologist (1998)

Dose levels leading to opacities (ICRP 118)

- Lens opacities may occur at doses between 0.2 Gy and 0.5 Gy
- The severity may increase progressively with dose and time.
- Threshold (1% risk of cataract) is 0.5 Gy acute or chronic exposure.
- Previously cataract was only thought to occur at higher doses and not progress with time.
- Based on exposure over a working lifetime with 15 - 20 y follow-up.

New occupational eye lens limit: 20 mSv per year

(averaged over 5 year, with not more than 50 mSv/year)

Stochastic Effects

- **For a high dose of radiation received over a short period of time, it is very likely (but not certain) that cancer will be induced.**

- **For a low dose of radiation, we think that cancer may be induced (maybe many years after exposure) but we don't know for sure.**

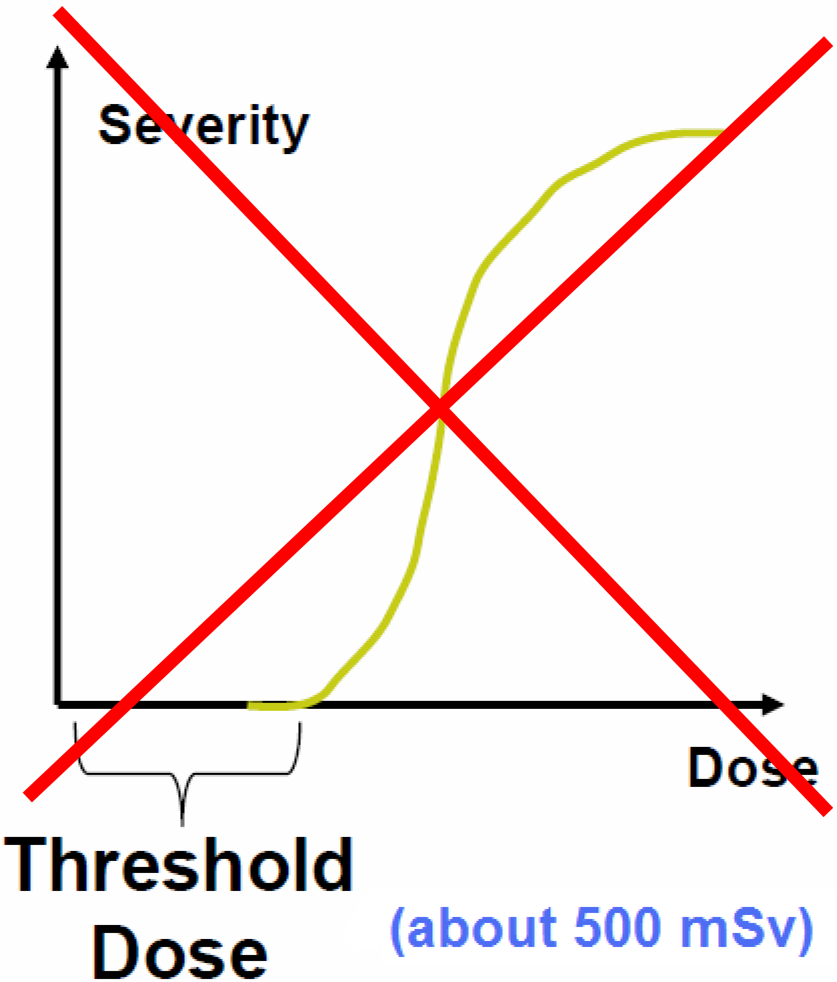
Effects of Chernobyl Disaster

- **28 workers known to have died from Radiation Sickness (deterministic effect)**
- **15 children known to have died from thyroid cancer (stochastic effect)**
- **An additional 4000 may have died from stochastic effects – we don't know for sure.**

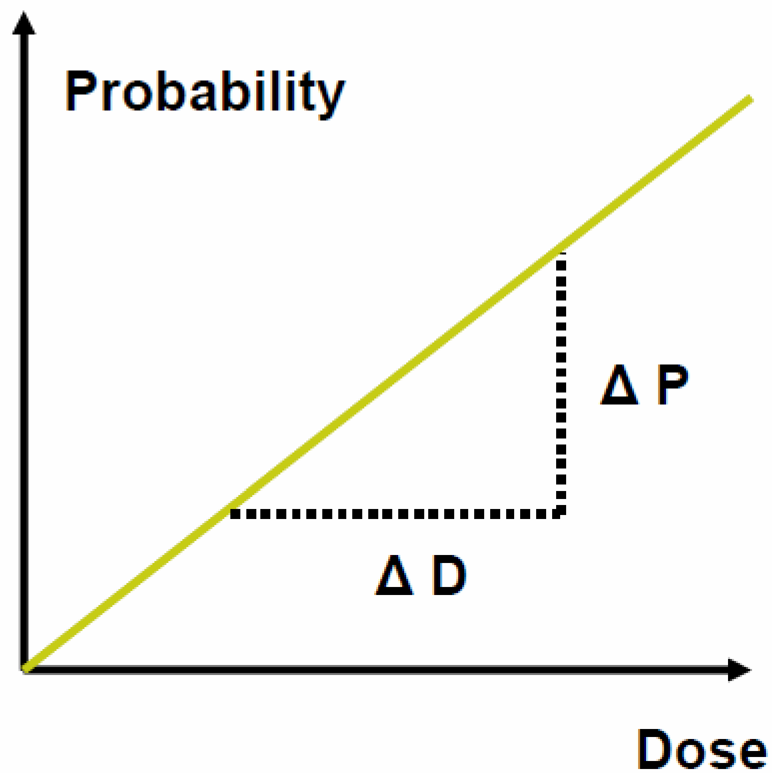
Population (years exposed)	Number	Average total in 20 years (mSv)[1]
Liquidators (1986–1987) (high exposed)	240 000	>100
Evacuees (1986)	116 000	>33
Residents SCZs (>555 kBq/m2) (1986–2005)	270 000	>50
Residents low contam. (37 kBq/m2) (1986–2005)	5 000 000	10–20
Natural background	2.4 mSv/year (typical range 1–10, max >20)	48

http://www.who.int/ionizing_radiation/chernobyl/backgrounder/en/

Deterministic Effects | **Stochastic Effects**



Should not see in dental practice!



Risk Factor = Δ P / Δ D

(about 5% per Sievert)

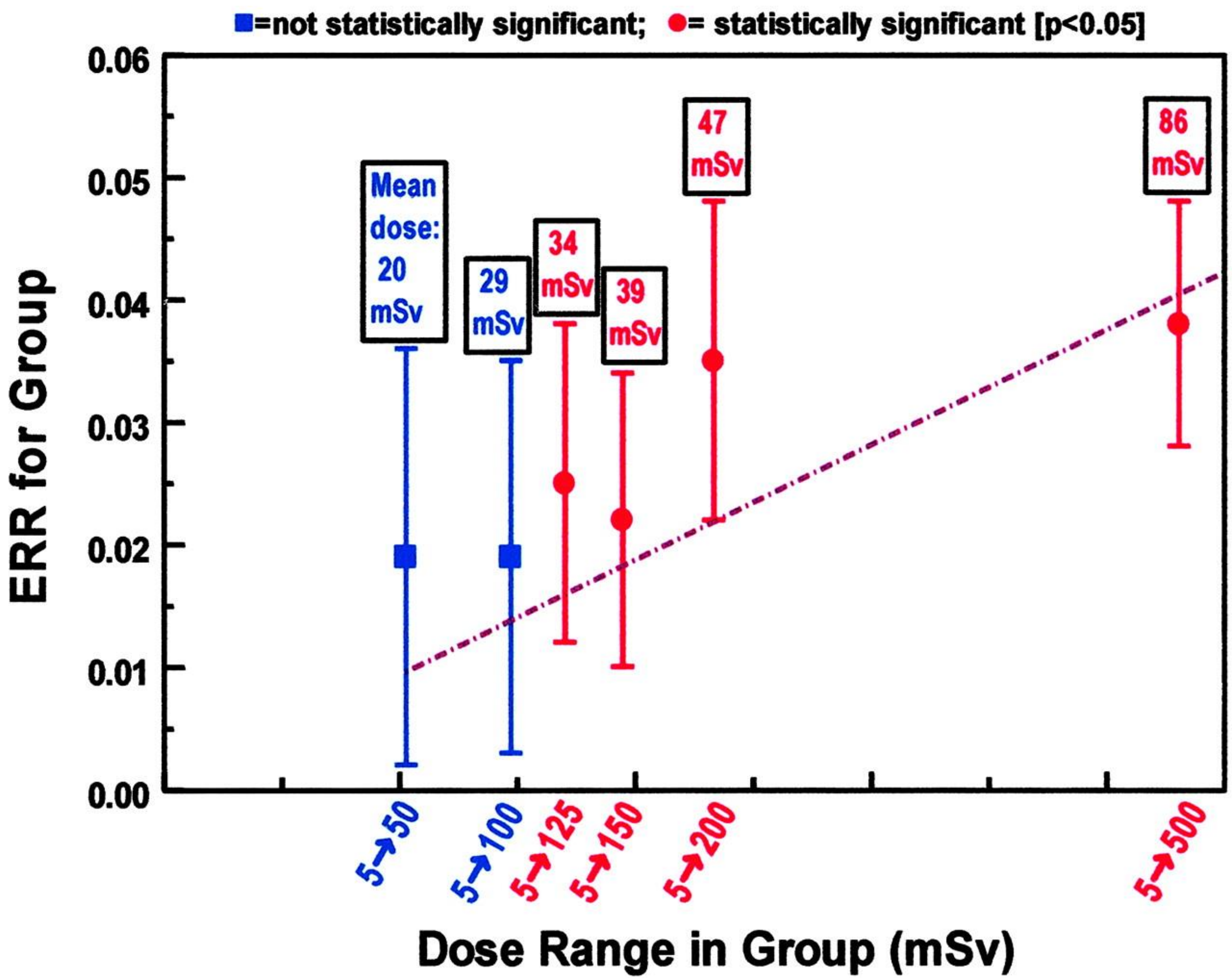
PNAS
Proceedings of the National Academy of Sciences of the United States of America

Cancer risks attributable to low doses of ionizing radiation: Assessing what we really know

David J. Brenner[a,b], Richard Doll[c], Dudley T. Goodhead[d], Eric J. Hall[a], Charles E. Land[e], John B. Little[f], Jay H. Lubin[g], Dale L. Preston[h], R. Julian Preston[i], Jerome S. Puskin[j], Elaine Ron[e], Rainer K. Sachs[k], Jonathan M. Samet[l], Richard B. Setlow[m], and Marco Zaider[n]

Contributed by Richard Doll, August 29, 2003

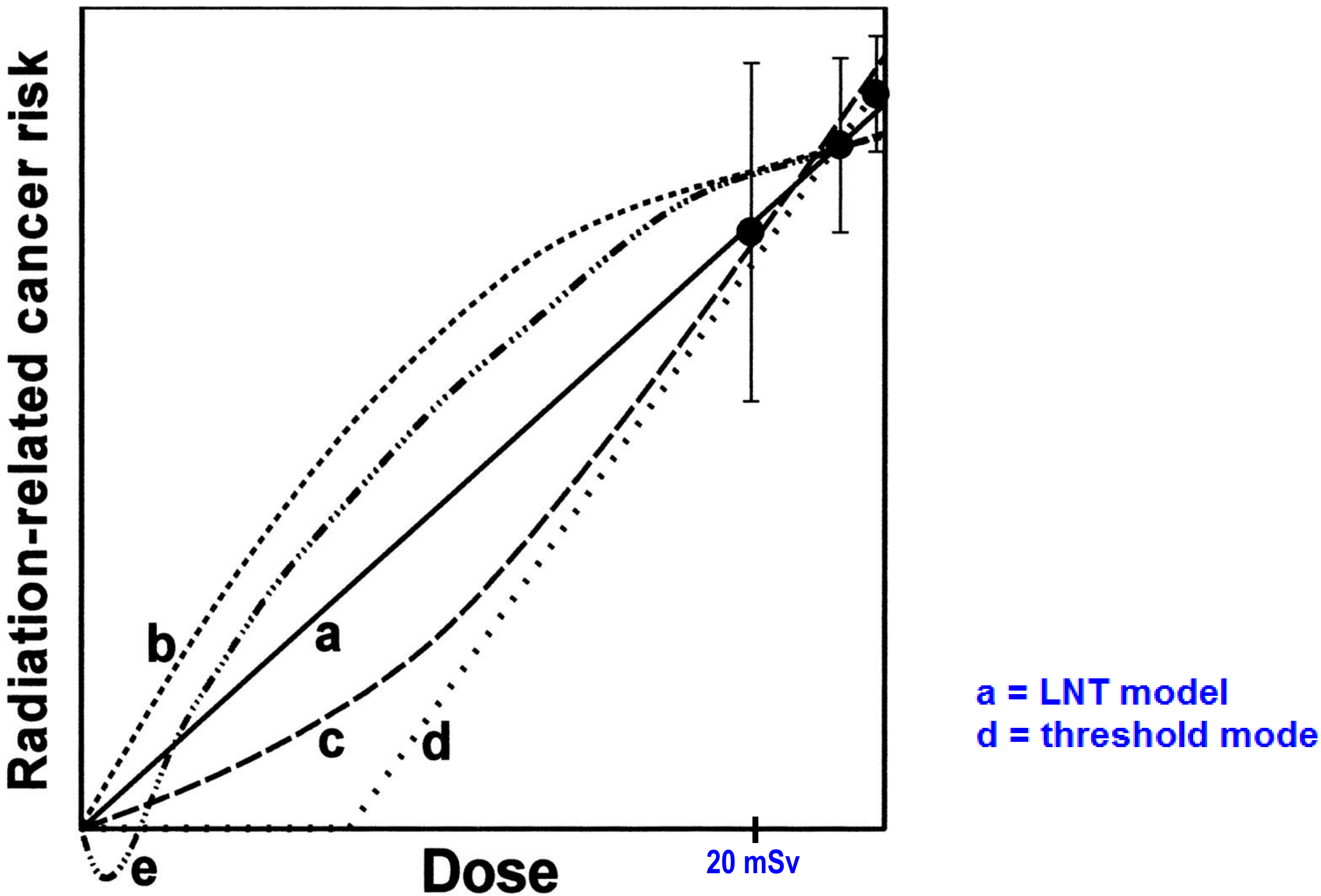
Estimated excess relative risk (±1 SE) of mortality (1950–1997) from solid cancers among groups of survivors in the LSS cohort of atomic bomb survivors, who were exposed to low doses (<500 mSv) of radiation (2).



Brenner D J et al. PNAS 2003;100:13761-13766

PNAS

Schematic representation of different possible extrapolations of measured radiation risks down to very low doses, all of which could, in principle, be consistent with higher-dose epidemiological data.



Brenner D J et al. PNAS 2003;100:13761-13766

The Linear No-Threshold (LNT) Model

Assumes that the risk of producing cancer is proportional to the dose (no safety threshold)

Assumes that cellular damage does not accumulate from one x-ray exposure to the next

Assumes that the risk for a given exposure depends only on the dose for that x-ray exposure and not on the patient's previous dose history

Assumes that x-ray exposures are independent events.

Criticism of the LNT Model

Doesn't take dose rate into account

Implies that cells do not have a repair mechanism (if they did, the curve would be less than linear and maybe have a threshold)

Implies that cellular damage does not accumulate from one x-ray exposure to the next (if it did, the curve would be greater than linear)

There is no proof that the LNT model is correct – but it is prudent to use it for Radiation Protection.

The concept of Effective Dose

We know the risks from high doses of radiation

- **e.g. Atom Bomb survivors**

- **Atom Bomb survivors received whole body doses**
- **Dental patients receive doses to a very small region**
- **How can we relate the risks?**

Effective Dose **is a way of describing the dose to a limited region in terms of the whole body dose that would result in the same risk to the patient**

Effective Dose is a measure of risk!

Effective Dose (Recap)

Absorbed Dose Energy absorbed by tissue (Gray, Gy)	1 Gray (Gy) = 1 Joule per Kilogram (J/Kg)
Equivalent Dose H_T (Sievert, Sv)	Multiply the Absorbed Dose by the Radiation Weighting factor W_R (= 1 for x-rays) to get H_T "Local Dose"
Effective Dose E (Sievert, Sv)	Multiply the Equivalent Dose H_T by the Tissue Weighting factor (W_T) for each organ, and add them up to get the Effective Dose E "Whole Body Dose"

More about Effective Dose

- **The Effective Dose calculation takes the size of the region and the body parts irradiated into account**

- **It's tempting to say "My CBCT scanner might deliver a high Effective Dose, but it's only to a very small region" but this argument is not valid.**

To obtain the Effective Dose in practice:

Method 1: Measure it!

1. **Measure Absorbed Dose to each organ of interest**

2. **Apply Radiation Weighting factor to obtain Equivalent Dose for each organ of interest**

3. **Take the weighted sum of all the Equivalent Doses.**

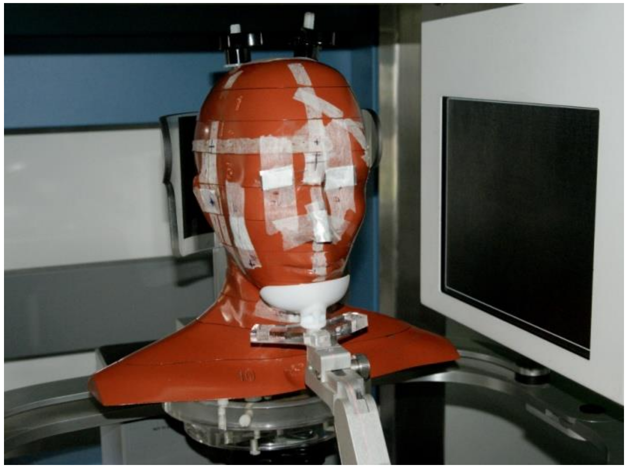
Effective Dose (E)

$$E = \sum_T H_T w_T$$

H_T = Organ Equivalent Dose
w_T = Tissue weighting factor

Unit = (Sv) Sievert
Effective Dose is proportional to risk of fatal cancer

	w_T value ICRP103
Brain	0.01
Salivary glands	0.01
Skin	0.01
Thyroid	0.04
Oesophagus	0.04
Lung	0.12
Red bone marrow	0.12
Breast	0.12
Bone surface	0.01
Liver	0.04
Stomach	0.12
Colon	0.12
Ovary	0.08
Bladder	0.04
Testes	0.08
Remainder	0.12

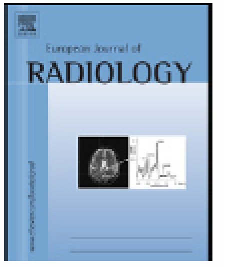


Method 2: Use published data.

Contents lists available at ScienceDirect

European Journal of Radiology

journal homepage: www.elsevier.com/locate/ejrad

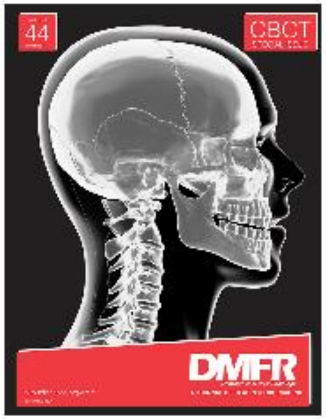


Effective dose range for dental cone beam computed tomography scanners

Ruben Pauwels[a,*], Jilke Beinsberger[a,1], Bruno Collaert[b,2], Chrysoula Theodorakou[c,d,3], Jessica Rogers[e,3], Anne Walker[c,3], Lesley Cockmartin[f,4], Hilde Bosmans[f,5], Reinhilde Jacobs[a,6], Ria Bogaerts[g,7], Keith Horner[d,8], The SEDENTEXCT Project Consortium[9]

[a] *Oral Imaging Center, School of Dentistry, Oral Pathology and Maxillofacial Surgery, Faculty of Medicine, Catholic University of Leuven, Belgium*
[b] *Center for Periodontology and Implantology, Heverlee, Belgium*
[c] *North Western Medical Physics, The Christie NHS Foundation Trust, Manchester Academic Health Sciences Centre, UK*
[d] *School of Dentistry, University of Manchester, Manchester Academic Health Sciences Centre, UK*
[e] *School of Medicine, University of Manchester, Manchester Academic Health Sciences Centre, UK*
[f] *Department of Radiology, University Hospital Gasthuisberg, Leuven, Belgium*
[g] *Department of Experimental Radiotherapy, University Hospital Gasthuisberg, Katholieke Universiteit Leuven, Belgium*

Eur J Radiol 81,2,267-271 (February 2012)



DentoMaxilloFacial Radiology

CBCT Special Issue

VOLUME 44, ISSUE 1, 2015

Dentomaxillofacial Radiology (2015) 44, 20140197

birpublications.org/dmfr

CBCT SPECIAL ISSUE: REVIEW ARTICLE

Effective dose of dental CBCT—a meta analysis of published data and additional data for nine CBCT units

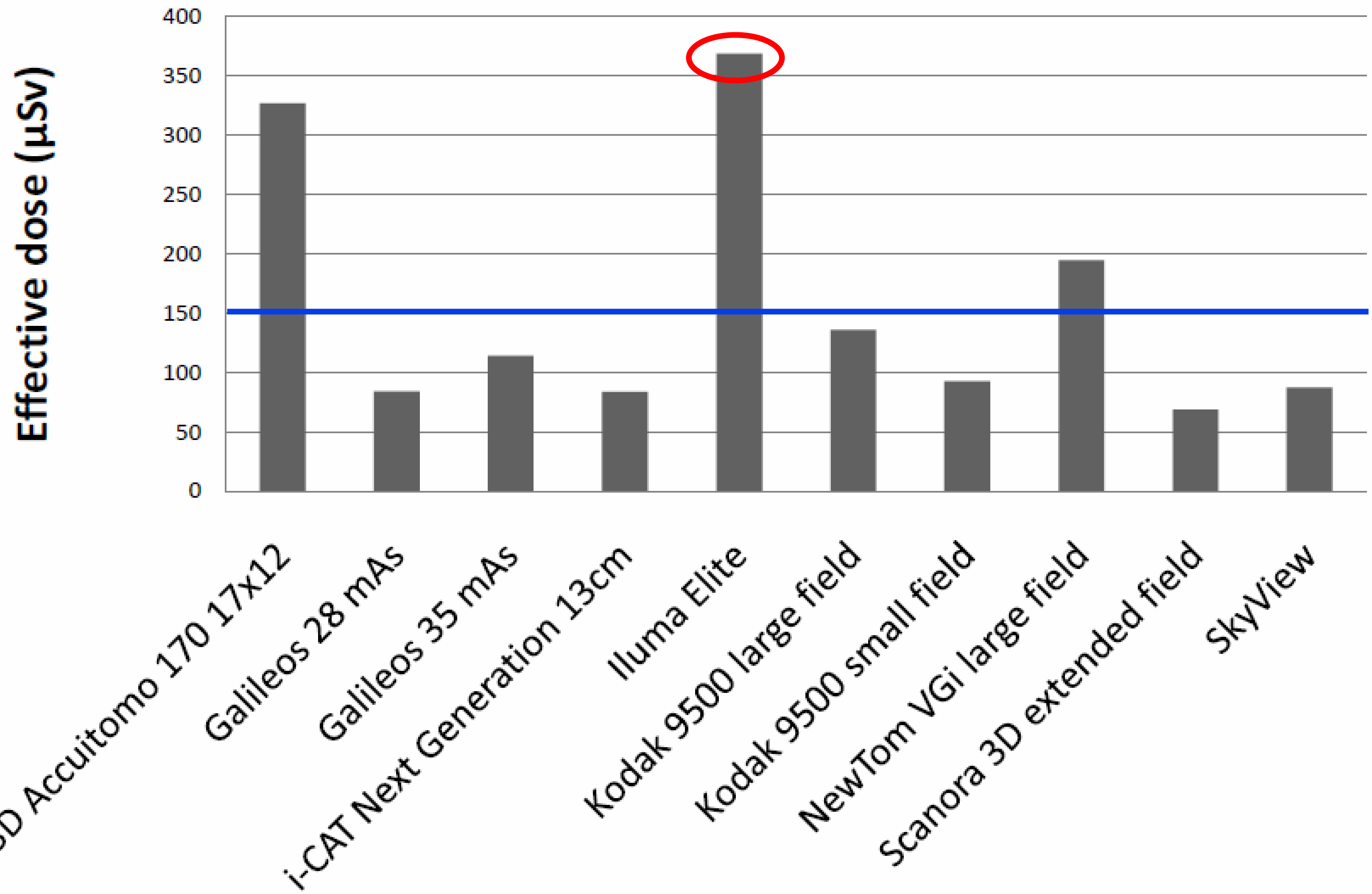
[1]J B Ludlow, [2]R Timothy, [3]C Walker, [4]R Hunter, [5]E Benavides, [6]D B Samuelson and [6]M J Scheske

[1]North Carolina Oral Health Institute, Koury Oral Health Sciences, Chapel Hill, NC, USA; [2]Graduate Program in Oral and Maxillofacial Radiology, University of North Carolina, Chapel Hill, NC, USA; [3]Department of Orthodontics, University of Missouri, Columbia, MO, USA; [4]Private Practice of Orthodontics, Houston, TX, USA; [5]University of Michigan School of Dentistry, Ann Arbor, MI, USA; [6]University of North Carolina School of Dentistry, Chapel Hill, NC, USA

SEDENTEXCT measured Effective Doses for common CBCT scanners and found they were in the range

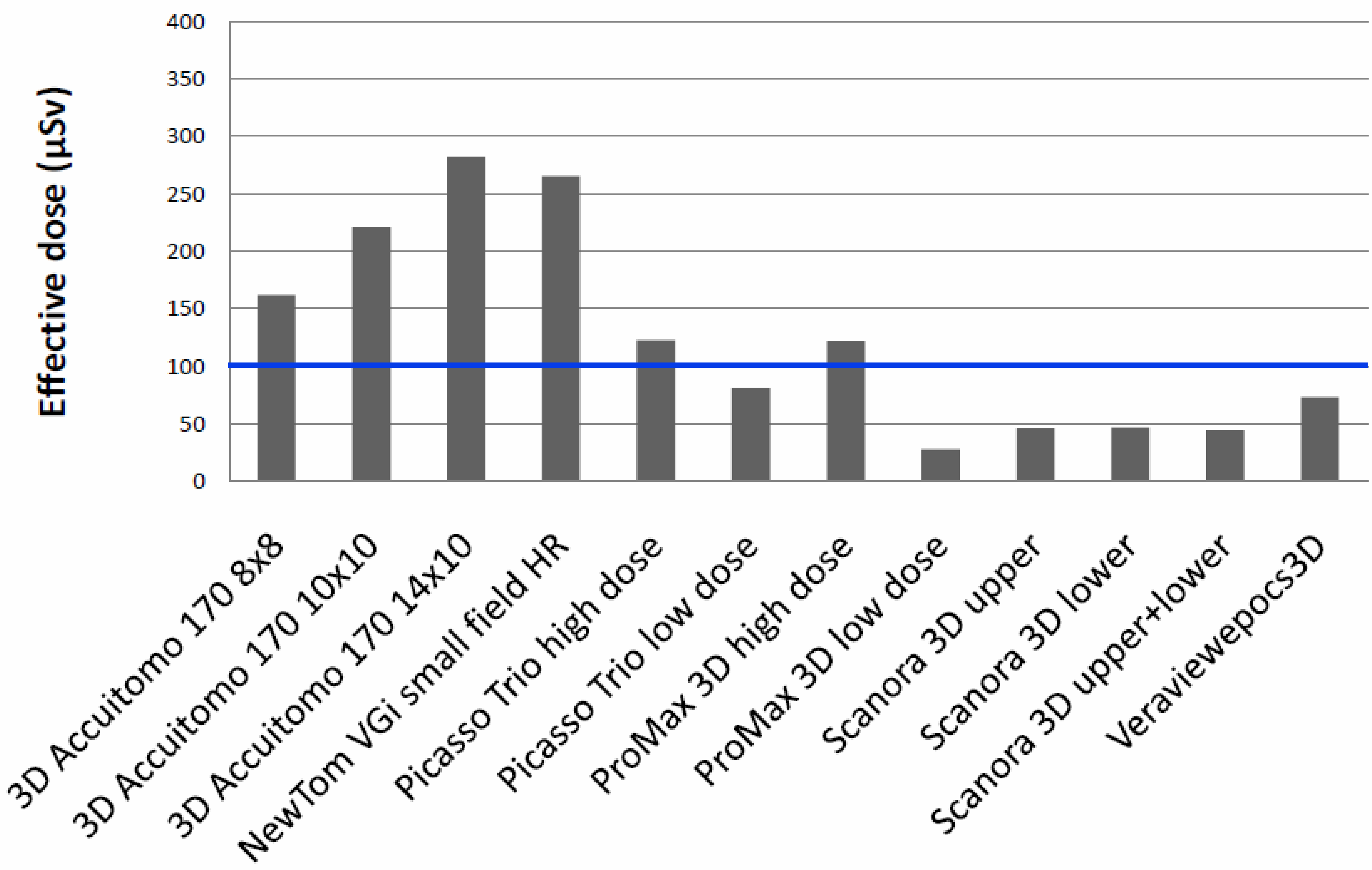
20 microSieverts to 370 microSieverts

Effective dose for large field CBCTs



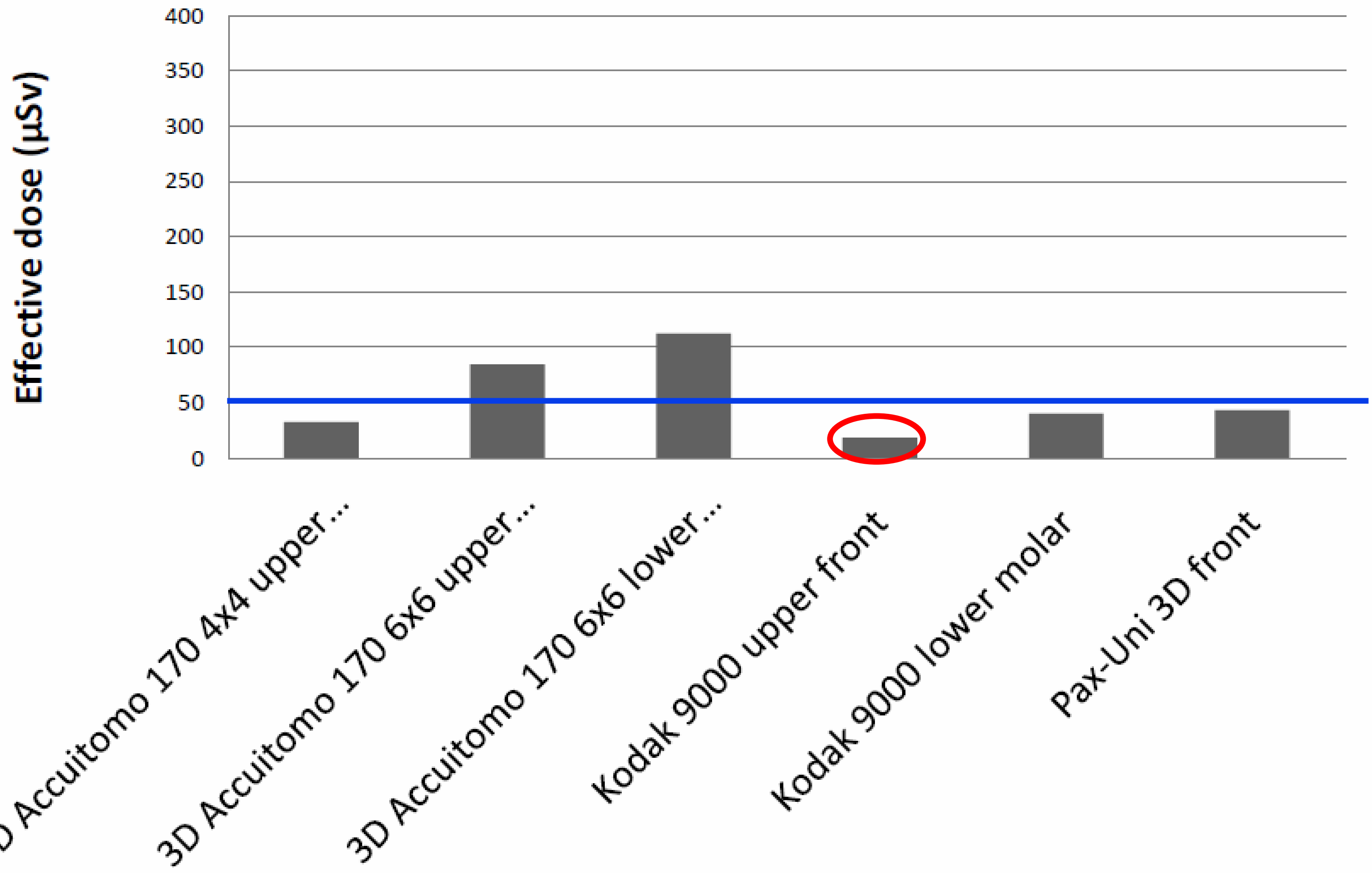
Prof. Ria Bogaerts, Katholieke Universiteit Leuven, March 2011

Effective dose for medium field CBCTs



Prof. Ria Bogaerts, Katholieke Universiteit Leuven, March 2011

Effective dose for small field CBCTs



Prof. Ria Bogaerts, Katholieke Universiteit Leuven, March 2011

Review

E.A.O. guidelines for the use of diagnostic imaging in implant dentistry 2011. A consensus workshop organized by the European Association for Osseointegration at the Medical University of Warsaw

David Harris[1,*], Keith Horner[2], Kerstin Gröndahl[3], Reinhilde Jacobs[4], Ebba Helmrot[3], Goran I. Benic[5], Michael M. Bornstein[6], Andrew Dawood[7] and Marc Quirynen[8]

Article first published online: 20 MAR 2012

DOI: 10.1111/j.1600-0501.2012.02441.x

Issue

Clinical Oral Implants Research

Volume 23, Issue 11, pages 1243–1253, November 2012

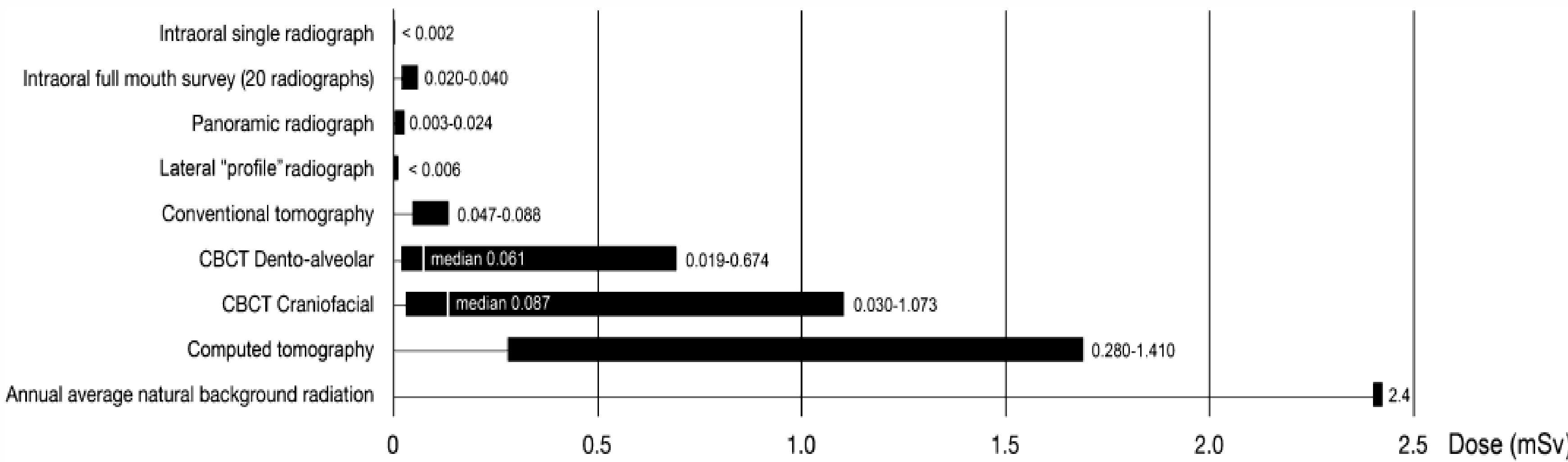


Fig. 1. Ranges of effective dose for the imaging modalities used in implant dentistry.

Method 3: Use the DAP (with caution!)

Cone Beam Computed Tomography

radiation dose and image quality assessments

Sara Lofthag-Hansen

Department of Oral and Maxillofacial Radiology
Institute of Odontology at Sahlgrenska Academy

UNIVERSITY OF GOTHENBURG

REGION VÄSTRA GÖTALAND

Gothenburg 2010

Table 5. Most commonly used exposure parameters in three specified regions and corresponding dose-are product (DAP) value and effective dose according to ICRP 60 (1991)

Region	*Volume size (mm x mm)*	*Tube voltage (kV)*	*Tube current (mA)*	*DAP value (mGy cm²)*	*Effective dose (µSv)*
Upper jaw					
Cuspid	30 x 40	80	5.0–6.0	263–316	21–25
	40 x 40	75	4.0–5.0	260–325	21–26
	60 x 60	75	4.5–5.5	645–788	52–63
Lower jaw					
Second premolar–first molar	30 x 40	75–80	3.0–6.0	140–316	11–25
	40 x 40	75	4.0–6.0	260–390	21–31
	60 x 60	75	5.0–6.0	716–859	57–69
Lower jaw					
Third molar	30 x 40	75–80	3.0–6.5	140–342	11–27
	40 x 40	75–80	4.0–5.0	260–366	21–29
	60 x 60	75–80	4.5–6.0	645–967	52–77

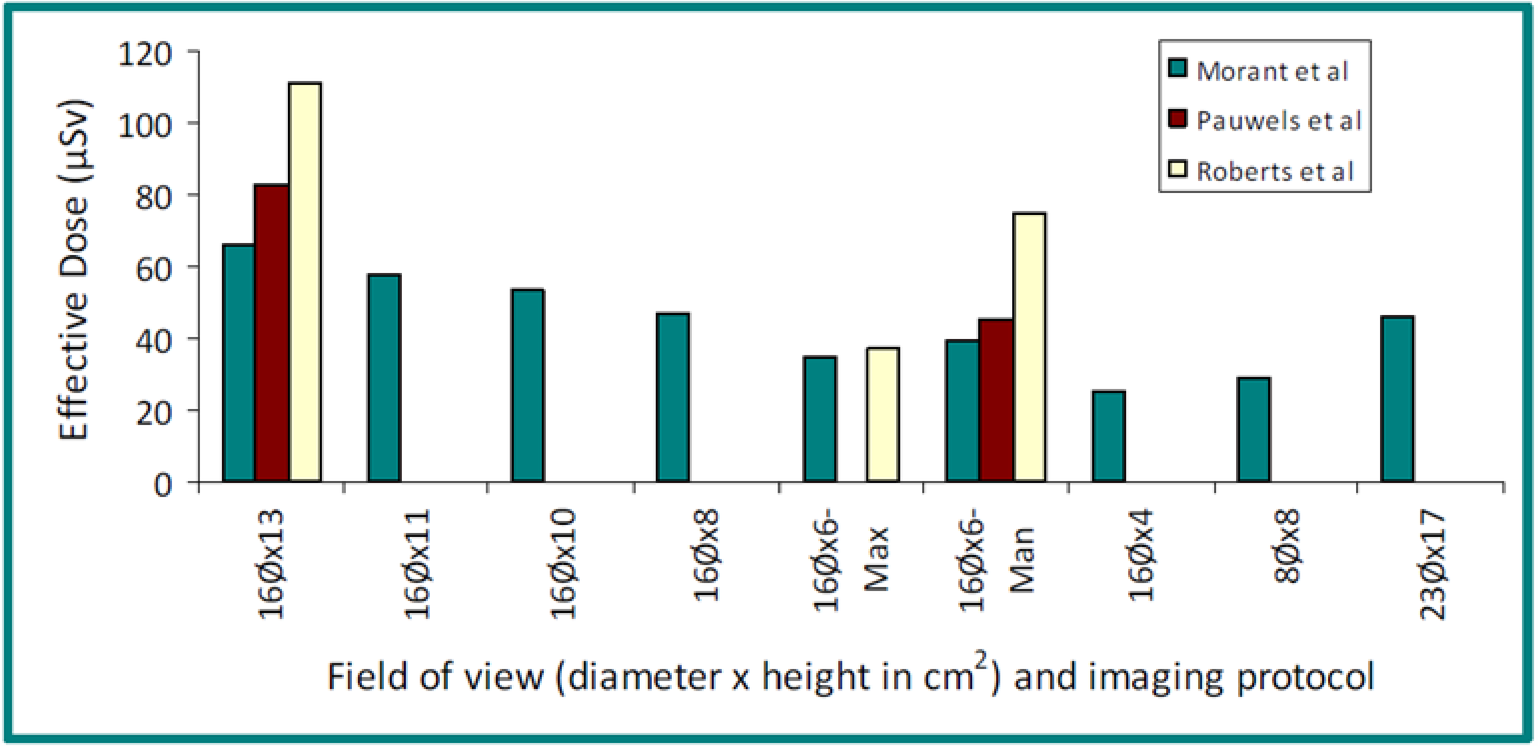
Effective Dose (µSv) = 0.1 x DAP (mGy.cm2) for **Maxilla**
Effective Dose (µSv) = 0.15 x DAP (mGy.cm2) for **Mandible**
Effective Dose (µSv) = 0.125 x DAP (mGy.cm2) for **Mn & Mx**

VERY ROUGH – USE WITH CAUTION !

Results of Monte Carlo calculations

Morant J, Salvadó M, Hernández-Girón I, Casanovas R, Ortega R, Calzado A. Dosimetry of a cone beam CT device for oral and maxillofacial radiology using Monte Carlo techniques and ICRP adult reference computational phantoms. Dentomaxillofac Radiol. 2012 Aug 29. [Epub ahead of print]

i-CAT 17-19

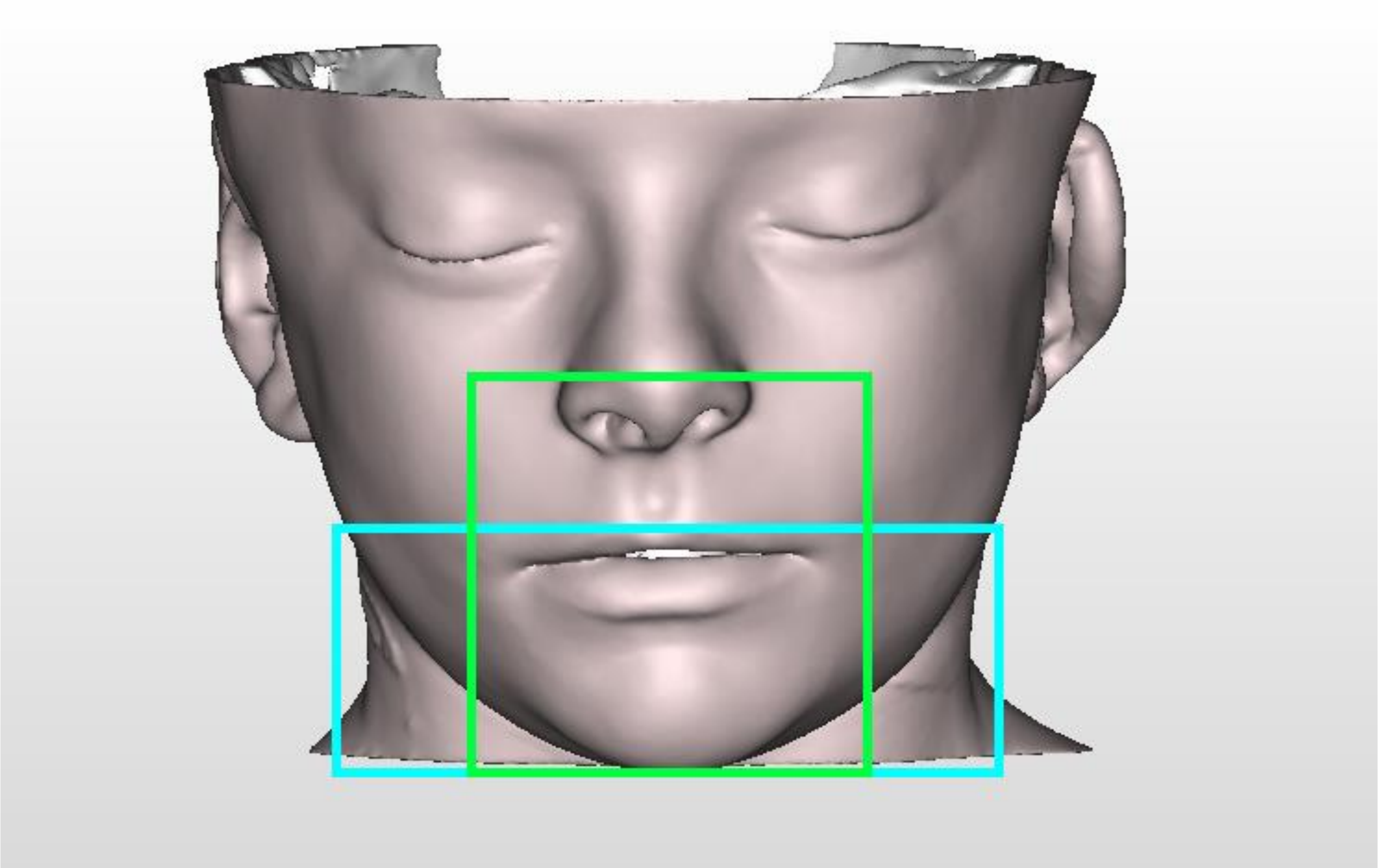


- Effective dose-DAP relationship:
  - Effective dose (µSv) = 0.130 x DAP (mGycm^2), r^2=0.994

slide from presentation by
Dr Chrysoula Theodorakou, "Dental Cone Beam Computed Tomography", BIR, London, 6 November 2012

The Christie NHS
NHS Foundation Trust

Use the DAP with caution!



- **Same DAP**
- **Different Dose**

How accurate do we need to be?

A factor of 2 change in risk is unlikely to bring about a change in the patient's management.

A factor of 10 would be in line with estimates of risk in other areas.

Cancer: science and society and the communication of risk

Kenneth C Calman

BMJ VOLUME 313 28 SEPTEMBER 1996

This article is based on the Calum Muir lecture, delivered in Edinburgh in September 1996.

Table 2—*Descriptions of risk in relation to the risk of an individual dying (D) in any one year or developing an adverse response (A)*

Term used	Risk range	Example	Risk estimate
High	≥1:100	(A) Transmission to susceptible household contacts of measles and chickenpox[6]	1:1-1:2
		(A) Transmission of HIV from mother to child (Europe)[7]	1:6
		(A) Gastrointestinal effects of antibiotics[8]	1:10-1:20
Moderate	1:100-1:1000	(D) Smoking 10 cigarettes a day[9]	1:200
		(D) All natural causes, age 40[9]	1:850
Low	1:1000-1:10 000	(D) All kinds of violence and poisoning[9]	1:3300
		(D) Influenza[10]	1:5000
		(D) Accident on road[9]	1:8000
Very low	1:10 000-1:100 000	(D) Leukaemia[9]	1:12 000
		(D) Playing soccer[9]	1:25 000
		(D) Accident at home[9]	1:26 000
		(D) Accident at work[9]	1:43 000
		(D) Homicide[9]	1:100 000
Minimal	1:100 000-1:1 000 000	(D) Accident on railway[9]	1:500 000
		(A) Vaccination associated polio[10]	1:1 000 000
Negligible	≤1:1 000 000	(D) Hit by lightning[9]	1:10 000 000
		(D) Release of radiation by nuclear power station[9]	1:10 000 000

Risk Bands

Negligible	< 1 in a million risk
Minimal	1 in 100,000 to 1 in a million risk
Very Low	1 in 10,000 to 1 in 100,000 risk
Low	1 in 1,000 to 1 in 10,000 risk

Department of Health (1995)

Dental x-rays are in the range "Negligible" to "Minimal"

ICRP 103:

“Effective dose is not recommended for epidemiological evaluations, nor should it be used for detailed specific retrospective investigations of individual exposure and risk.”

- But we use it anyway!

What is the Risk from an Intraoral x-ray?

- **Assume adult patient, F speed, rectangular collimation**
- **Effective Dose might be 2 microSieverts (worst case)**
- **Risk that patient might develop fatal cancer in 20 years time**

= 5% (1 in 20) per Sievert (from ICRP103)

= 1 in 20 million for 1 microSievert

= 2 in 20 million for 2 microSieverts

= 1 in 10 million for 2 microSieverts

Health & Safety people would call this a "Negligible Risk"

Cancer: science and society and the communication of risk

Kenneth C Calman

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		(D) Accident at home[9]	1:26 000
		(D) Accident at work[9]	1:43 000
		(D) Homicide[9]	1:100 000
Minimal	1:100 000-1:1 000 000	(D) Accident on railway[9]	1:500 000
		(A) Vaccination associated polio[10]	1:1 000 000
Negligible	≤1:1 000 000	(D) Hit by lightning[9]	1:10 000 000
		(D) Release of radiation by nuclear power station[9]	1:10 000 000

What is the Risk from a CBCT scan?

- **Assume adult patient, dento-alveolar scan, both jaws**
- **Effective Dose might be 100 microSieverts (worst case)**
- **Risk that patient might develop fatal cancer in 20 years time**

= 5% (1 in 20) per Sievert (from ICRP103)

= 1 in 20 million for 1 microSv

= 100 in 20 million for 100 microSv

= 1 in 200,000 (roughly) for CBCT scan

Health & Safety people would call this a "Minimal Risk"

*** If your patient is a child the risk is 3x more**

Risk varies with Age

Age group (years)	Multiplication factor for risk
<10	x 3
10-20	x 2
20-30	x 1.5
30-50	x 0.5
50-80	x 0.3
80+	Negligible risk

5% per Sievert at age 30

RADIATION PROTECTION N° 172 A report prepared by the SEDENTEXCT project 2011

www.sedentexct.eu

What is the Dose from a Dental CT or CBCT Scan?

- **Medical CT Scanner (using dental protocol):**
  - **About 300 µSv per jaw (20 x OPG)**
- **Cone Beam CT:**
  - **About 50 µSv per jaw (3 x OPG)**
  - **Equivalent to about 8 days of Background Radiation (per jaw)**
  - **Carries a theoretical risk of about 1 in 200,000 of inducing a fatal cancer (1 in 400,000 per jaw)**
  - **On top of 1 in 3 risk we all have already**
  - **Much safer than smoking, driving or playing soccer!**

Implant Surgery Complications: Etiology and Treatment

Kelly Misch, DDS,* and Hom-Lay Wang, DDS, MSD, PhD†

ISSN 1056-6163/08/01702-159
Implant Dentistry
Volume 17 • Number 2

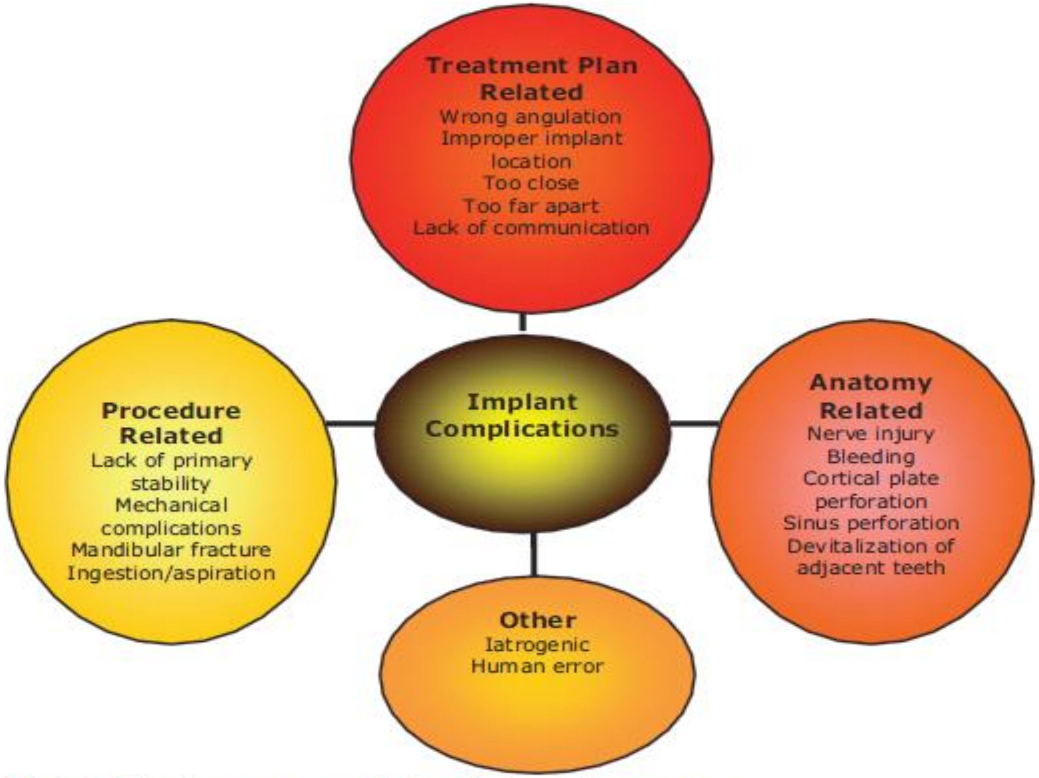


Fig. 1. Outline of common complications during implant surgery.

The Risk of Not Having a CBCT Scan

We advance the science, education and professional practice of medical physics

Professional/Education/Science Policies

POLICY NUMBER	POLICY NAME	POLICY DATE	SUNSET DATE
PP 25-A	AAPM Position Statement on Radiation Risks from Medical Imaging Procedures	12/13/2011	12/31/2016

Policy source

Policy text

The American Association of Physicists in Medicine (AAPM) acknowledges that medical imaging procedures should be appropriate and conducted at the lowest radiation dose consistent with acquisition of the desired information. Discussion of risks related to radiation dose from medical imaging procedures should be accompanied by acknowledgement of the benefits of the procedures. Risks of medical imaging at effective doses below 50 mSv for single procedures or 100 mSv for multiple procedures over short time periods are too low to be detectable and may be nonexistent. Predictions of hypothetical cancer incidence and deaths in patient populations exposed to such low doses are highly speculative and should be discouraged. These predictions are harmful because they lead to sensationalistic articles in the public media that cause some patients and parents to refuse medical imaging procedures, placing them at substantial risk by not receiving the clinical benefits of the prescribed procedures.

AAPM members continually strive to improve medical imaging by lowering radiation levels and maximizing benefits of imaging procedures involving ionizing radiation.

Typical Doses from Dental X-Rays

	Effective Dose (μSv)	Risk
Intraoral (F speed, rect coll)	2	
Intraoral (E speed, round coll)	6	
Lateral Ceph	10	
Panoramic	3 to 24	
Cone Beam CT	19 to 1073	
Medical CT (using dental protocol)	280 to 1410	

Typical Doses from Dental X-Rays

	Effective Dose (µSv)	Risk	
Intraoral (F speed, rect coll)	2	1 in 10 million	Negligible
Intraoral (E speed, round coll)	6	1 in 3.3 million	Negligible
Lateral Ceph	10	1 in 2 million	Negligible
Panoramic	3 to 24	1 in 6.7 million to 833 thousand	Negligible to Minimal
Cone Beam CT	19 to 1073	1 in 1.05 million to 1 in 19 thousand	Mimimal to Very Low
Medical CT (using dental protocol)	280 to 1410	1 in 71 thousand to 1 in 14 thousand	Very Low

Risks from Dental x-rays

- **Negligible to Very Low risk of radiation induced cancers**

- **Negligible risk of serious hereditary disease in an individual's descendants**

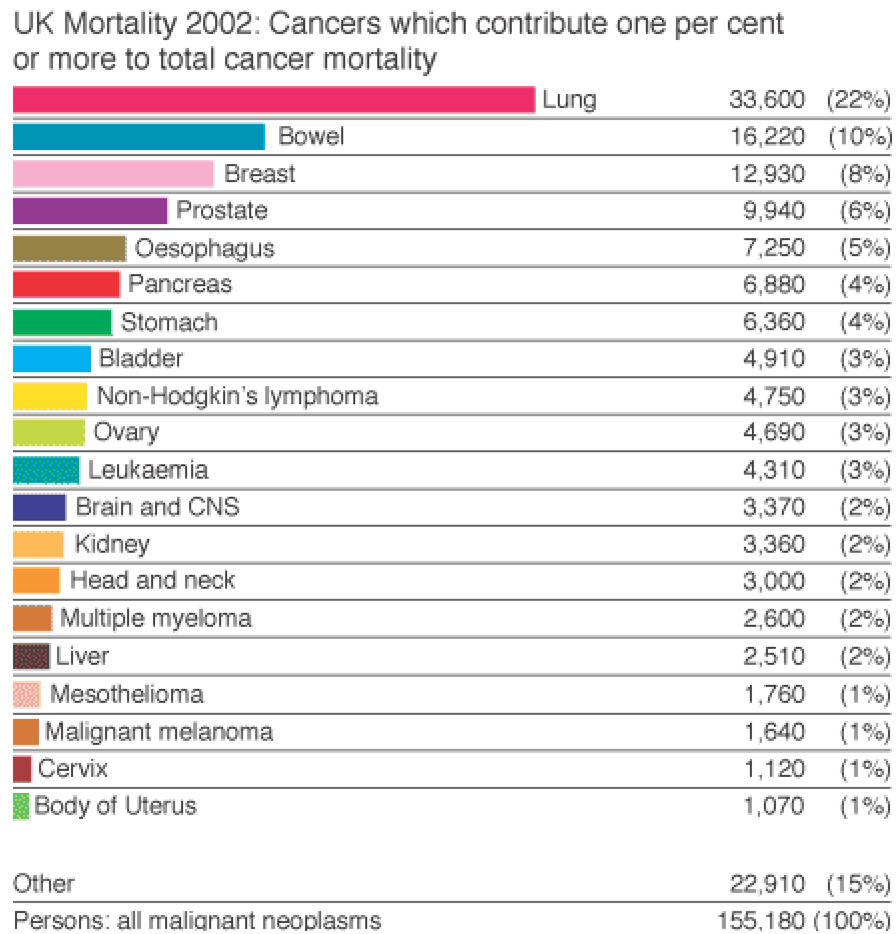
Radiation dose from x-ray exams

Examination	Effective dose (mSv)	Equivalent period of background radiation (UK)*
Dental intraoral	0.002	8 hours
Dental CBCT scan	0.10	2.4 weeks
Lumbar spine x-ray	0.70	3.8 months
Low-dose CT lung	1.30	7.2 months
CT brain	2.10	11.5 months
Barium enema	7.20	3.3 years
CT chest CT abdomen or pelvis	8.00 10.00	3.7 years 4.6 years

**UK annual background dose 2.2 mSv approx.*

If everyone in the UK had a dental CBCT scan every year ...

- ***There might be 160 extra cancer deaths per year** (if LNT is correct)*
- ***Compared to 155,000 cancer deaths from other causes***



http://www.cancerresearchuk.org/aboutcancer/statistics/mortality

Quiz - True or False?

1. **Medical CT scanners should never be used for dental CT scans.** NEVER SAY NEVER

2. **Radiation damage is cumulative.** NOT FOR DIAGNOSTIC X-RAYS

3. **The risk of cancer increases with the number of scans.** TRUE AS FAR AS WE KNOW

4. **The CBCT scan was non-diagnostic but I shouldn’t repeat it because of the dose.** FALSE

5. **My patient has had several CBCT scans already - she shouldn’t have any more.** FALSE

Outline of Lectures

- ✓ Introduction / Disclosures
- ✓ Diagnostic Imaging in Dentistry
  - Conventional Radiography
  - CT / CBCT Scans
- ✓ Quality Assurance
- ✓ Radiation Dose and Risk
- Compliance with the Legislation

Compliance with the Legislation

Anthony Reynolds BA MSc PhD
Registered Clinical Scientist CS03469

Image Diagnostic Technology Ltd.

Annals of the ICRP

PUBLICATION 103

The 2007 Recommendations of the International Commission on Radiological Protection

Editor
J. VALENTIN

PUBLISHED FOR

The International Commission on Radiological Protection

by

ELSEVIER

European Directives for Radiation Safety

- **Basic Safety Standards Directive**
  - **96/29/Euratom of 13 May 1996**
- **Medical Exposure Directive**
  - **97/43/Euratom of 30 June 1997**
- **Basic Safety Standards Directive (revised)**
  - **2013/59/Euratom of 5 December 2013**

Transposition into UK Law

Ionisation Radiations Regulations 1999 – "IRR99"

- **Exposure of members of the public (e.g. staff and visitors)**
- **Enforced by Heath and Safety Executive (HSE)**

Ionising Radiation (Medical Exposure) Regulations 2000 (amended in 2006 and 2011) – "IR(ME)R 2000"

- **Medical exposures (e.g. patients)**
- **Enforced by Care Quality Commission**

Both IRR99 and IR(ME)R 2000 were revised in 2017.

Framework for Radiation Protection

- **Based on International Commission for Radiation Protection (ICRP)**
  - **an advisory body with no formal powers**

- **Legal & Administrative Requirements**
  - **IRR 2017**
  - **IR(ME)R 2017**
  - **SI 478 of 2002 in Ireland (hasn't yet been revised to meet BSSD)**

- **Local Rules / Written Procedures at each hospital or dental practice**

- **Each professional has an individual responsibility**

Ionising Radiation Regulations 2017 (IRR 2017)

- **Regulates all use of radiation in the workplace (industry as well as medicine and dentistry)**
- **Not directly concerned with patient exposures (unless accidental)**
- **Regulated by Health and Safety Executive (HSE) not Department of Health or Care Quality Commission.**

Terminology

The Employer is the legal person responsible for compliance with IRR 2017.

The Employer could be:

- **An NHS Trust**
- **The owner of a dental practive**
- **The owner of an x-ray repair and servicing company**
- **etc.**

IRR 2017 - New System of Authorisation

- **Under IRR99 employers had to notify HSE 28 days in advance of commencing work with ionising radiation.**

- **Under IRR 2017 you just have to register in advance (doesn't specify how much in advance).**

- **Graded system under IRR2017:**
  - **Notification: work with radionuclides only**
  - **Registration: work with radiation generators including x-ray tubes. Costs £25 to register (for all sites under one Employer).**
  - **Consent: administering radiopharmaceuticals to patients (costs £25 per Employer)**

- **Must re-register (and pay a new fee) after a material change (such as change of Employer's name or address)**

IRR 2017 - New System of Authorisation

- **Employers (e.g. dental practice owners) had to register and pay £25 fee by 5 February 2018.**

- **Associates (working at someone else's practice and following the owner's rules and regulations) do not have to register.**

- **If you should have registered but haven't already done so you can register online here: https://services.hse.gov.uk/bssd/**

Employer's Duties

- **Risk Assessment – identify main radiological risks**
- **Contingency plans for reasonably foreseeable radiation accidents**
- **Keep employees and other persons' exposure ALARP (As Low As Reasonably Practical)**
- **Comply with Dose Limits**
- **Measure and/or estimate maximum annual Effective Doses**
- **Measure and/or estimate maximum annual Equivalent Doses to lens of the eye, extremities, single organ or tissue**
- **Provide adequate training for employees**
- **Appoint Radiation Protection Advisor (RPA) and consult him/her on the observance of IRR 2017**
- **Draw up Local Rules and appoint Radiation Supervisor**
- **Designate and demarcate Controlled and Supervised Areas**
- **Ensure built-in features, safety features and engineering controls are designed to keep exposure to radiation ALARP.**

Risk Assessment

A Risk Assessment is required before commencing new activities involving ionising radiation.

1. **Look for the hazards**

2. **Decide who may be harmed and how**

3. **Decide if existing control measures are adequate or if more are needed**

4. **Record the findings of the Risk Assessment**

5. **Review the Assessment periodically (e.g. once per year) and revise if necessary.**

Hierarchy of Control Measures

Control Measures should be considered in this order:

1. **Engineering Controls**
   - **Beam collimation, shielding, warning devices**

2. **Systems of Work**
   - **Controlled Areas**
   - **Local Rules**

3. **Personal Protective Equipment (should be a last resort)**
   - **Lead aprons**

Staff Protection

Based on 3 principles:

- **Distance**
  - **the further you are from the source the less radiation you receive**
  - **follows Inverse Square Law ($1/d^2$)**
- **Shielding**
  - **fixed (built into the walls) or a mobile shield**
  - **something you wear (e.g. lead apron for staff)**
- **Time**
  - **shorter exposure to radiation results in less dose.**

Staff are present 8 hours a day so it is vital to protect them.

Patient Protection

Addressed in more detail under IR(ME)R 2017.

- **lead aprons for patients not usually necessary in dental radiography**
- **you can give the patient a lead apron if it makes them feel more comfortable.**
- **thyroid shields for patients can be useful for CBCT scans.**

Members of the Public

- **Adequate shielding needs to be built into the walls, ceilings, floors, doors, windows of rooms containing x-ray equipment**
  - **if you have windows in the doors make sure they contain lead**

- **Think carefully about the best locations for waiting rooms, toilets etc**

- **Think how to prevent members of the public from walking into a Controlled Area**
  - **warning signs**
  - **radiographer stands at the door**
  - **good building design ensuring the public have no reason to walk past a Controlled Area.**

Sources of Radiation

- **Primary Beam**
  - **only the patient should be exposed to the primary beam.**
- **Tube Leakage**
  - **must be less than 1mGy/hour at 1 meter**
  - **tests are performed to ensure this.**
- **Scattered Radiation**
  - **radiation scattered from the patient**
  - **staff can protect themselves through Distance, Shielding, Time.**

Pregnant and Breastfeeding Employees

- **Breastfeeding not relevant (unless administering radiopharmaceuticals)**
- **Female employees should be advised of the importance of informing employer of pregnancy**
- **Risk Assessment should be carried out**
- **Dose to foetus must be less than 1mSv (2mSv to surface of abdomen) for the remainder of pregnancy**
- **Changes to work practices are not usually required (except for increased monitoring).**

Personal Monitors

- **Staff in dental practices usually receive a negligible radiation dose (less than 1mSv per year).**
- **Personal Monitors (film badges) are not usually necessary.**
- **However, they can be reassuring if an incident occurs.**
- **They can also be useful to prove that dose limits have not been exceeded.**

Dose Limits

- **Dose Limits are set so that risks to staff are comparable with other industries e.g. manufacturing, trade, service, government.**
- **Risk of death in “safe industries” is approximately 1 in 10,000 per year**
- **Risk to most radiation workers would be much lower than this.**

Dose Limits for Employees

Annual Dose limits (mSv)			
	Adults (over 18 yrs)	Trainee (under 18 yrs)	Other persons
Whole body	20	6	1
Lens of the eye	150	50	15
Skin	500	150	50
Hands etc.	500	150	50
Women of reproductive capacity 13 mSv averaged over the abdomen in any consecutive 3 months			

IRR 2017: Dose Limit to Lens of Eye is now 20mSv per year

Classified Persons

Employees must be "classified" if they are likely to receive:

- **An Effective Dose of more than 6mSv per year, or**
- **An Equivalent Dose to lens of eye of more than 15mSv per year, or**
- **An Equivalent Dose to extremities of more than 150mSv per year (skin, hands, forearms, feet or ankles)**

If they are Classified they must have

- **An appointed doctor**
- **A passbook if they work in another Employer's controlled environment.**

You don't want this to happen in your dental practice!

Controlled Areas

An area is *Controlled* if "special procedures designed to restrict significant exposure" are necessary.

Workloads up to 100 intra-orals or 50 DPTs:

- **Within the primary x-ray beam until sufficiently attenuated**
- **Within 1.5m of the x-ray tube and patient in any other direction.**

Dental CBCT:

- **Usually the entire room is a Controlled Area.**

Controlled Areas

Radiation Protection Advisor (RPA) will advise on:

- **Room Shielding**
- **Controlled / Supervised Areas**
- **Warning Signs**
- **Local Rules**

For dental radiography, a Controlled Area only exists while the power is on.

Local Rules

Work in a Controlled Area must be carried out according to Local Rules

Local Rules should be on display in each room where x-ray equipment is used

Employees must read Local Rules and sign an undertaking that they have been read.

Some dental practices put the Local Rules on their website.

Minimum Content

Local Rules should contain at least the following:

- Description of the Controlled Area
- Arrangements to restrict access
- Conditions under which members of the public may enter (e.g. comforters and carers)
- Instructions for safe working
- Dose investigation levels
- Contingency arrangements for foreseeable radiation accidents
- The names of the Radiation Protection Supervisor and the Radiation Protection Adviser.

Radiation Protection Advisor

- **Dental Practices must appoint a suitable RPA**
- **Must consult RPA to ensure observance of IRR 2017**
- **RPA should review radiation safety for each new x-ray installation and at least every 3 years for existing installations**
  - **e.g. adequate shielding**
  - **designation of controlled areas**
  - **training of operators**
  - **local rules / written procedures**

Radiation Protection Advisor

- **RPA is generally a physicist with certification from HSE-approved Assessing Body**
- **Usually an outside consultant**
- **Should be available for consultation (otherwise, get a different one)**
- **A list of RPAs is available at www.rpa2000.org.uk**

Radiation Protection Supervisor (RPS)

- **Where work is subject to Local Rules, employer must appoint a Radiation Protection Supervisor (RPS)**
- **Usually a member of staff who can command authority (e.g. a dentist)**
- **Should be trained to have knowledge of the Regulations and understand the precautions to be taken**
- **Legal responsibility remains with the employer.**

IRR 2017 – Differences from IRR99

An Outside Worker is someone who carries out work in the Controlled Area of an Employer other than their own

- **Includes both Classified and Non-Classified workers**
- **Service engineers, contractors etc**
- **You are responsible for their safety**
- **However, you can hand over responsibility temporarily through a Handover Procedure.**

Handover Procedure

- **Applies to x-ray equipment undergoing testing, service or repair by an external physicist or engineer**

- **Equipment is “handed over” to physicist or engineer who accepts responsibility for radiation safety during the repair**

- **Equipment is “handed back” after repair is complete**

- **Forms signed by Employer (equipment owner) and external Physicist / Engineer.**

RADIATION CONTROLLED AREA AND EQUIPMENT HANDOVER FORM

Part 1: CUSTOMER – Handover of controlled area and equipment to Company Representative

FACILITY / DEPARTMENT:		CONTROLLED AREA / ROOM:	
		EQUIPMENT:	
COMPANY CARRYING OUT WORK:		ID SEEN: YES ☐ / NO ☐	CALL REFERENCE NO:
REASON FOR HANDOVER:			
IDENTIFY KNOWN HAZARDS WITH CONTROLLED AREA OR EQUIPMENT:			

Customer: As an authorised representative of the customer, I hereby hand over the controlled area and equipment as above. Information has been exchanged to enable appropriate risk assessment to be made.		**Company:** As an authorised representative of the company, I accept responsibility of the controlled area and equipment for the reason stated above. Risk assessment will be made using the information provided and company procedures followed.	
Customer Representative:	Signature:	Company Representative:	Signature:
Date:	Time:	Date:	Time:

Part 2: COMPANY REPRESENTATIVE – Handover of controlled area and equipment to customer

Please tick all applicable categories of work carried out.

	CATEGORY OF WORK	DETAILS
☐	Routine service	
☐	Fault diagnosis / repair	
☐	Installation of part(s)	
☐	Upgrade / Modification	Hardware ☐ / Software ☐
☐	Incident response	
☐	Hazard Notice response	
☐	Clinical protocol changes	
☐	Other	

Could this work have implications for radiation safety or patient dose or image quality? *Tick all boxes that apply.*

☐ Shielding	☐ Interlocks / exposure termination	☐ Safety features / warning devices
☐ Beam quality / filtration / grid	☐ Collimation / alignment / field sizes	☐ Detector dose / dose indicator
☐ Dose curve / protocol	☐ Patient dose / dose rate / AEC	☐ Imaging quality / processing
☐ DAP / skin dose indicator	☐ Mechanical / Electronic / Scale Cal.	☐ Other - please specify:
☐ None of the above	**See visit/service report for details.**	

1. **Equipment is OPERATIONAL following work as indicated above and on the visit/service report.** ☐
2. **Equipment is PARTIALLY OPERATIONAL limitations may exist, refer to visit/service report.** ☐
3. **Equipment is NOT OPERATIONAL and MUST NOT BE USED.** ☐

Company Representative:	**Signature:**	**Customer representative:**	**Signature:**
Date:	**Time:**	**Date:**	**Time:**

Part 3: CUSTOMER – Returning equipment to use

I confirm that I have been authorised as a competent customer representative ☐

I confirm the above company provided information and associated service report have been reviewed and carried out appropriate checks in accordance with the Ionising Radiation Regulations. I confirm all required local procedures have been completed.

1. **I am satisfied that the equipment is in a satisfactory condition for use in medical exposure.** ☐
2. **I am NOT satisfied that the equipment is satisfactory for use in medical exposure.** ☐

Reason:

Actions Taken:

Customer Representative:	**Signature:**	**Date:**	**Time:**

Version 4, 03 April 2018

AXREM ASSOCIATION OF HEALTHCARE TECHNOLOGY PROVIDERS FOR IMAGING, RADIOTHERAPY & CARE
AXREM, Rotherwick House, 3 Thomas More Street, London E1W 1YZ

IRR 2017 - Employee Co-operation

Employees have a duty to co-operate with the Employer under IRR 2017.

- **Must wear and take reasonable care of Personal Protective Equipment (PPE) including dosemeters if they have been provided by the Employer.**
- **Employee may be commiting an offence under section 7 of the Health & Safety at Work Act if they fail to co-operate with their Employer.**

Ionising Radiation (Medical Exposure) Regulations 2017

Ionising Radiation (Medical Exposure) Regulations 2000 (amended in 2006 and 2011) – "IR(ME)R 2000"

- **Medical exposures (e.g. patients)**
- **Enforced by Care Quality Commission www.cqc.org.uk**

IR(ME)R 2000 was replaced by IR(ME)R 2017.

Principles of Patient Protection

- **Justification** **(benefits must outweigh the risks)**
- **Optimisation (keep doses As Low As Reasonably Practicable)**
  (consistent with the intended diagnostic purpose)
- **Dose Constraints**
  (20 mSv per year for Classified Persons)
  (1 mSv per year for members of the public)
  (no dose limits for medical exposures)
  (must set limits for research programs)
  (must set limits for carers and comforters)

Duty Holders under IR(ME)R 2000

The Employer

- provides a framework of policies and procedures

The Referrer **("Prescriber" in most EU countries)**

- **must supply sufficient clinical information to allow the exposure to be justified**

The Practitioner

- **is responsible for justifying the exposure in terms of benefits versus risks**

The Operator

- **is responsible for carrying it out safely.**

Employer

- **Employers (e.g. practice owners, or Trusts) must set up written policies and procedures**
- **They must also identify those individuals who can refer patients.**
- **As a minimum, this would be a list of dentists they agree to accept referrals from.**
- **Best Practice would be to have a written Service Level Agreement (SLA) between the referring dentist and the practice owner / Trust.**

Employer's Procedures

- Correctly identify patient to be exposed
- Establish whether the patient may be pregnant
  (not a contra-indication for dental x-rays in most cases)
- Identify individuals entitled to act as referrer, practitioner, operator
- Record an evaluation for each exposure including factors relevant to patient dose
- Ensure accidental or unintended exposures are kept ALARP
- Set Dose Constraints for Carers and Comforters
- Set Dose Constraints for Research Programs.

Employer's Procedures

- **Ensure referrer, practitioner and patient are informed of any significant accidental or unintended exposure**
- **Document procedures to be observed for non-medical exposures (medico-legal, insurance, sports medicine …)**
- **Dose Constraints and guidance for exposure of carers and comforters**
- **Wherever practical and prior to an exposure, provide the patient with information relating to benefits and risks**
- **Ensure that QA programmes (written procedures, written protocols) are followed**
- **CT/CBCT equipment installed after 5 Feb 2018 must have the capacity to transfer all dose related parameters to the patient's exposure record.**

Informed Consent

- We must convey information on the benefits and risks to those likely to be affected by it.

- We must not tell them:
  - What is not understood
  - What cannot be remembered
  - What is not believable
  - What is not relevant (Prof Jim Malone)

- For dental radiography, informative leaflets in the waiting room would usually be sufficient.

Accidental or Unintended Exposures

- **“Significant events” (not defined) must be analysed, recorded and reported (including near misses)**
- **Includes equipment or procedural failures**
- **Duty of candour to disclose “clinically significant” (not defined) events to patient, referrer, practitioner “professionals involved with the care of the patient”**
- **If not in patient’s best interests to inform patient then representatives must be informed instead.**

Dose Reference Levels (DRLs)

- **Local DRLs should be set for each type of x-ray procedure**
- **Local DRLs should not normally exceed National DRLs**
- **For intra-orals the National DRL is 1.7 mGy (entrance dose)**
- **For DPTs the National DRL is 67 mGy.cm for children and 93 $mGy.cm^2$ for adults (Dose Area Product, DAP)**

Estimates of Population Doses

- **Employers must collect dose estimates and provide these (when requested) in a form that allows generation of National DRLs**

Practitioner

- Practitioner must decide if the exposure is justified (i.e. the benefits must outweigh the risks)
- Must take into account the objectives of the exposure and the characteristics of the patient
- Is there another way to obtain the required information?
- What do the Referral Guidelines say?
- Urgency of the procedure
  (e.g. pregnant women may prefer to postpone it).

Justifying the Exposure

- **There must be procedures to ensure that a clinical evaluation of the outcome of the exposure is carried out and recorded**

- **If it is known, prior to the exposure, that no clinical evaluation will occur then the procedure cannot be justified and the exposure must not take place**

- **If exposure will not change the patient's management it cannot be justified and must not take place.**

Referrer

- ***Referrers*** **may prescribe (request) x-ray examinations.**
- **They must be registered health care professionals.**
- **They must provide sufficient clinical information to substantiate the need for an x-ray examination.**
- **A history and clinical examination of the patient is essential prior to any request for an exposure.**
- **Previous x-ray examinations should also be investigated**
- **“Routine” x-rays are not allowed.**

Operator

- ***Operators*** **are responsible for carrying out the exposure safely.**
- **They should ensure the dose from the exposure is as low as reasonably practicable and consistent with the intended diagnostic purpose**
  - ***dose should not be so low as to give non-diagnostic images***
- **There should be written protocols in place for each type of examination**
- **If the dose is above the Diagnostic Reference Levels (DRL) the reason should be recorded.**

Medical Physics Expert (MPE)

Under IRR 2017 dental practices have to appoint an RPA

Under IR(ME)R 2017 they have to appoint an MPE (who will often be the same person):

- **MPE to be available for consultation on Optimisation**
- **Give advice on radiological equipment**
- **Setting of local DRLs**
- **Establish and maintain QA programme**

A list of RPAs and MPEs is available at www.rpa2000.org.uk

Optimisation

Want to Optimise

$$\frac{\text{Benefit to Patient*}}{\text{Risk to Patient}}$$

*** not to the dentist!**

CBCT Scans

Risk

- Exposure to ionising radiation
- Might induce a cancer
- Might induce a hereditary defect

Benefit

- Accurately pre-plan the treatment
- Less risk of damaging a critical structure
- Reduce operating time
- Improved aesthetic results

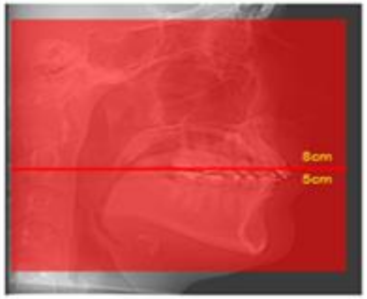
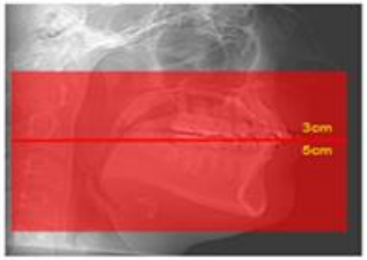
Clinical  Decision

Practical ways to Reduce the ~~Risk~~ Dose

CBCT Scans:

1. **Reduce the Height (vertical collimation)**

   Reduces the risk without loss of benefit in most cases.

	Full face 13cm height x 16cm diameter 83 microSieverts
	Both arches 8cm height x 16cm diameter 56 microSieverts (interpolated)
	Mandible 6cm height x 16cm diameter 45 microSieverts

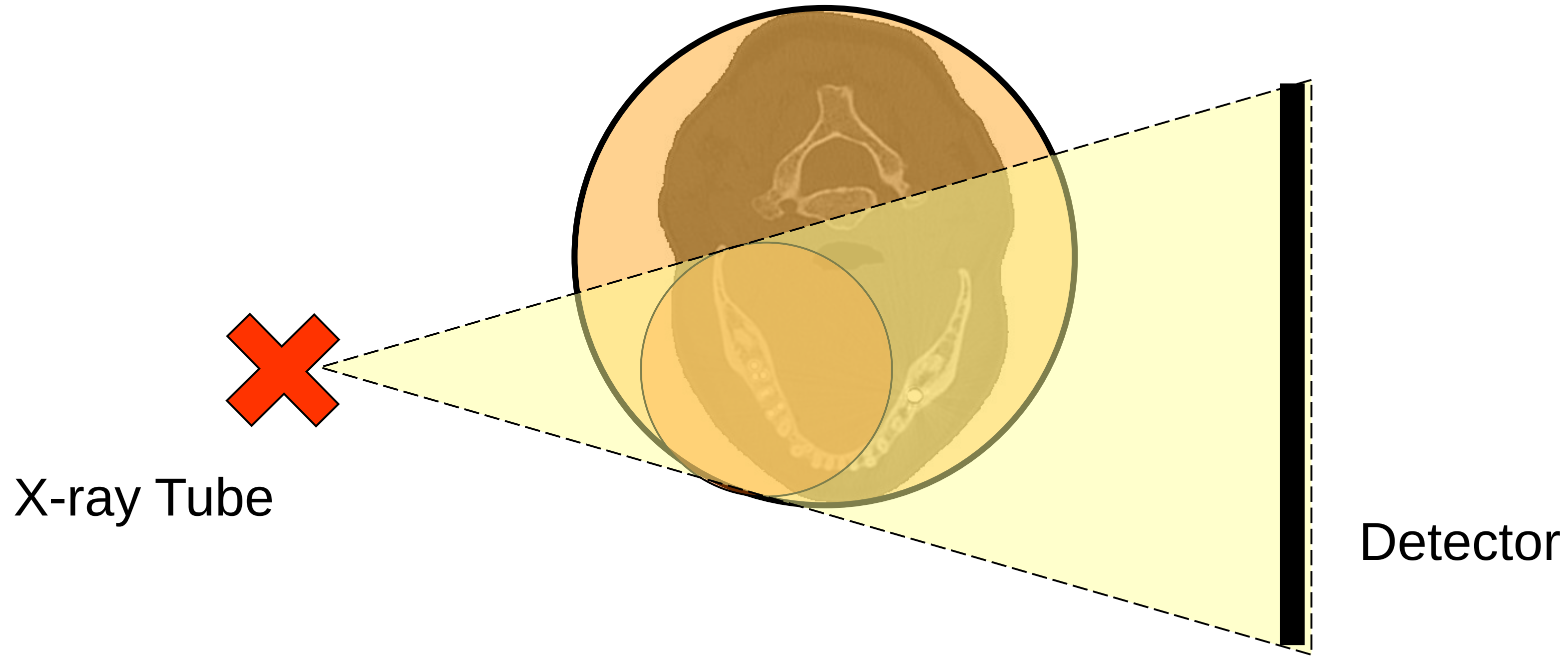
Absorbed Dose outside primary beam is effectively zero

CBCT Scans

2. **Reduce the mAs (tube current, scan time)**

- **Reducing the mAs may have a negative impact on image quality**
- **On some scanners, the voxel size is linked to the mAs**

3. Reduce the Width (horizontal collimation)



- **Absorbed Dose outside primary beam is not zero (about 50% from SEDENTEXCT measurements)**
- **There may be some loss of benefit**

Notes e.g. specific imaging parameters / protocols / concerns..............................

PLEASE AVOID SCANNING THE SPINE

"Sorry mate – no can do!"

Summary of Changes in IR(ME)R 2017

- **Evolution of IR(ME)R 2000, not revolution**
- **Now covers non-medical imaging using medical radiological equipment (replaces "medico-legal exposures")**
- **Doses to "comforters and carers" must be justified and optimised and are subject to constraints**
- **Clarification of Medical Physics Expert (MPE) role**
- **Equipment QA is now addressed in IR(ME)R instead of IRR.**

Training Requirements – IRR 2017 and IR(ME)R 2017

- **Employers must maintain an up-to-date record of training, available for inspection, with date and nature of training recorded.**

Practitioner Training

Practitioners **must have received adequate training both in radiation safety and clinical aspects (e.g. selection criteria)**

- for dentists this would normally be a degree course
- must keep up to date with CPD

Operator Training

Operators **must have received adequate training specific to the tasks that they undertake**

- ***dental nurses, hygienists, therapists etc required to take x-rays would normally require the Certificate in Dental Radiography or equivalent***
- ***must receive training on practical aspects of operating the equipment***
- ***must keep up to date with CPD***

Referrer Training

There are no specific requirements in IR(ME)R 2017 for Referrer training, however, many people believe that training of Referrers would be beneficial, especially for Dental CBCT.

Dentomaxillofacial Radiology (2014) 43, 20130291

http://dmfr.birjournals.org

SHORT COMMUNICATION

Basic training requirements for the use of dental CBCT by dentists: a position paper prepared by the European Academy of DentoMaxilloFacial Radiology

J Brown[1], R Jacobs[2], E Levring Jäghagen[3], C Lindh[4], G Baksi[5], D Schulze[6] and R Schulze[7]

[1]King's College London—Dental Institute, Dental Radiology, Guy's Hospital, London, UK; [2]OMFS IMPATH Research Group, Department of Imaging and Pathology, Faculty of Medicine, University of Leuven, Leuven, Belgium; [3]Oral and Maxillofacial Radiology, Department of Odontology, Umeå University, Umeå, Sweden; [4]Department of Oral and Maxillofacial Radiology, Faculty of Odontology, Malmö University, Malmö, Sweden; [5]Department of Oral and Maxillofacial Radiology, Ege University, School of Dentistry, Bornova, Izmir, Turkey; [6]Dental Diagnostic Center, Freiburg, Germany; [7]Department of Oral Surgery (and Oral Radiology), University Medical Center of the Johannes Gutenberg—University Mainz, Mainz, Germany

Royal College of Surgeons
ADVANCING SURGICAL CARE

https://www.rcseng.ac.uk/education-and-exams/courses/

Saturday 9 June 2018 £340

Dental CBCT Course for Referrers

Cone Beam Computed Tomography (CBCT) is increasingly common in hospital and general dental practice. This course is based on the Level 1 training criteria published in the latest European EADMFR guidelines. Upon completion participants will have fulfilled their legal and ethical responsibilities.

The course is hosted by the RCS and the British Society of Dental and Maxillofacial Radiology and is delivered by experienced consultant dental maxillofacial radiologists.

Saturday 19 October 2018 £450

Basics of Dentoalveolar CBCT Interpretation

This hands-on course is designed to train dentists to interpret and write reports on CBCT scans limited to dento-alveolar regions. The course content is modified from the "Level 2" training criteria published in the latest European guidelines.

This course is jointly hosted by the British Society of Dental and Maxillofacial Radiology (BSDMFR) and the Royal College of Surgeons of England and is delivered by experienced consultant dental maxillofacial radiologists.

Radiology Reports

- **IR(ME)R 2017 requires a *clinical evaluation* of the outcome of each exposure (other than for carers and comforters) and that this must be *recorded.***
- **There is no legal requirement to send the images to a Radiologist for reporting**
- **If you have received sufficient training, it is good practice to report on the images yourself**
- **If you haven’t received sufficient training, or if you suspect pathology may be present, it is good practice to send the images to a Specialist in Dental and Maxillofacial Radiology for a Report.**

Due Diligence

- **“In any proceedings against any person for an offence consisting of the contravention of these Regulations it is a defence for that person to show that the person took all reasonable steps and exercised all due diligence to avoid committing the offence”**
- **Document everything!**

Guidance Documents

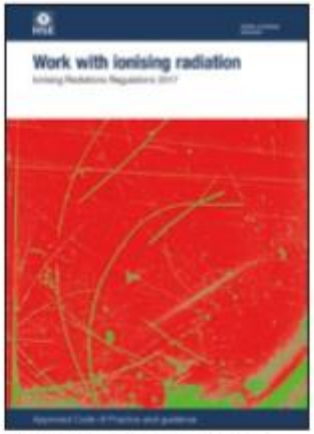
- **New Approved Code of Practice L121 (costs £27)**
  www.hse.gov.uk/pubns/priced/l121.pdf

- **Revised Medical and Dental Guidance Notes – to be published.**

- **Guidance Notes for Dental Practitioners on the Safe Use of X-Ray Equipment – no updates planned.**

- **IR(ME)R Companion Guide – to be published.**

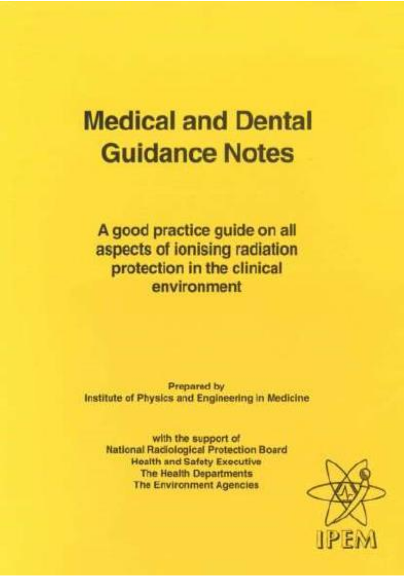
- **IR(ME)R 2017 legislation is available here:**
  www.legislation.gov.uk/uksi/2017/1322/contents/made



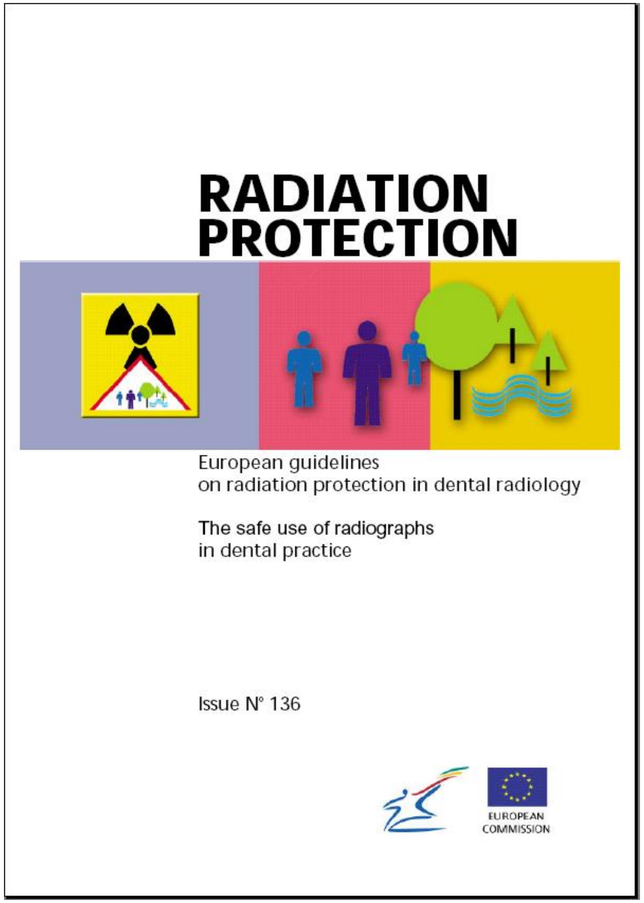
L121 (Second edition)
Published 2018

Medical and Dental Guidance Notes

- Provide general guidance on good practice
- Not an attempt to interpret legal requirements
- Following the guidance is not compulsory but should be sufficient to comply with the law
- Covers IR99, IR(ME)R 2000, equipment
- To be revised for IRR 2017 and IR(ME)R 2017



IPEM 2002
Costs £20

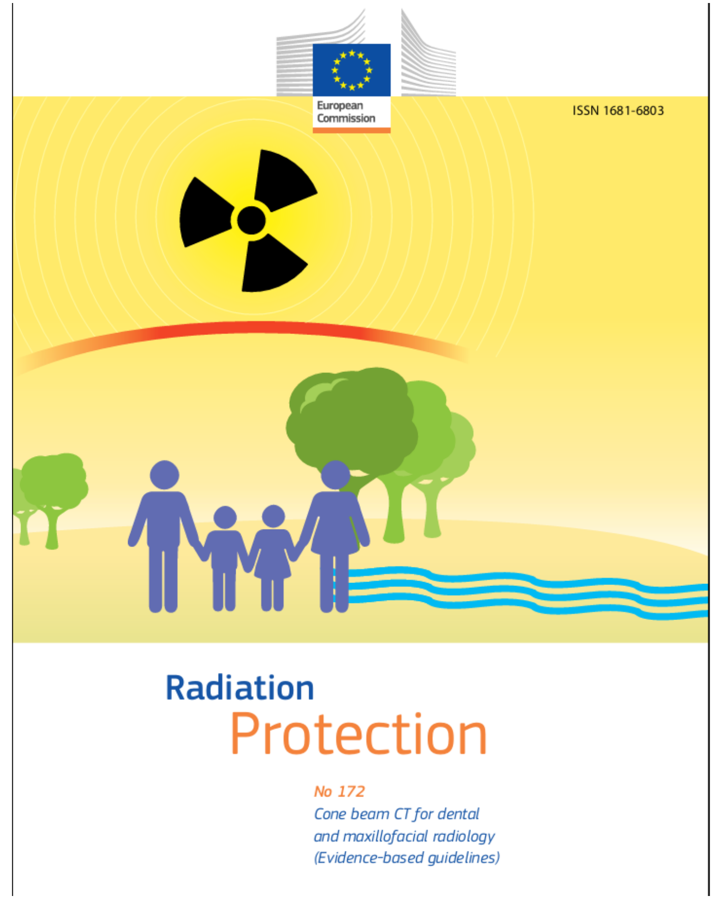

RADIATION PROTECTION

European guidelines
on radiation protection in dental radiology

The safe use of radiographs
in dental practice

Issue N° 136

EUROPEAN COMMISSION


European Commission

ISSN 1681-6803

Radiation
Protection

No 172
Cone beam CT for dental
and maxillofacial radiology
(Evidence-based guidelines)

http://europa.eu.int/comm/energy/nuclear/radioprotection/publication/doc/136_en.pdf