IDT

making the most of your image™

Image Diagnostic Technology Ltd

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Diagnostic Imaging and Radiation Safety

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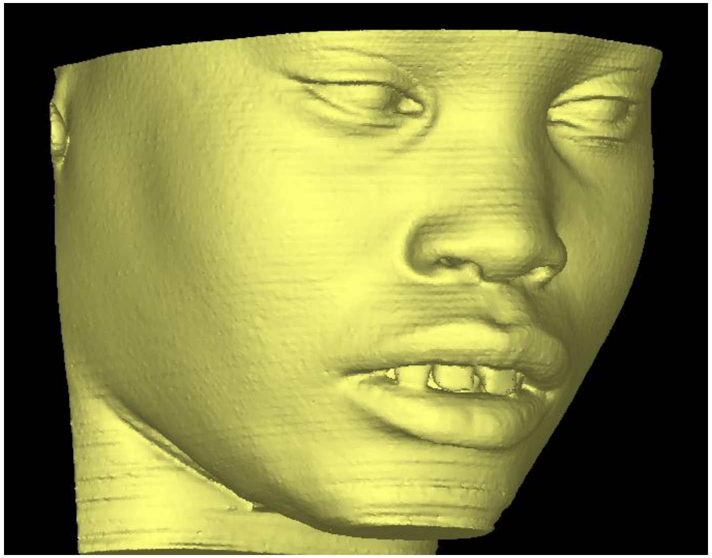
Registered Clinical Scientist CS03469
Medical Physics Expert ICPM 877781

Image Diagnostic Technology Ltd.

Who or what is IDT?

Image Diagnostic Technology Ltd aka "IDT Scans"

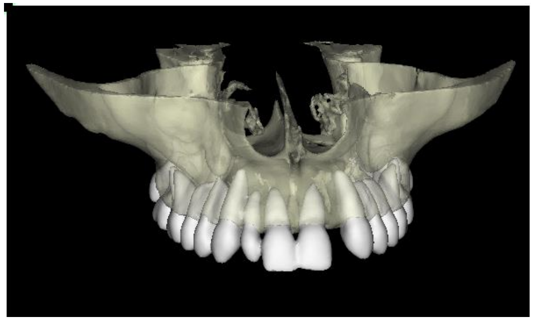


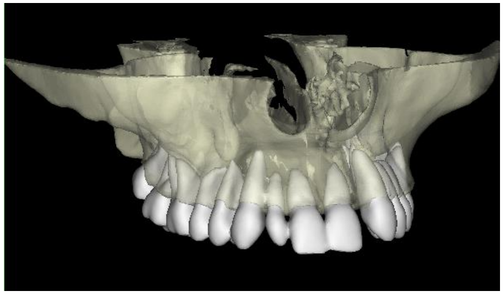
Specialises in:

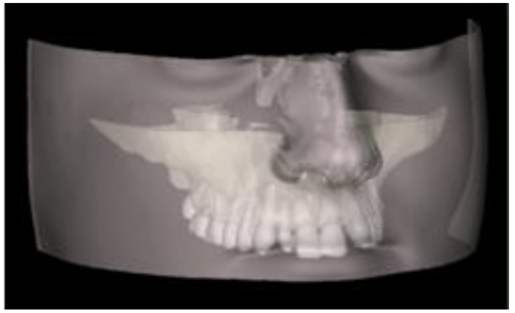
- **arranging dental CT/CBCT scans**
- **3D processing for Simplant**
- **radiology reports**
- **implant simulation**
- **3D models**
- **surgical drill guides**

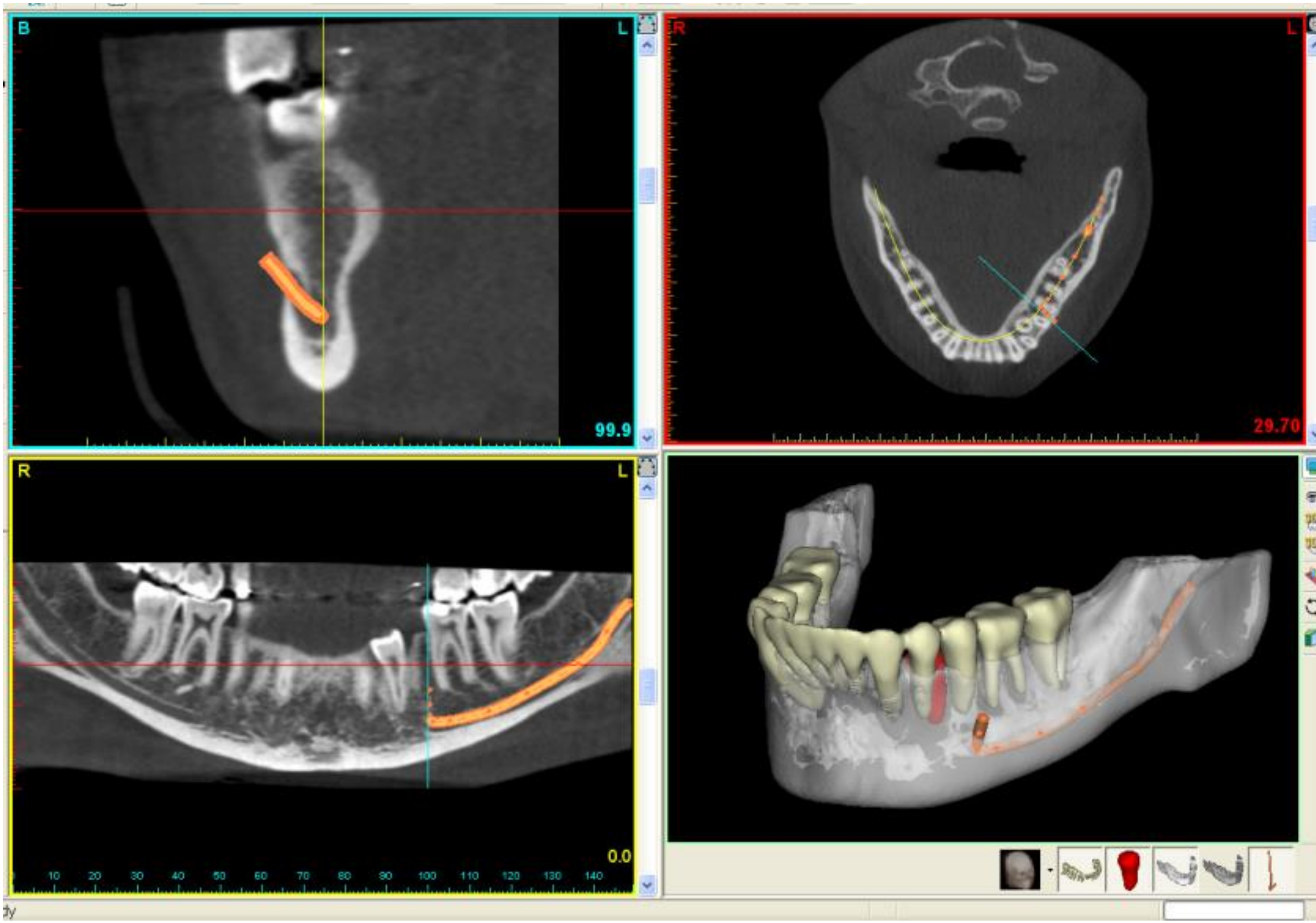
35,000 scans processed since 1991

Segmentation









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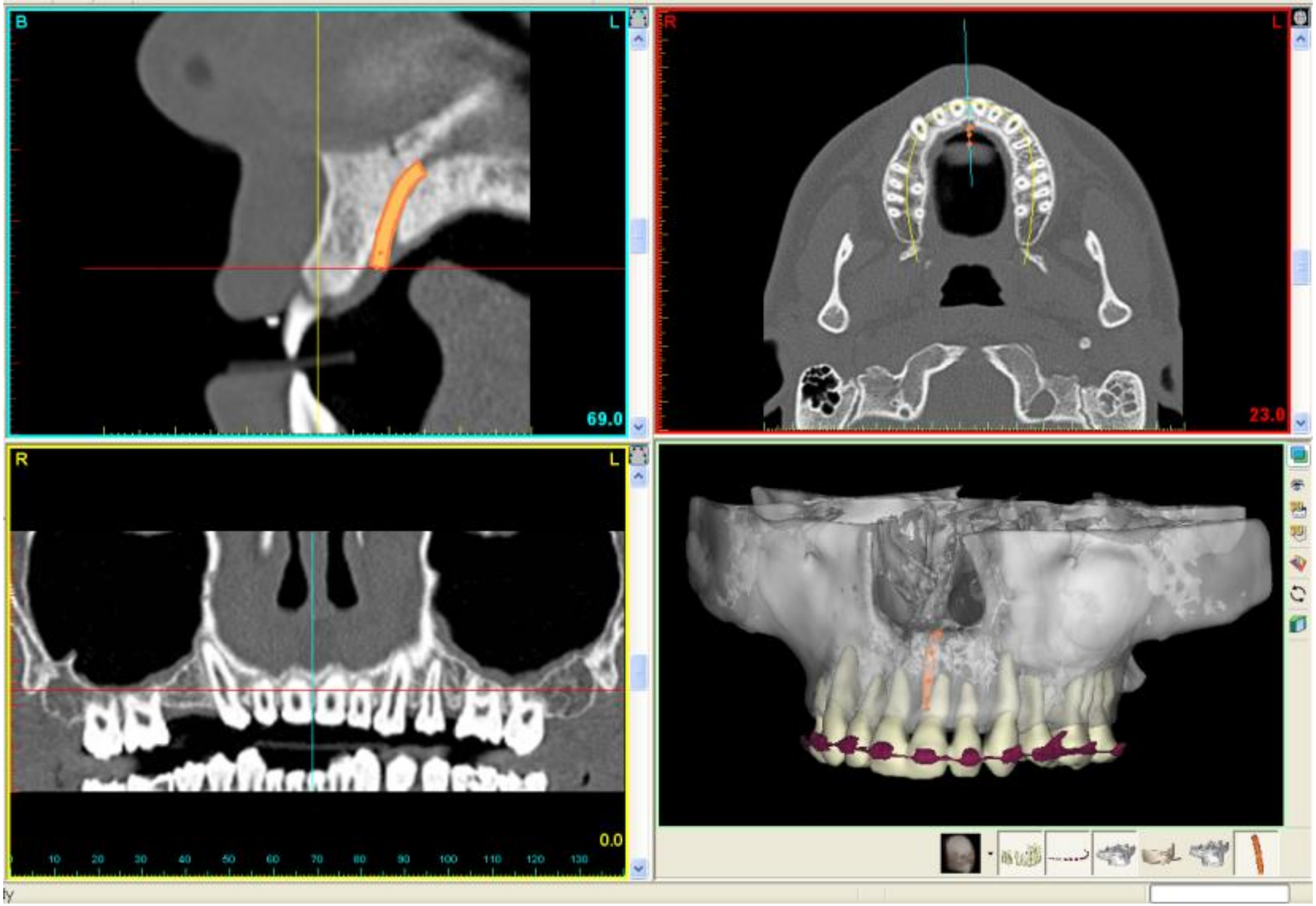

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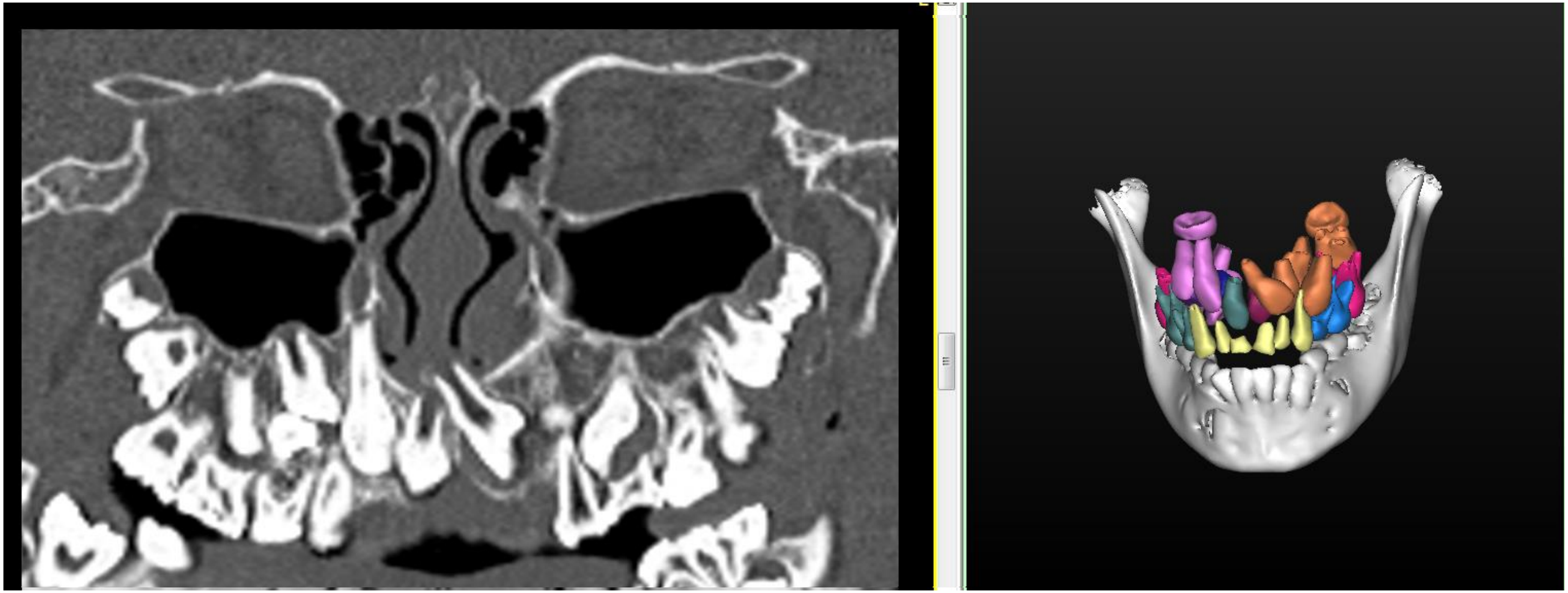
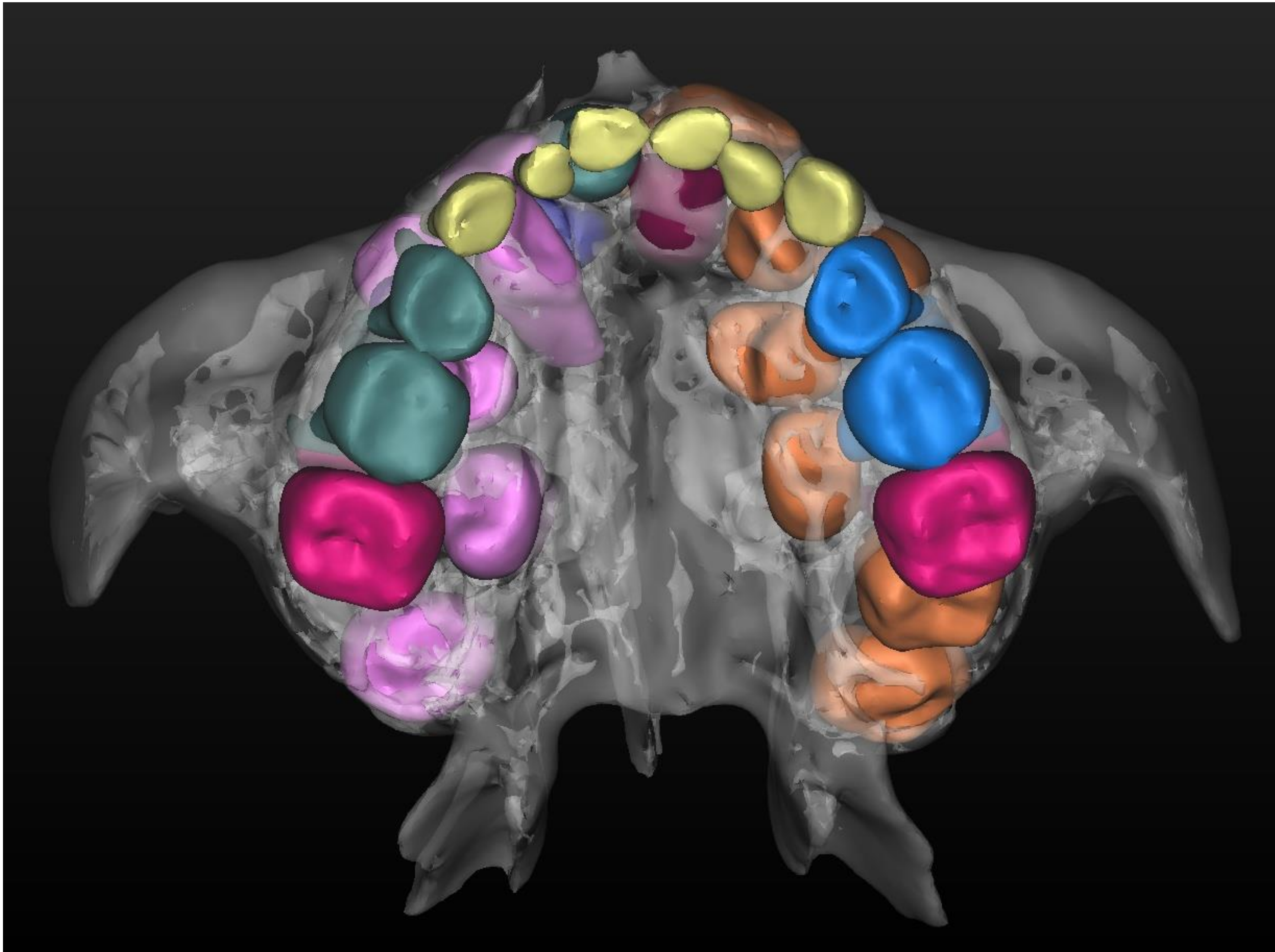
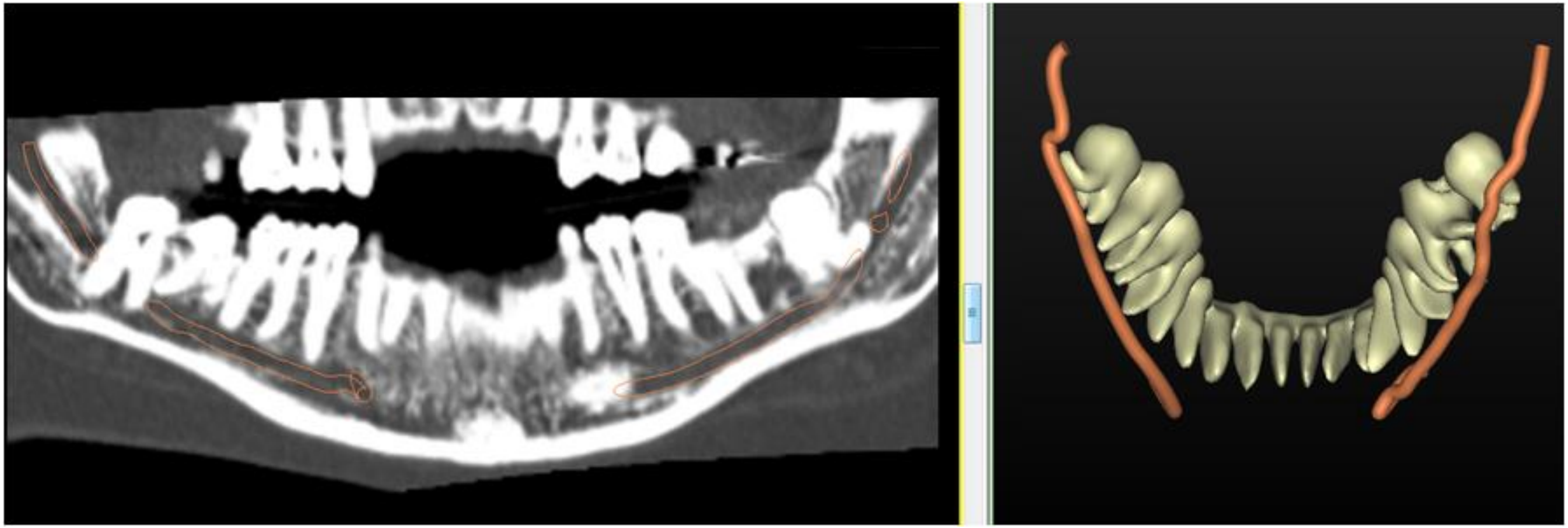
Hyperdontia



Courtesy of Nicolette Schroeder



Third Molars



Courtesy of Barry Dace

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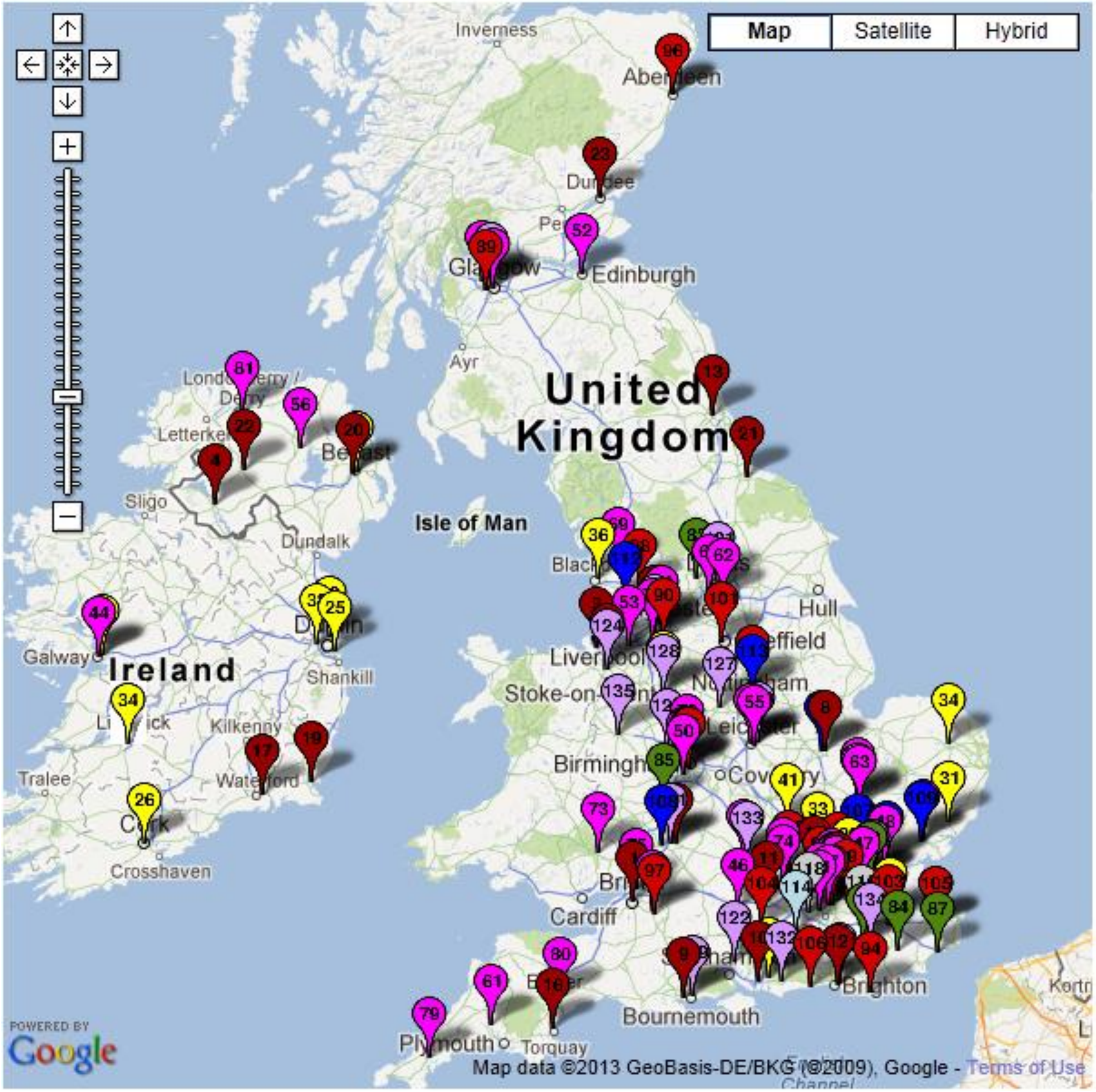

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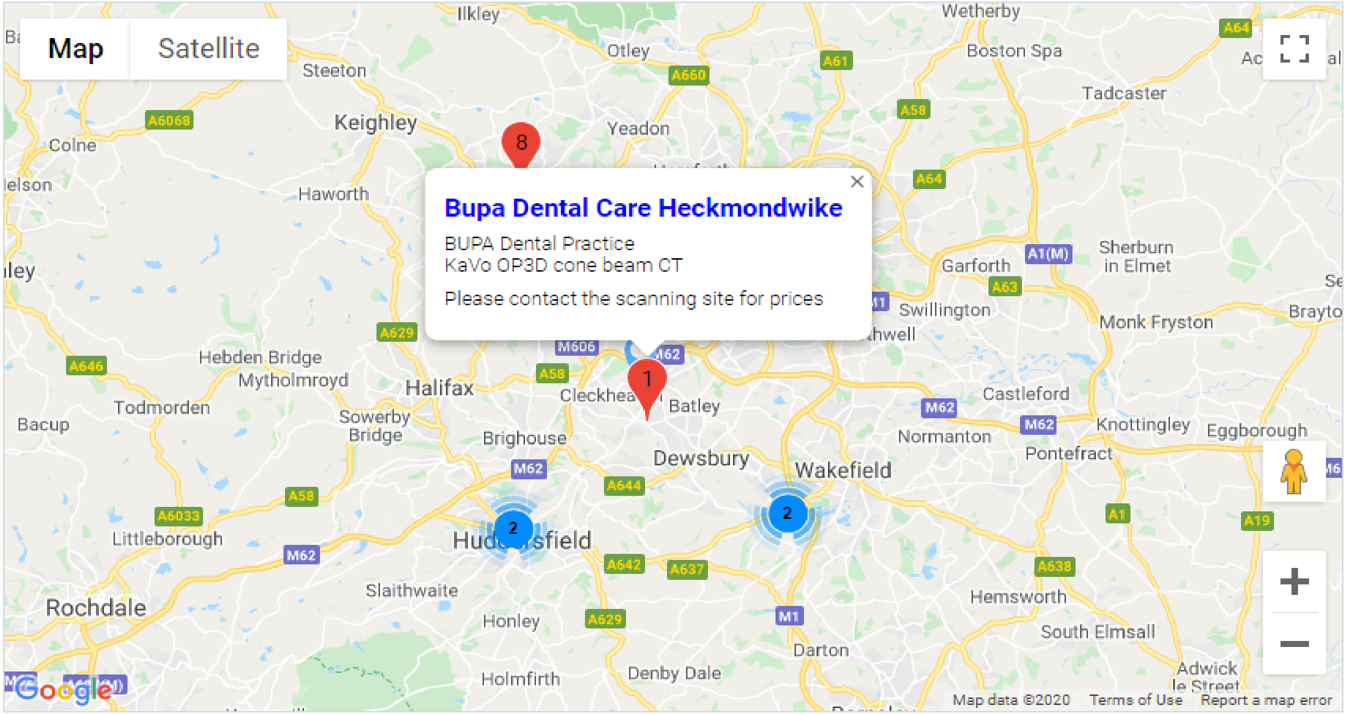
United Kingdom ◉ Ireland ○

Gomersal | 10 miles | Search



	Name	Distance	Description	Equipment
1	Bupa Dental Care Heckmondwike	1.5 miles	BUPA Dental Practice	KaVo OP3D cone beam CT
2	Edgerton Dental Care	7.0 miles	Dental Practice	Carestream 8100 3D cone beam CT
3	Horbury Dental Care	7.1 miles	Dental Practice	CareStream 9300 Select cone beam CT
4	Cote Royd Dental Practice	7.2 miles	Dental Practice	Sirona Orthophos SL3D cone beam CT
5	CT Dent Leeds	7.2 miles	Independent Imaging Centre	Instrumentarium OP300 cone beam CT
6	Nuffield Health Leeds Hospital	7.2 miles	Nuffield Hospital	Toshiba Aquilion ONE medical CBCT
7	Trinity House Orthodontics	8.1 miles	Dental Practice	i-CAT Classic cone beam CT
8	Honesty Dental Care	8.3 miles	Dental Practice	Vatech PaX-i3D cone beam CT

Downloads

Click here to download Lecture Slides

Click here to download our Publications.

For further assistance please contact IDT Scans

Outline of Lectures

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

What do we use dental imaging for?

Review patient anatomy and pathology

- **requires 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**
- **pain or inflamation that requires investigation**

Imaging for specific dental applications

- **Planning dental implants**
- **Endodontics**
- **Orthodontics**
- **Othognathic Surgery**
- **TMJ and Airway Analysis**

These have their own specific imaging requirements.

Imaging for Dental Implants

Need to be able to:

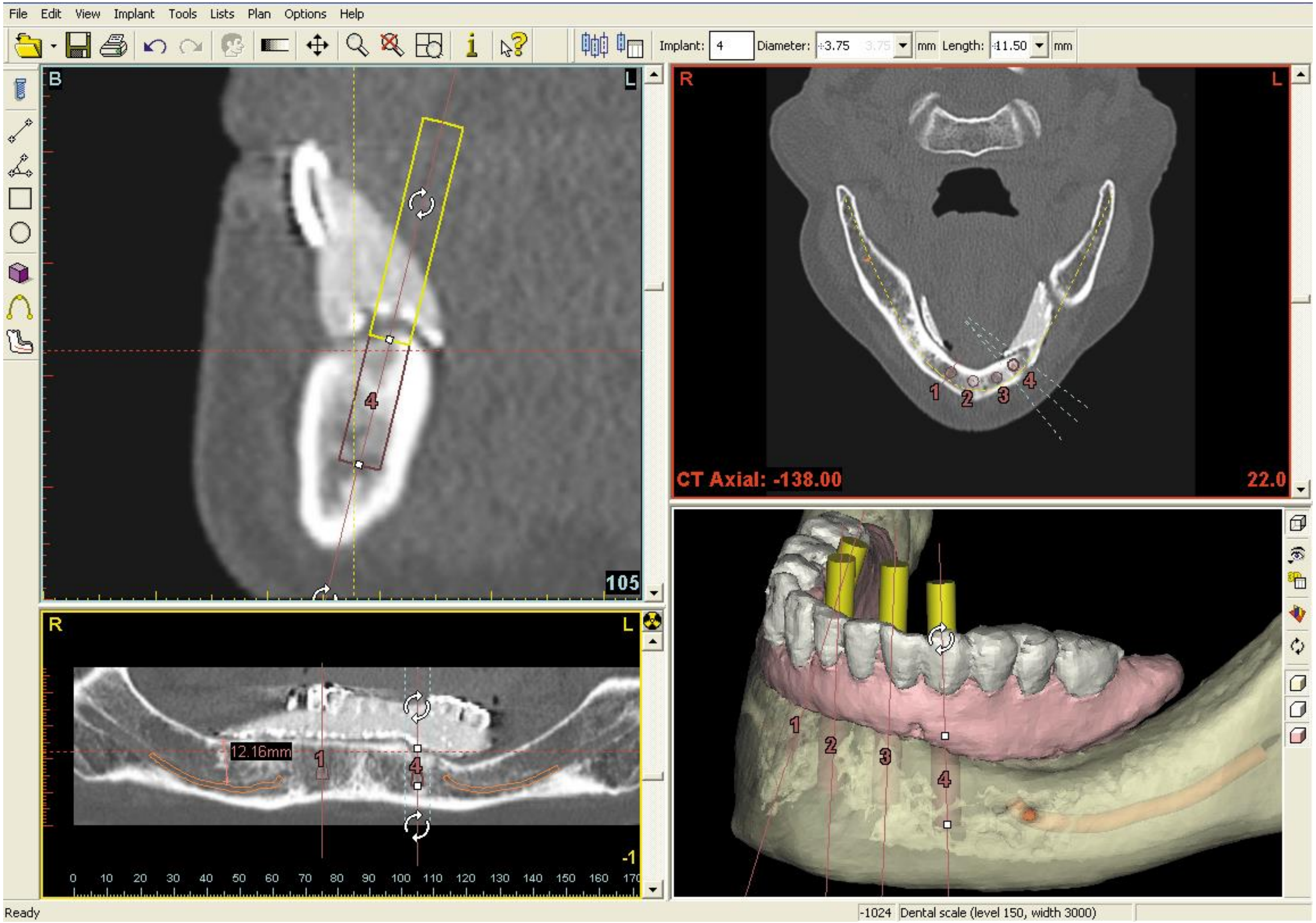
- **Review patient anatomy and pathology**
  - **diagnostic quality images**
- **Assess bone quantity and quality**
  - **quantitative assessment**
- **Decide where implants should go**
  - **accurate 3D measurements**
  - **avoid sensitive structures**
  - **must work mechanically and aesthetically**

Restoration-Driven Implant Planning

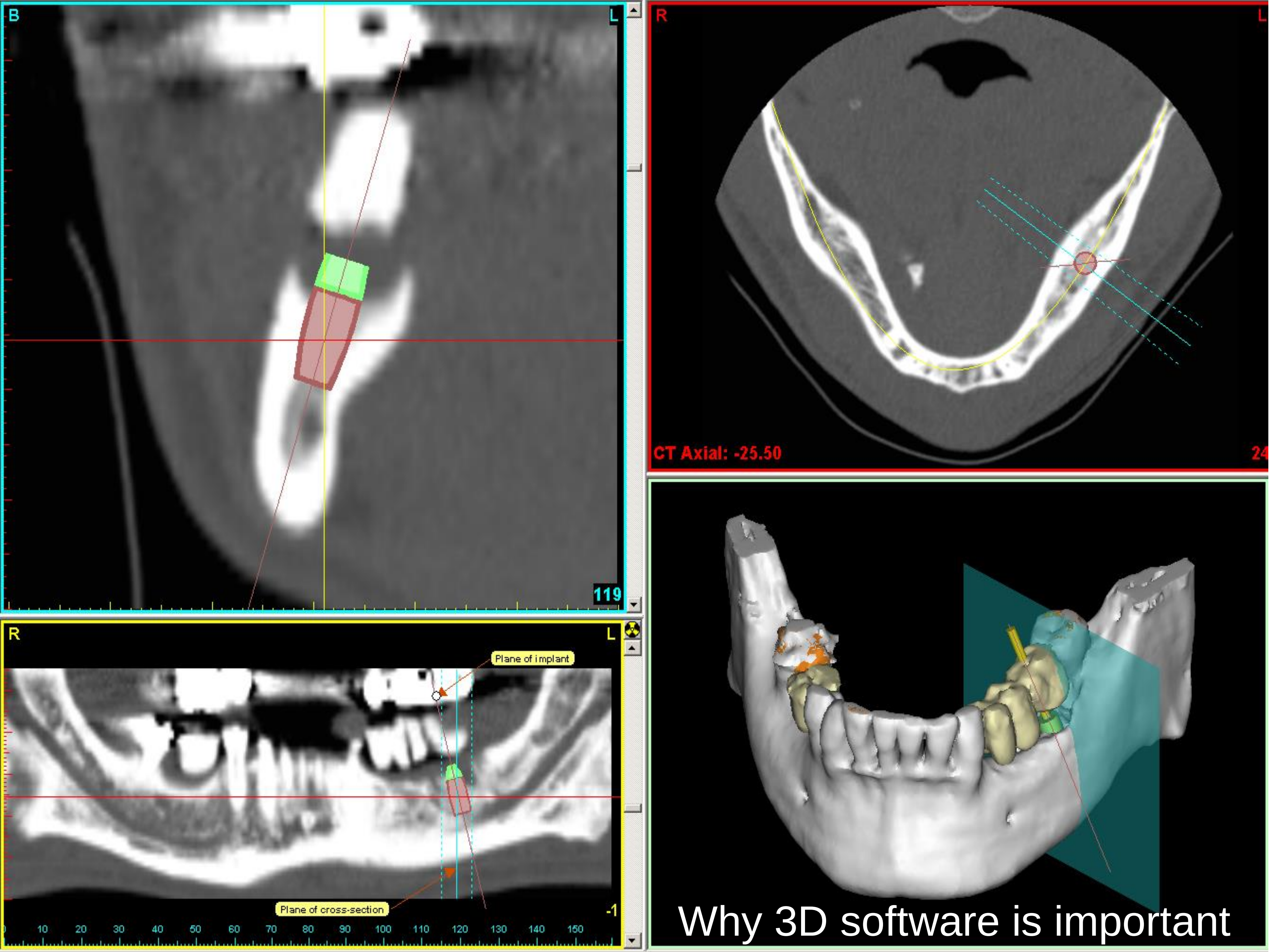
"Create a model of the desired result, then work backwards to determine how it can be achieved"

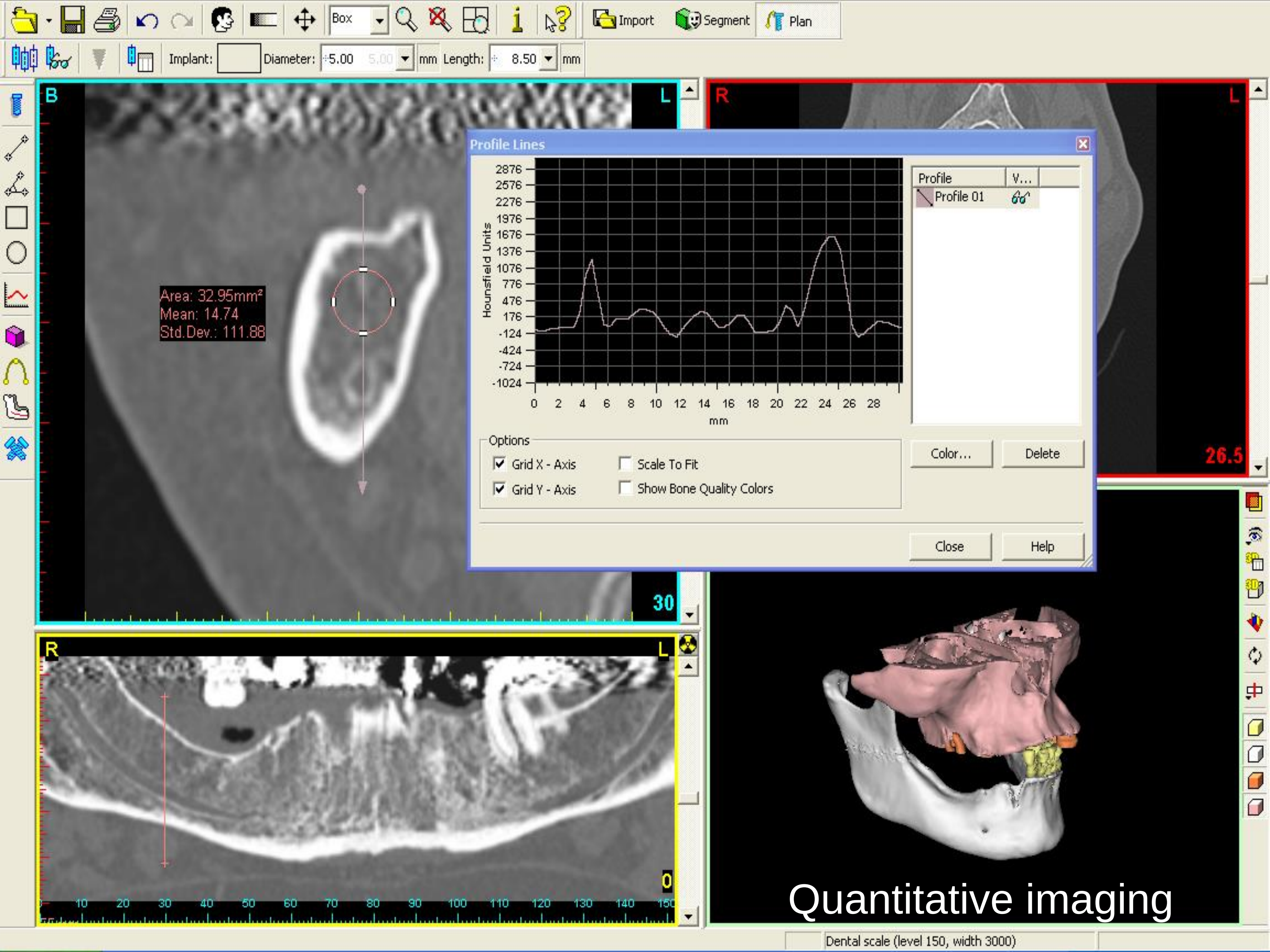
- ***3D Treatment Planning Software***
- ***Radio-Opaque Scanning Stents***
- ***Surgical Drill Guides***

SimPlant interactive implant planning software



Simplant™ is a trademark of Dentsply Sirona


B
L
119
R
L
Plane of implant
Plane of cross-section
-1
10 20 30 40 50 60 70 80 90 100 110 120 130 140 150
R
L
CT Axial: -25.50
24
Why 3D software is important



Quantitative imaging

Software for planning Dental Implants

- **Simplant (Dentsply Sirona)**
- **Blue Sky Plan (Blue Sky Bio)**
- **Osirix (with Dental3D plugin)**
- **In Vivo Dental (Anatomage)**
- **Nobel Clinician (Nobel Biocare)**
- **coDiagnostiX (Dental Wings)**
- **Carestream CS3D**
- **etc etc**

Restoration-Driven Implant Planning

"Create a model of the desired result, then work backwards to determine how it can be achieved"

- ✔ ***3D Treatment Planning Software***
- ***Radio-Opaque Scanning Stents***
- ***Surgical Drill Guides***

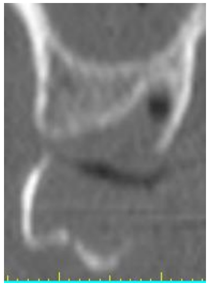
Advantages of using a Scanning Stent

- Gives inter-arch stability for the patient during the scan
- Opens the bite slightly (a few mm) using occlusal stops
- Shows position and size of the desired restorations
- Shows inter-arch relationship
- If you want a mucosa-supported surgical guide, edentulous patients MUST be scanned wearing a stent

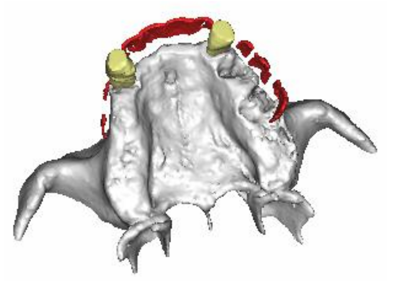
Making a Scanning Stent

- **Plastic and clear acrylic does not show up on a CT scan.**

- **To make it show up, you can:**



- **mix barium sulphate with the acrylic**
- **paint barium sulphate on the surface**
- **use radio-opaque teeth**
- **use markers made from a radio-opaque material**



  - **lab putty**
  - **gutta percha**
  - **glass ionomer**

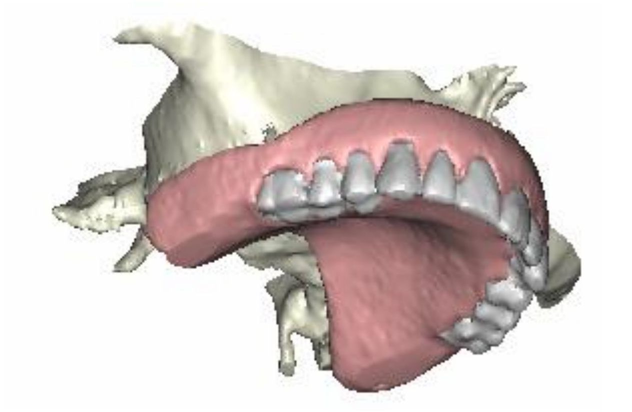
- **use a dual-scan technique.**

- We recommend using a barium sulphate-acrylic mix for both the radio-opaque teeth and the baseplate.

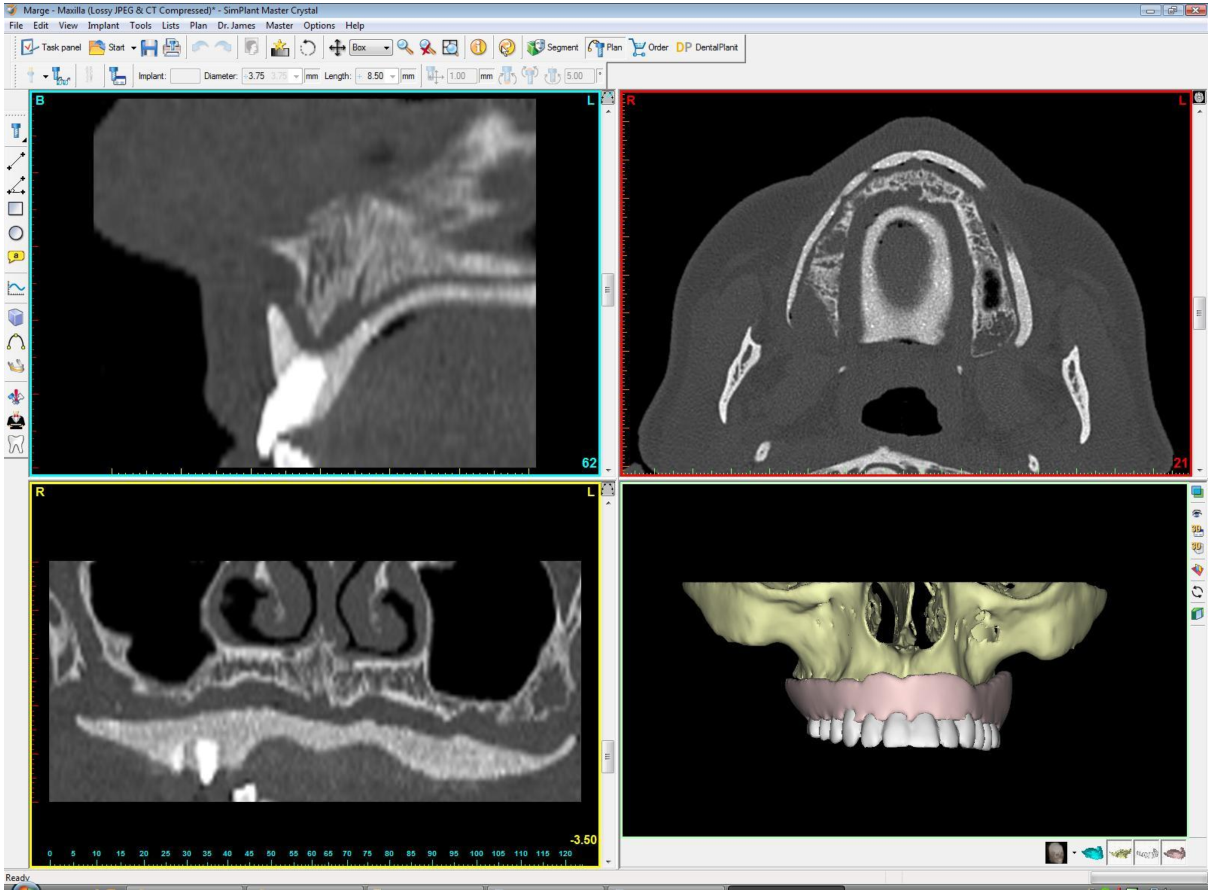
- Use 15% barium sulphate in the teeth and 10% barium sulphate in the baseplate. This allows the teeth to be picked out separately.

- Do not use too much Barium Sulphate as it will cause an artefact.

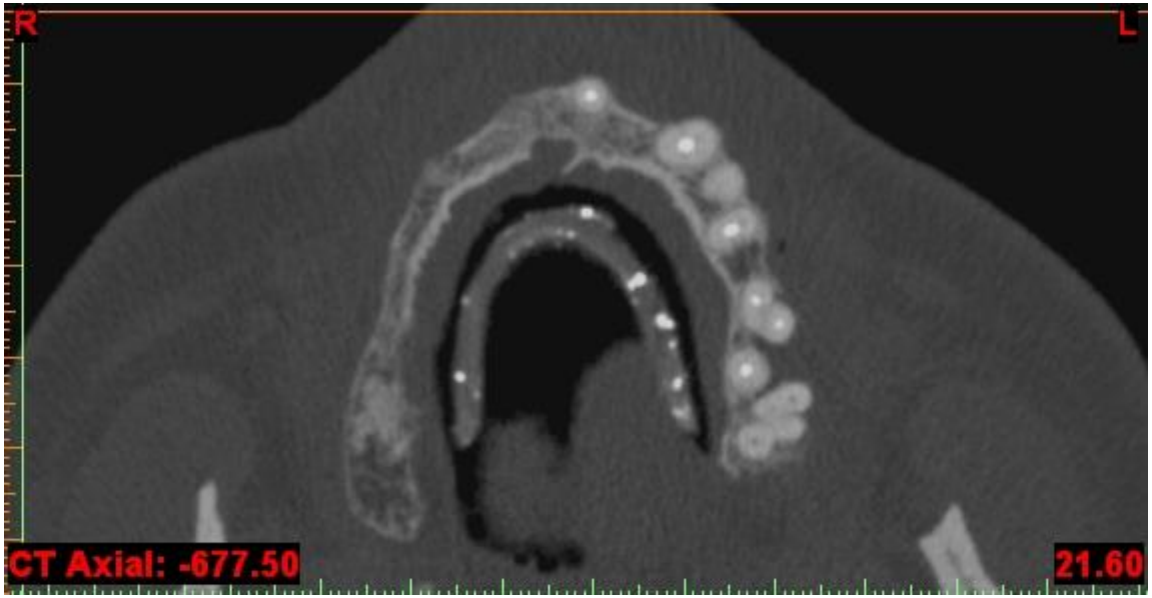
- An accurate fitting stent with radio-opaque baseplate is usually the best option for mucosa-supported surgical drill guides.



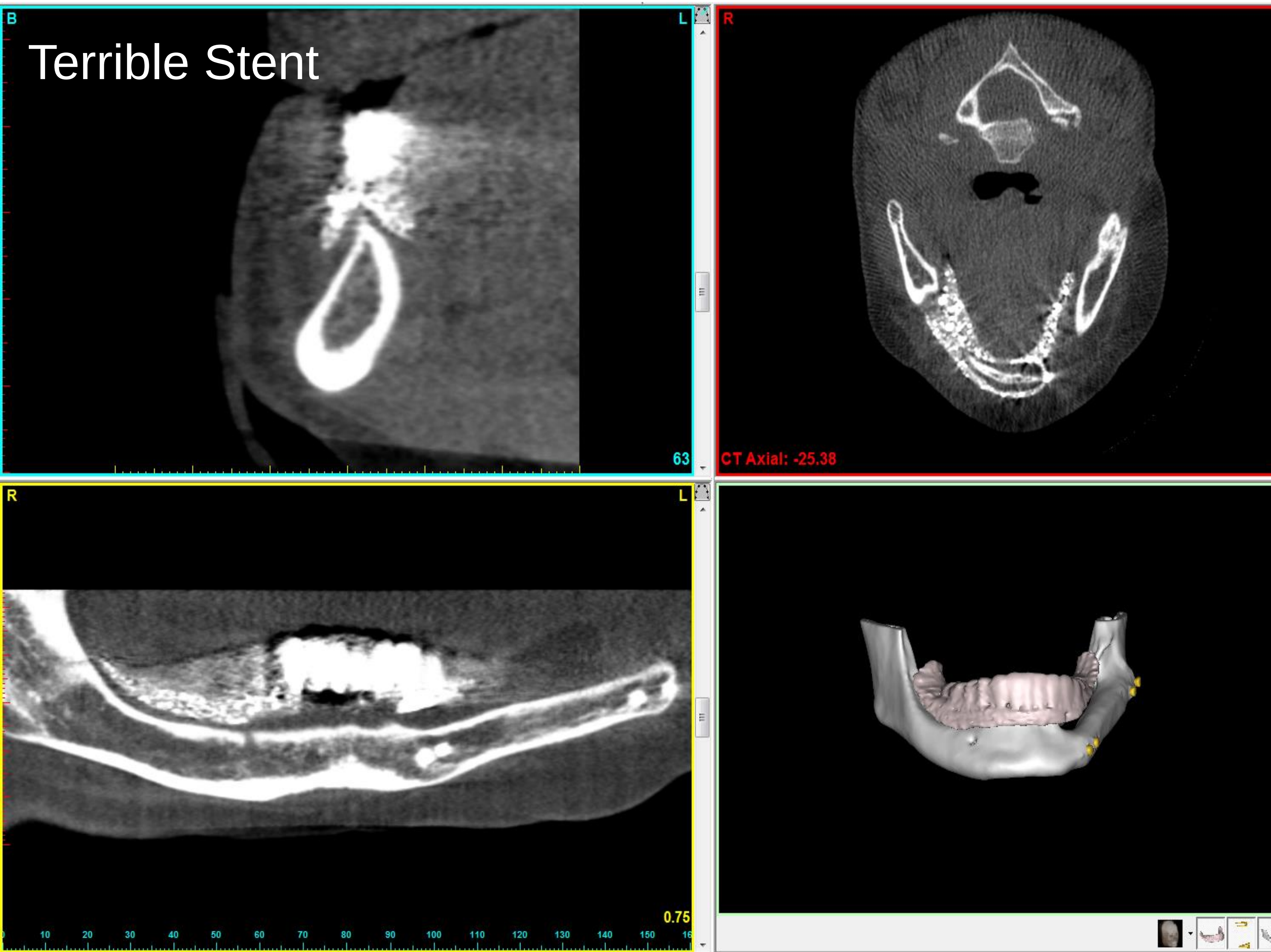
Good Stent


Marge - Maxilla (Lossy JPEG & CT Compressed)* - SimPlant Master Crystal
File Edit View Implant Tools Lists Plan Dr. James Master Options Help
Task panel Start Box Segment Plan Order DentalPlanit
Implant: Diameter: 3.75 mm Length: 8.50 mm 1.00 mm 5.00
B L 62
R L 21
R L -3.50
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100 105 110 115 120
Ready

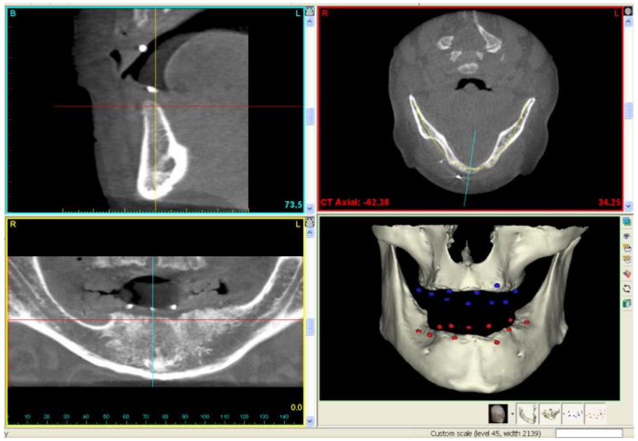
Bad Stent



Terrible Stent



Dual Scan Technique



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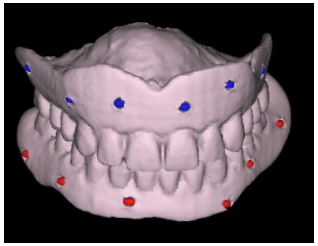

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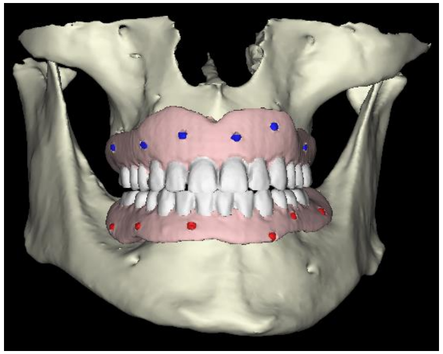

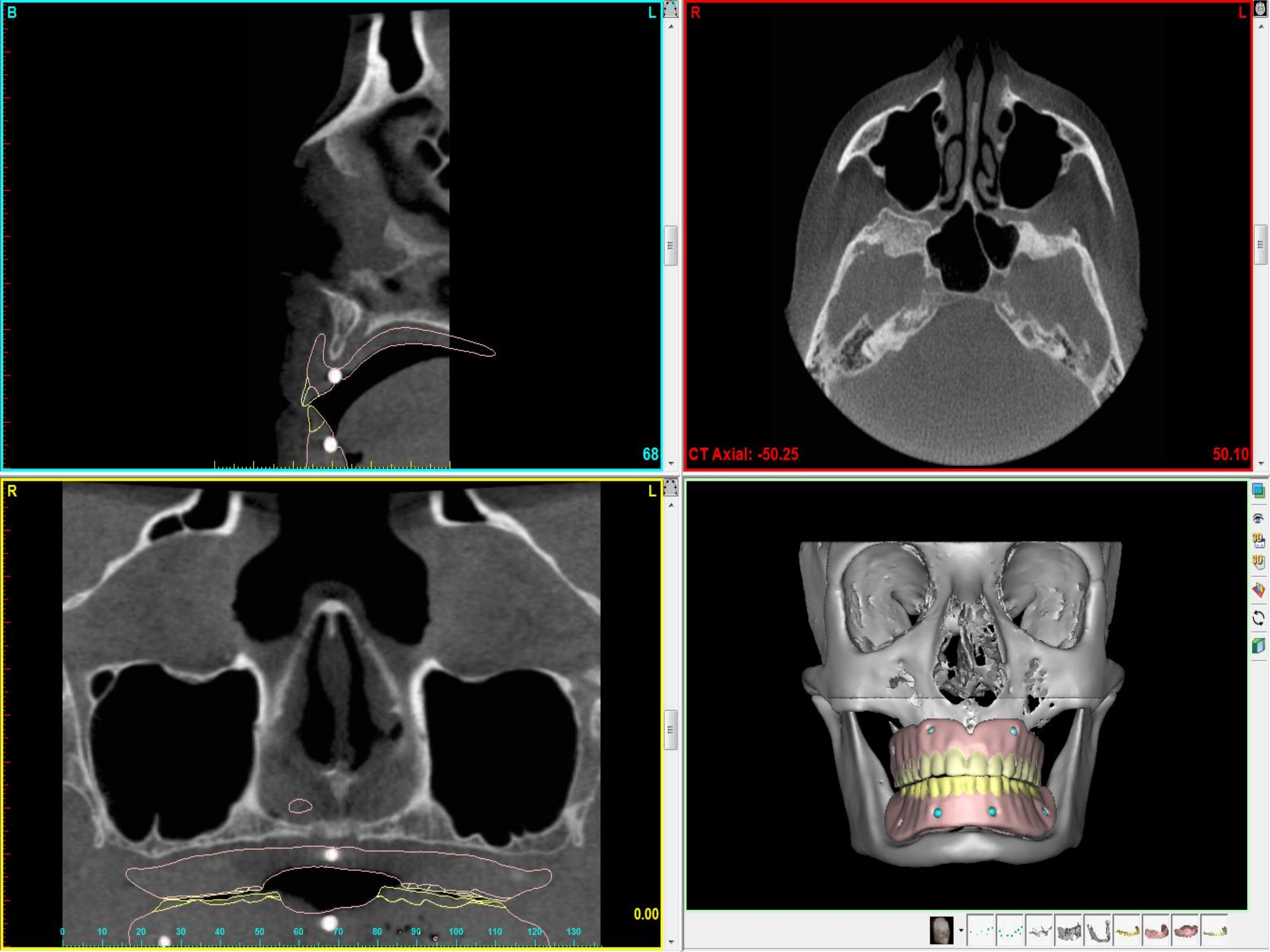
B
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CT Axial: -50.25
50.10
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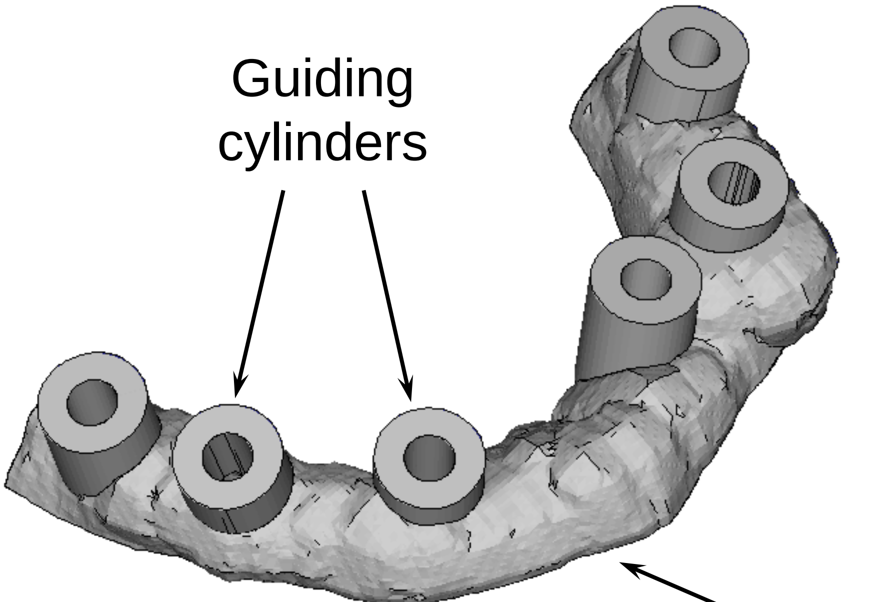
0 10 20 30 40 50 60 70 80 90 100 110 120 130

Restoration-Driven Implant Planning

"Create a model of the desired result, then work backwards to determine how it can be achieved"

- ✔ ***3D Treatment Planning Software***
- ✔ ***Radio-Opaque Scanning Stents***
- ***Surgical Drill Guides***

SIMPLANT drill guide

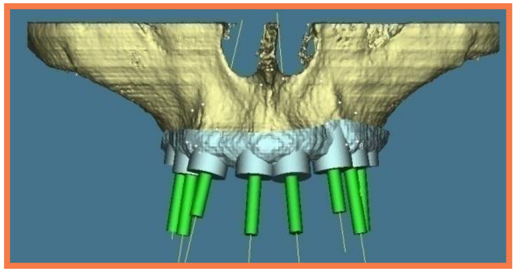


The SurgiGuide controls:
- Position
- Orientation
- (Depth)

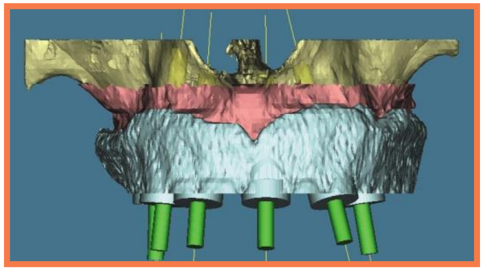
Guide resting on:
- Bone
- Mucosa
- Teeth

Simplant™ is a trademark of Dentsply Sirona

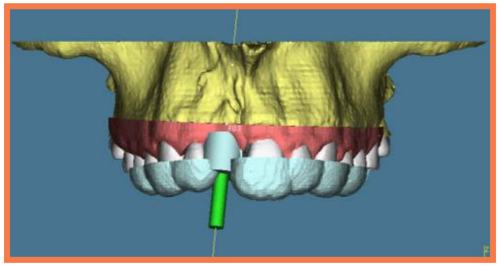
Drill Guides can be supported on



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:

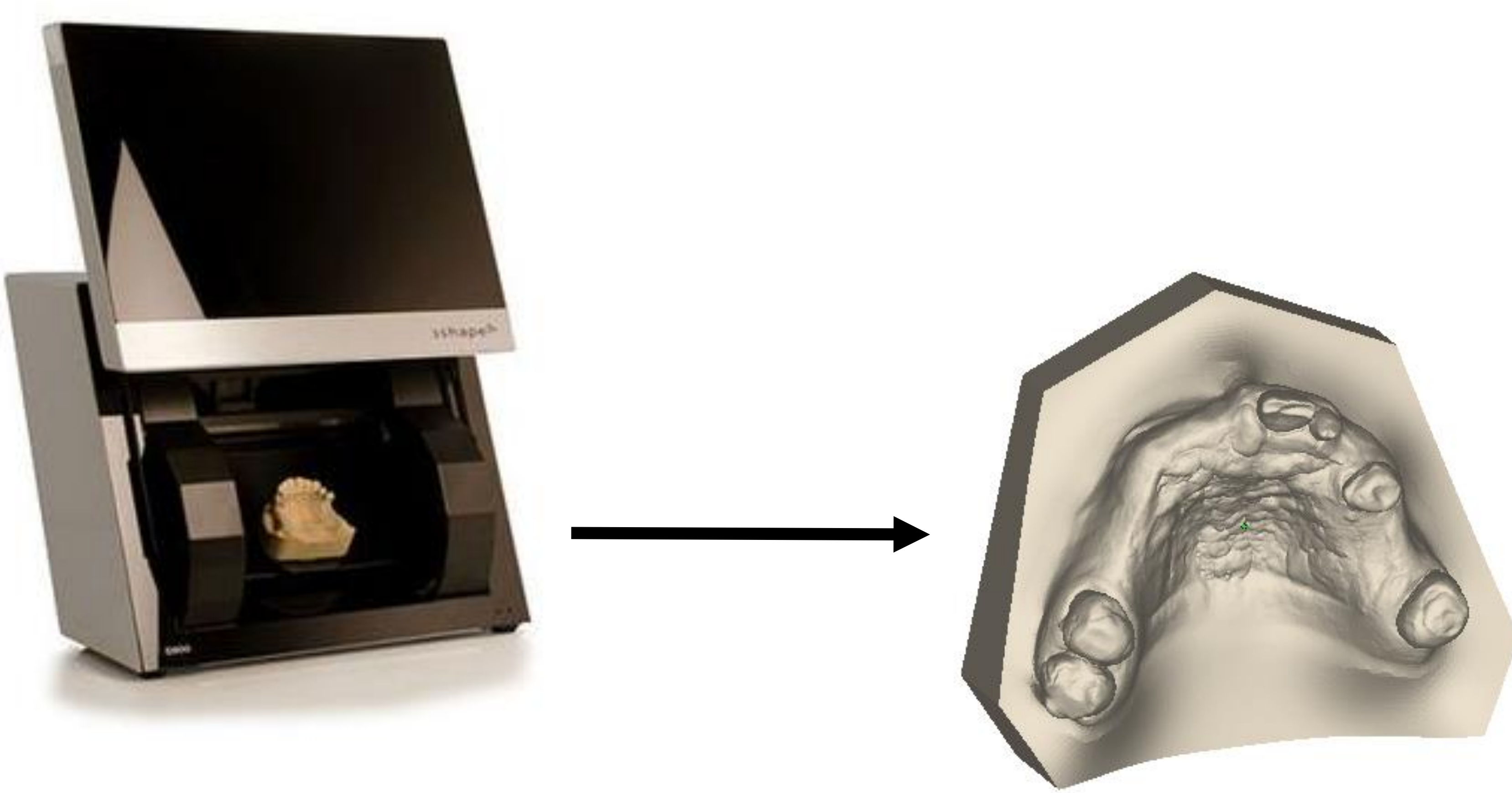
- **Tips of teeth must be clearly visible in the CBCT images**
- **A recent and accurate plaster cast will be required**

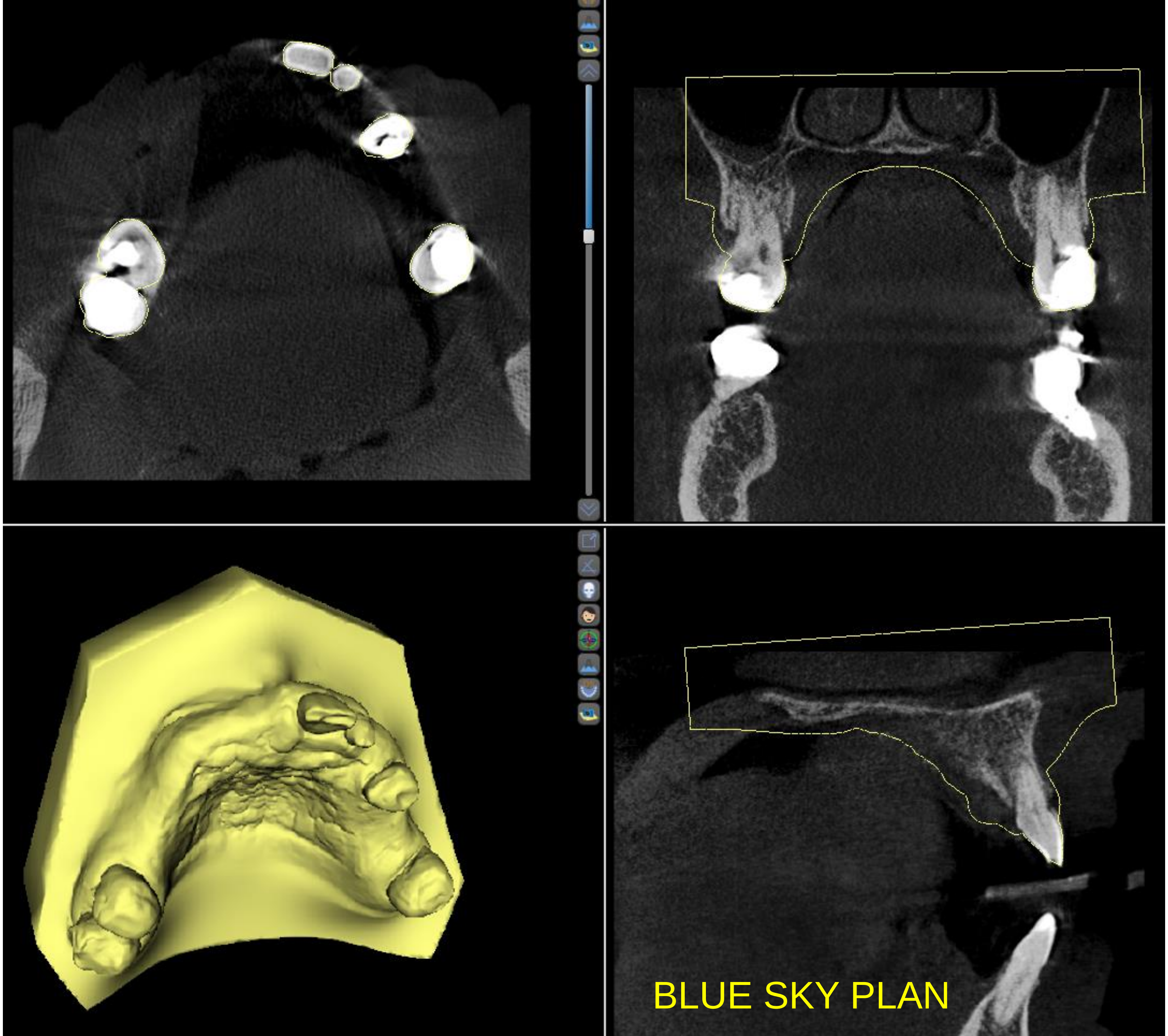
Need to think about the Guide before you request the CBCT Scan!

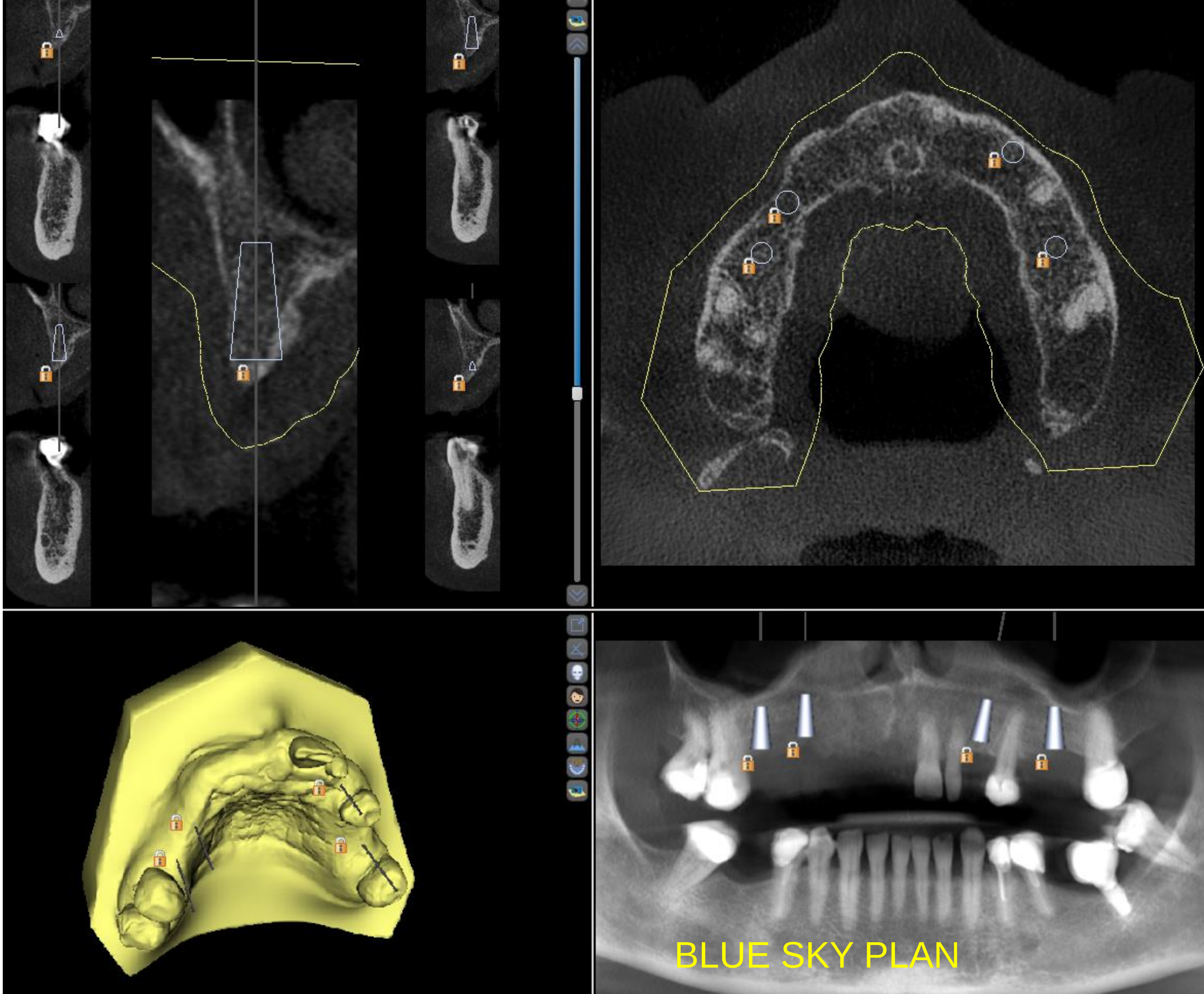
Tooth Supported Guides

- **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 (or intra-oral scan)**
- **Import optical scan into the implant planning software**
- **Guide will be designed to fit the plaster cast.**

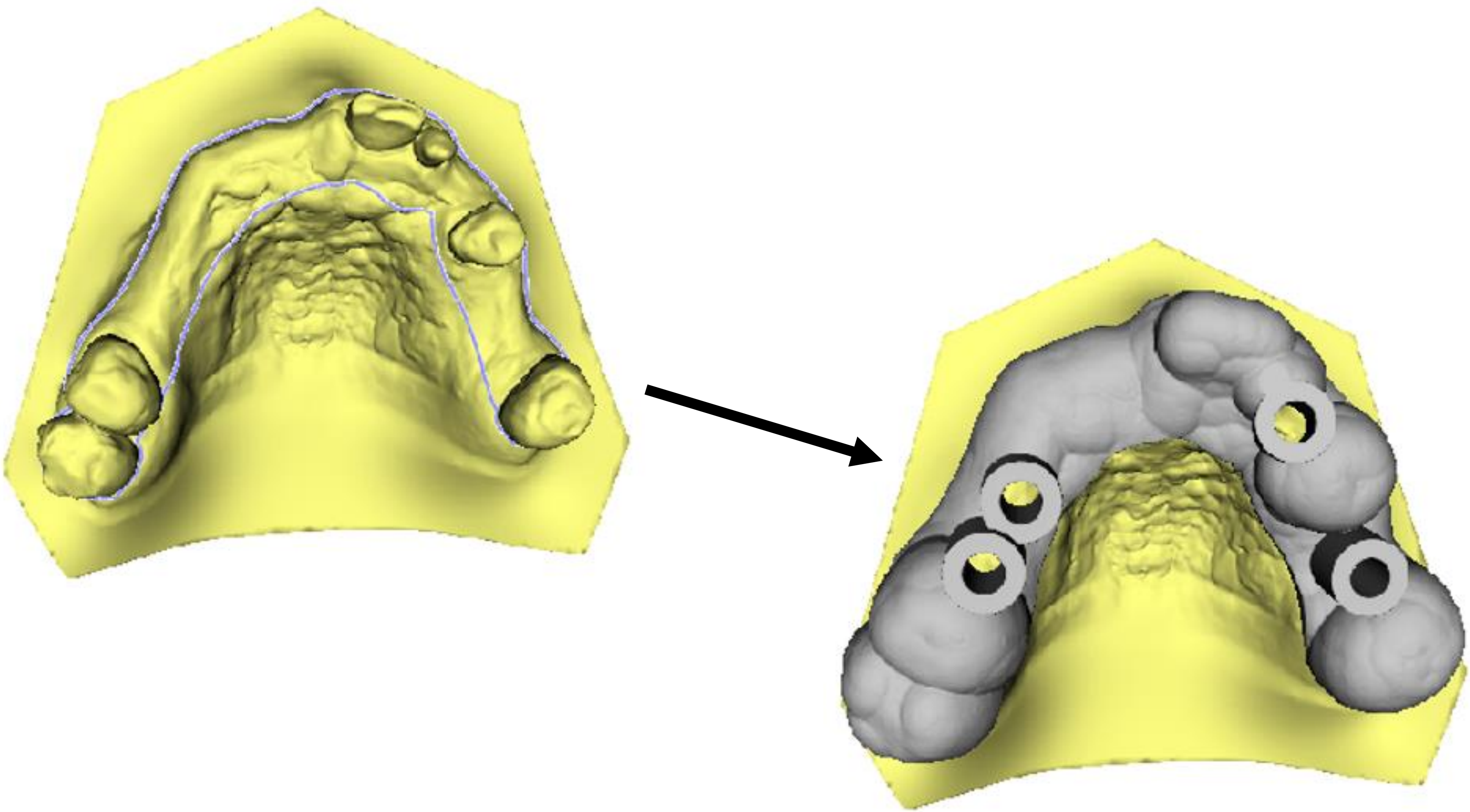
Optical Scan of Plaster Cast




BLUE SKY PLAN


BLUE SKY PLAN

Design the Guide




2.3

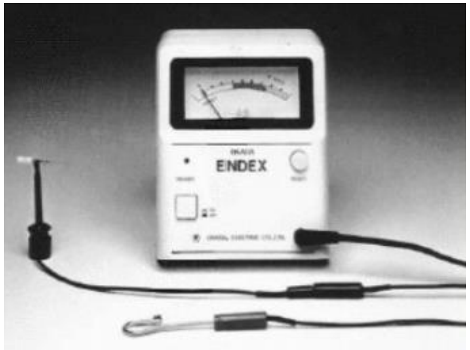
What Imaging Modalities are available?

- **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)**

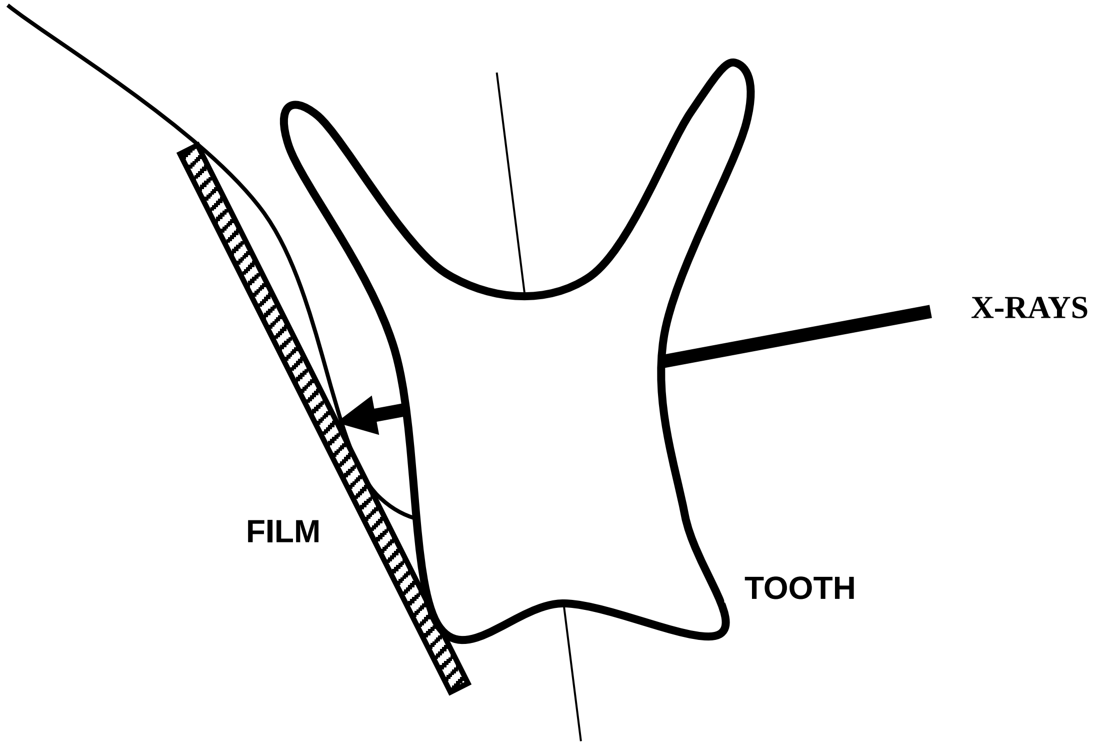
Intra-oral Imaging



- + 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 ✓

Types of Detector

Film

Phosphor Plate

CCD with wires

CCD (wireless)

Phosphor Plate Readers

Durr VistaScan

Gendex DenOptics

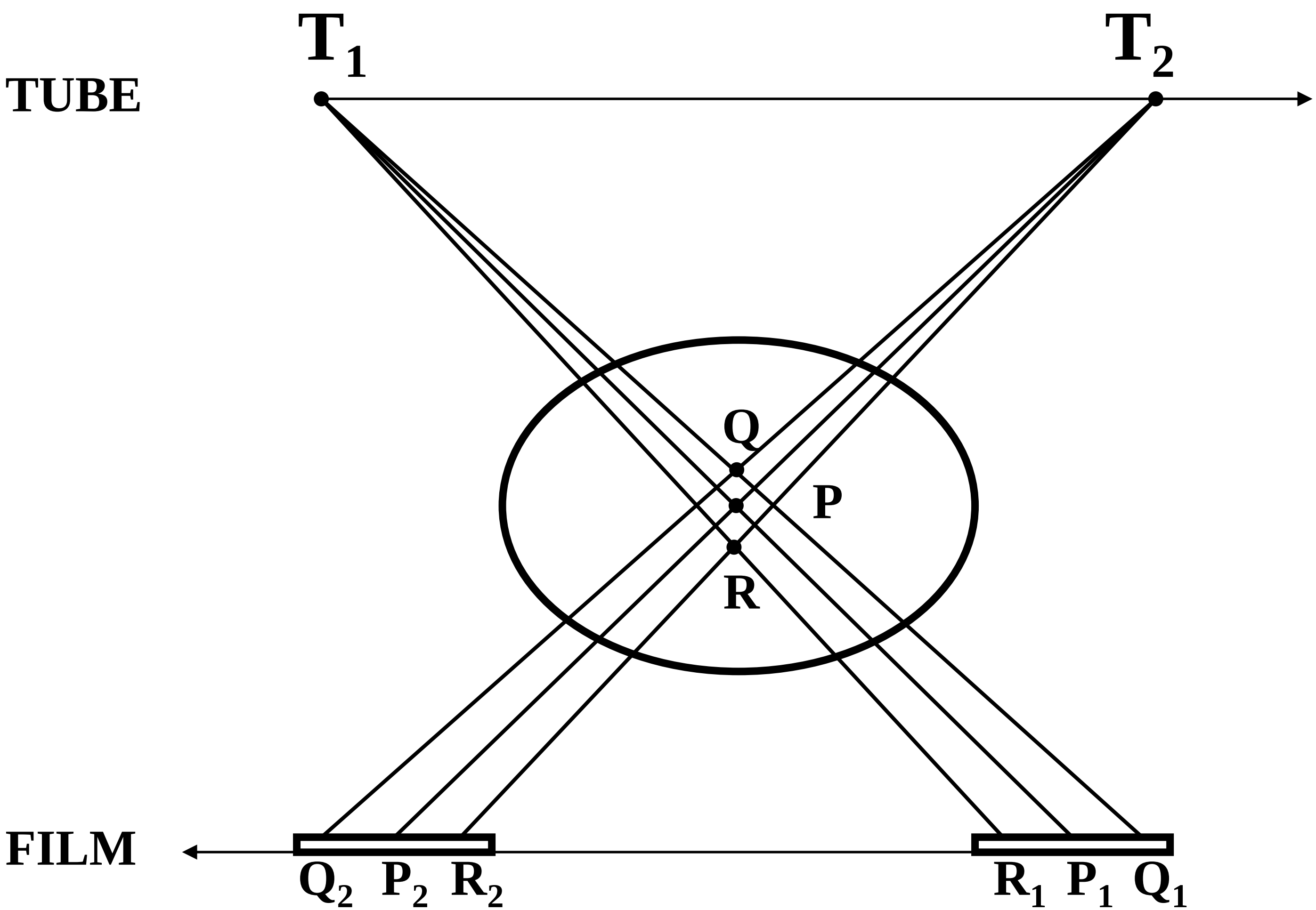
Soredex Diagora

Extra-oral: Lateral Cephs

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

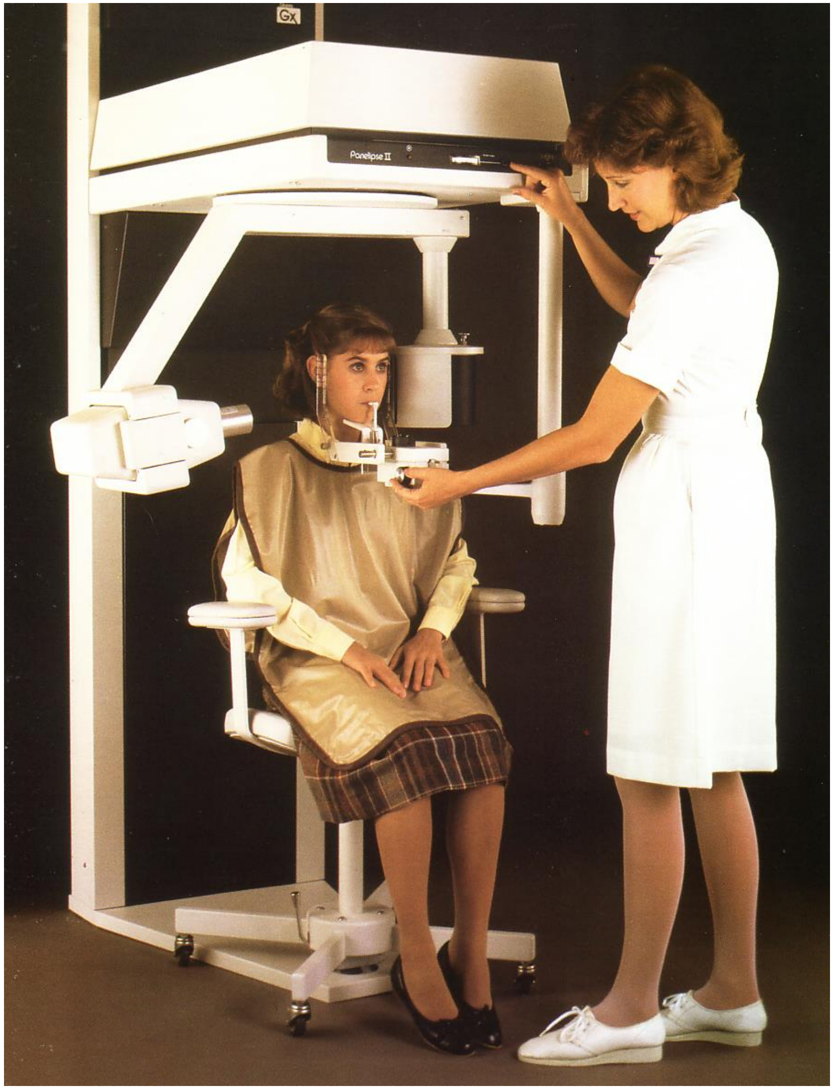
Conventional Tomography

(tomography by blurring)

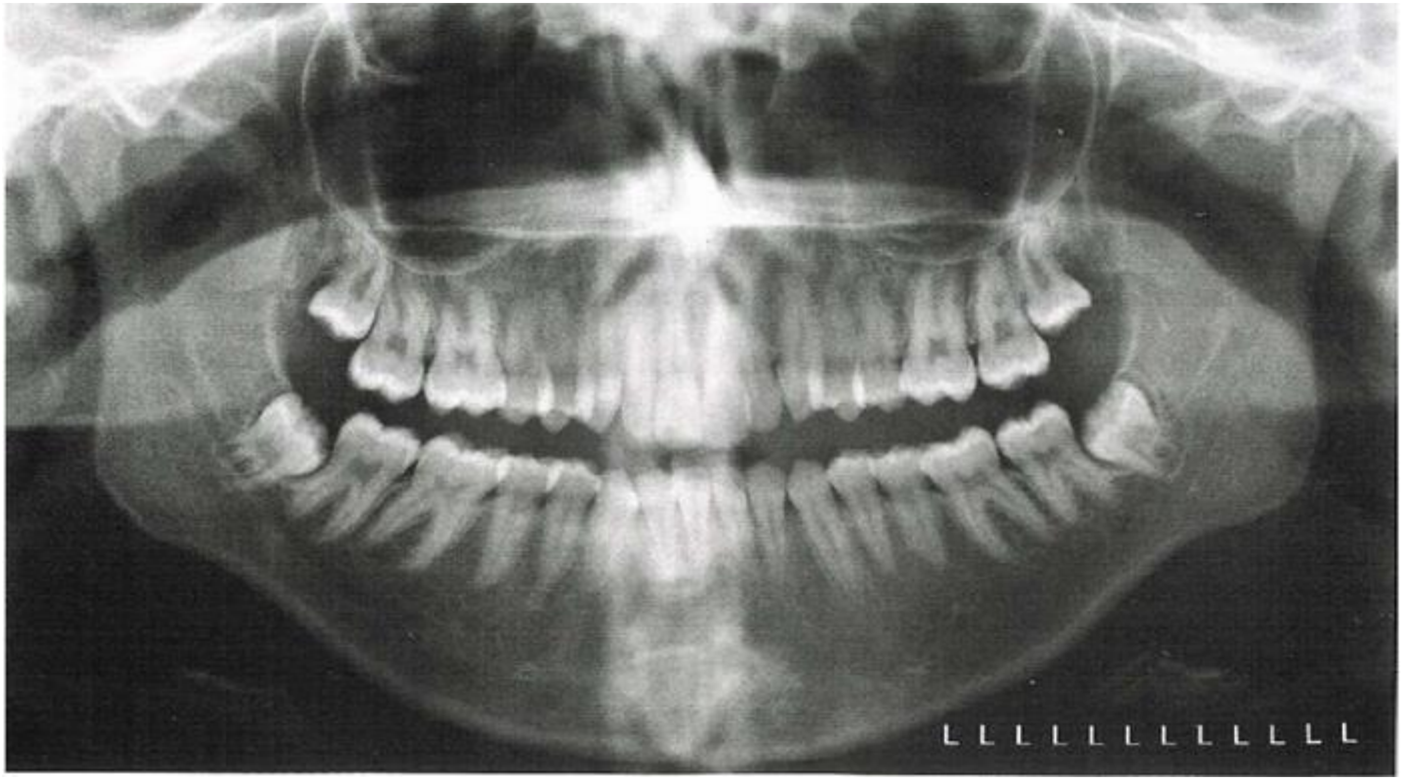


Dental Panoramic Tomography (DPT)

(tomography by blurring)

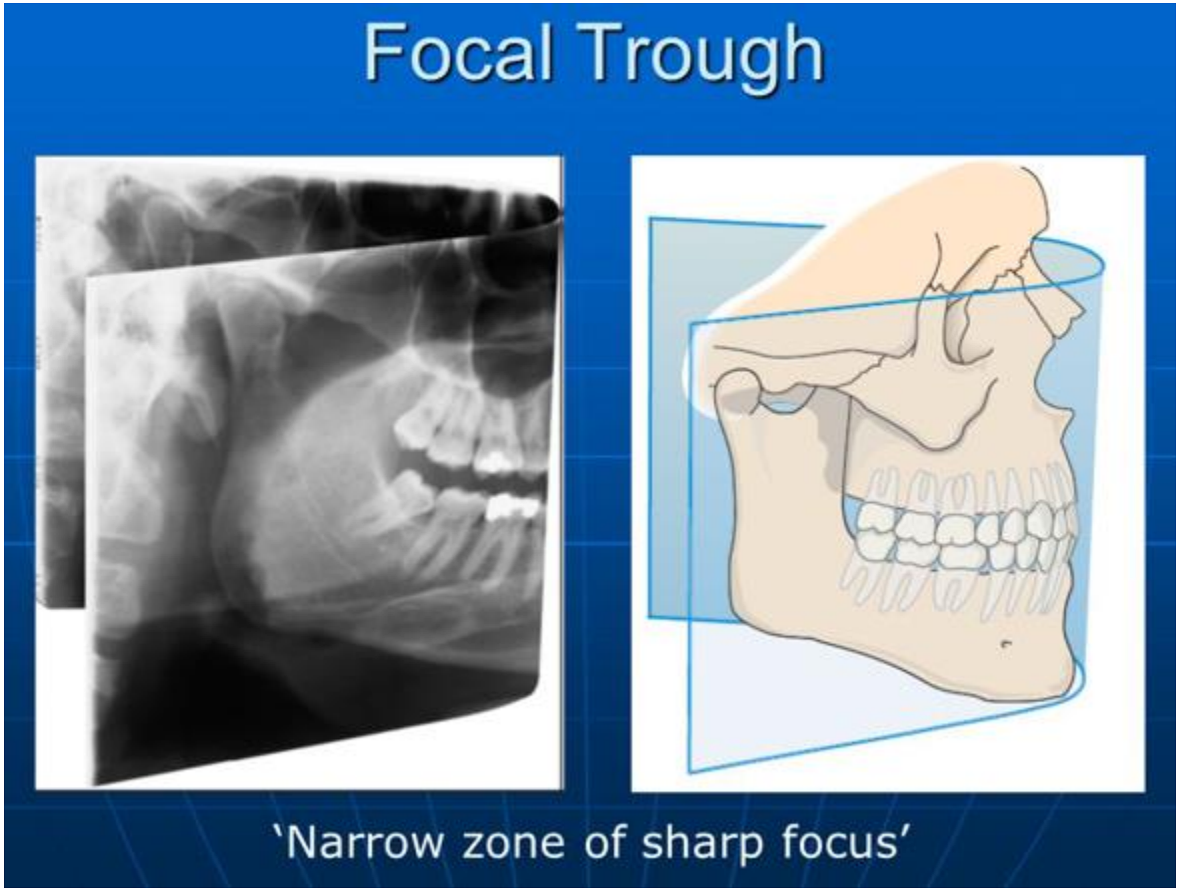


Dental Panoramic Tomography (DPT, OPG, OPT)



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

Positioning is crucial



The focal trough is fixed to the machine (not the patient)

DPTs are useful for:

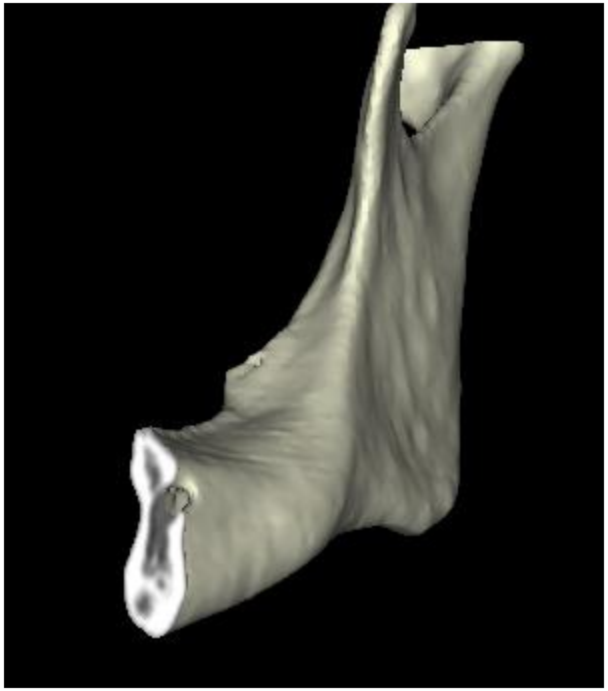
- Overall status of teeth and supporting bone
- Anatomical anomalies and pathological conditions
- Triage between:
  - Sites where placing implants will be straight-forward
  - Sites where grafting or distraction will be needed
  - Sites where implants are not advisable

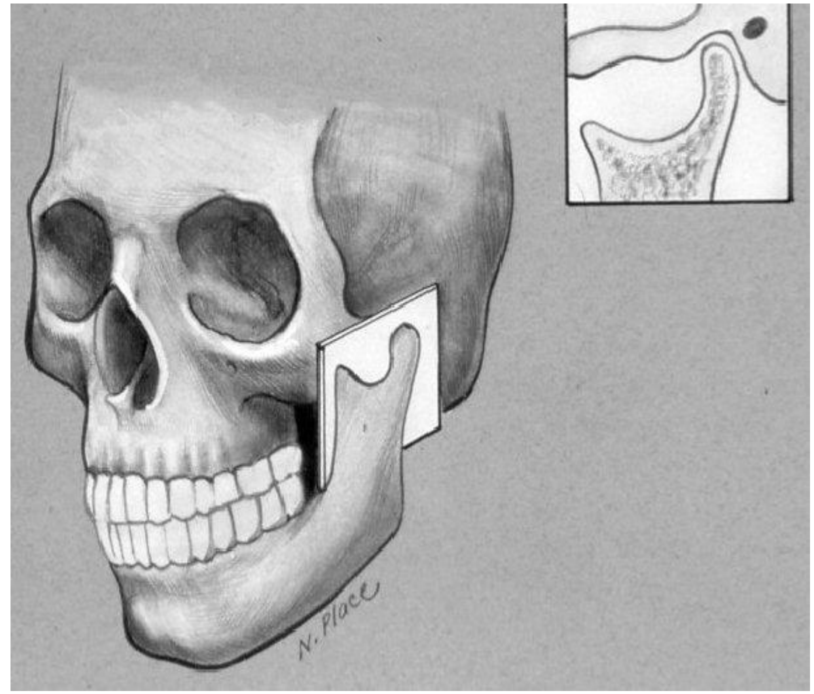
Measurements from DPTs are not accurate:

Reddy et al. Clin Oral Implants Res. 1994 Dec; 5(4):229-238

- Errors as large as 30% in estimating bone height from DPTs
- Bone width cannot be estimated at all.

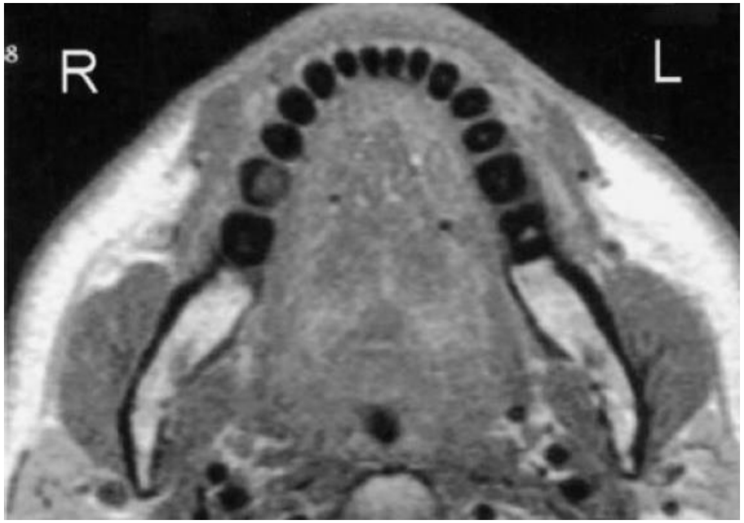
Cross-Sectional Imaging





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

Magnetic Resonance Imaging



+ no radiation dose
+ no metallic artefact
- large, expensive machine
- teeth generate no signal

Advanced imaging: Magnetic resonance imaging in implant dentistry

A review

Crawford F. Gray, Thomas W. Redpath,
Francis W. Smith, Roger T. Staff

Article first published online: 31 JAN 2003

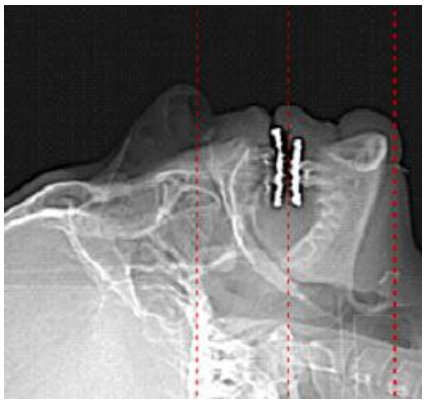
DOI: 10.1034/j.1600-0501.2003.140103.x

Issue

Clinical Oral Implants
Research

Volume 14, Issue 1, pages
18–27, February 2003

Dental (CB)CT Scans



The dentoalveolar region has
high natural contrast

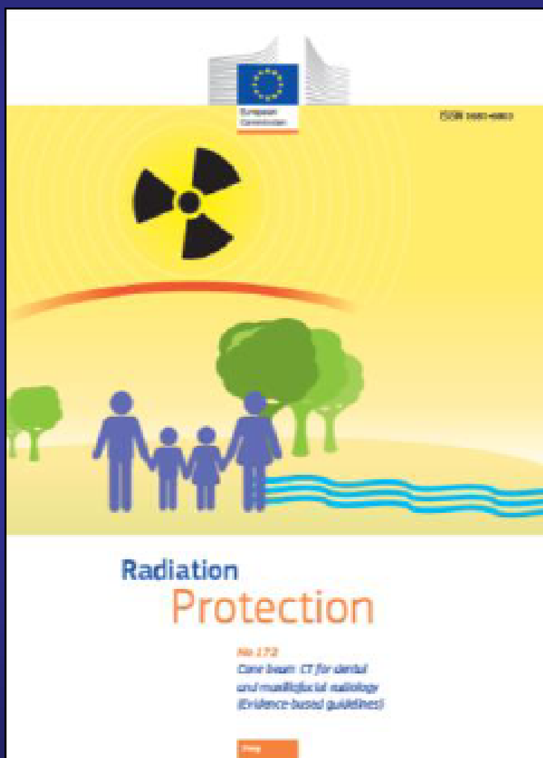
So we can get away with
- high resolution images
- low radiation dose

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**
  - **periapical disease**
  - **root canals, root fractures etc**
  - **impacted, supernumerary and abnormal teeth**
  - **maxillofacial surgery**
  - **cleft palate assessment**
  - **TMJ and airway analysis**

- **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

Grading systems used for levels of evidence [adapted from Scottish Intercollegiate Guidelines Network (SIGN), 2008].

Grade	
A	At least one meta-analysis, systematic review, or RCT rated as 1++, and directly applicable to the target population; or a systematic review of RCTs or a body of evidence consisting principally of studies rated as 1+, directly applicable to the target population, and demonstrating overall consistency of results
B	A body of evidence including studies rated as 2++, directly applicable to the target population, and demonstrating overall consistency of results; or extrapolated evidence from studies rated as 1++ or 1+
C	A body of evidence including studies rated as 2+, directly applicable to the target population and demonstrating overall consistency of results; or extrapolated evidence from studies rated as 2++
D	Evidence level 3 or 4; or extrapolated evidence from studies rated as 2+
GP	Good Practice (based on clinical expertise of the guideline group and Consensus of stakeholders)

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]

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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

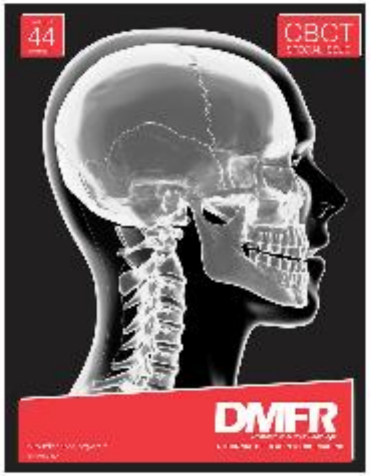
Invited Review Paper

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

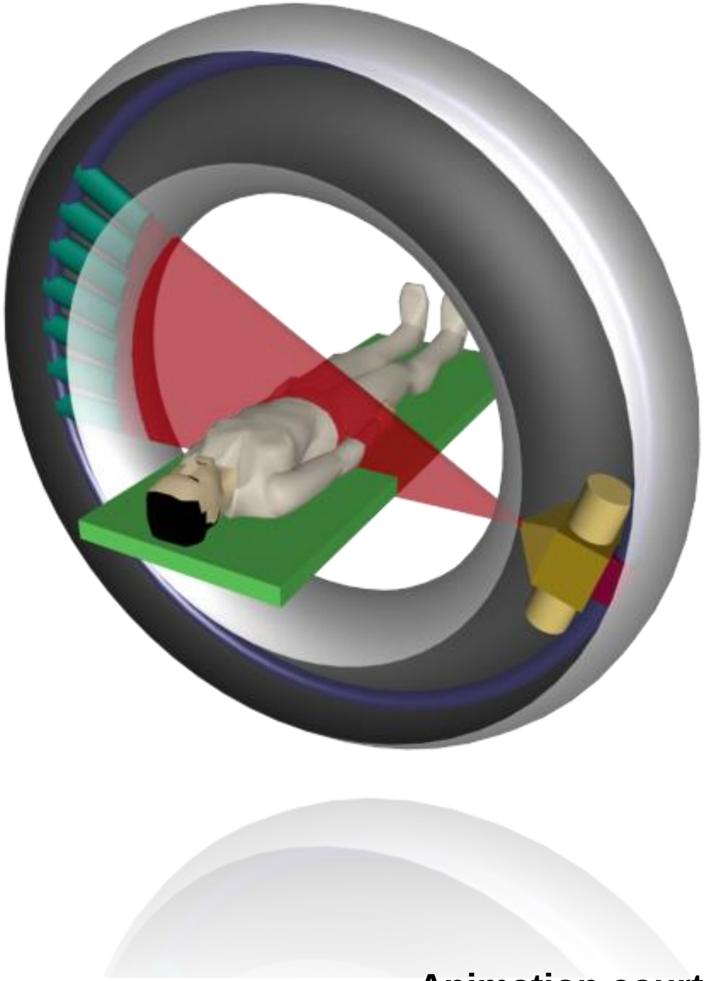
CBCT Special Issue

how CT works…

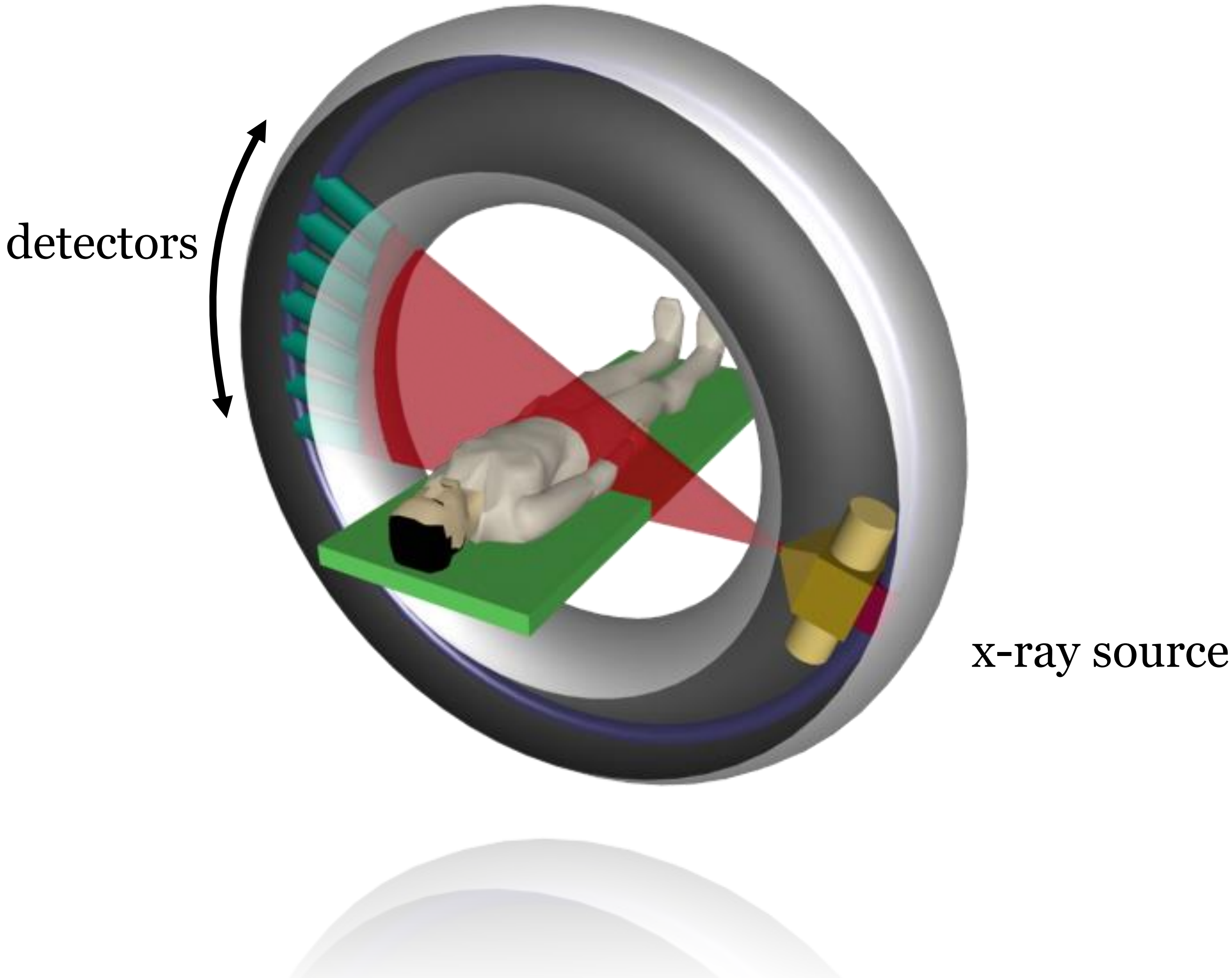
Godfrey Hounsfield

Allan Cormack

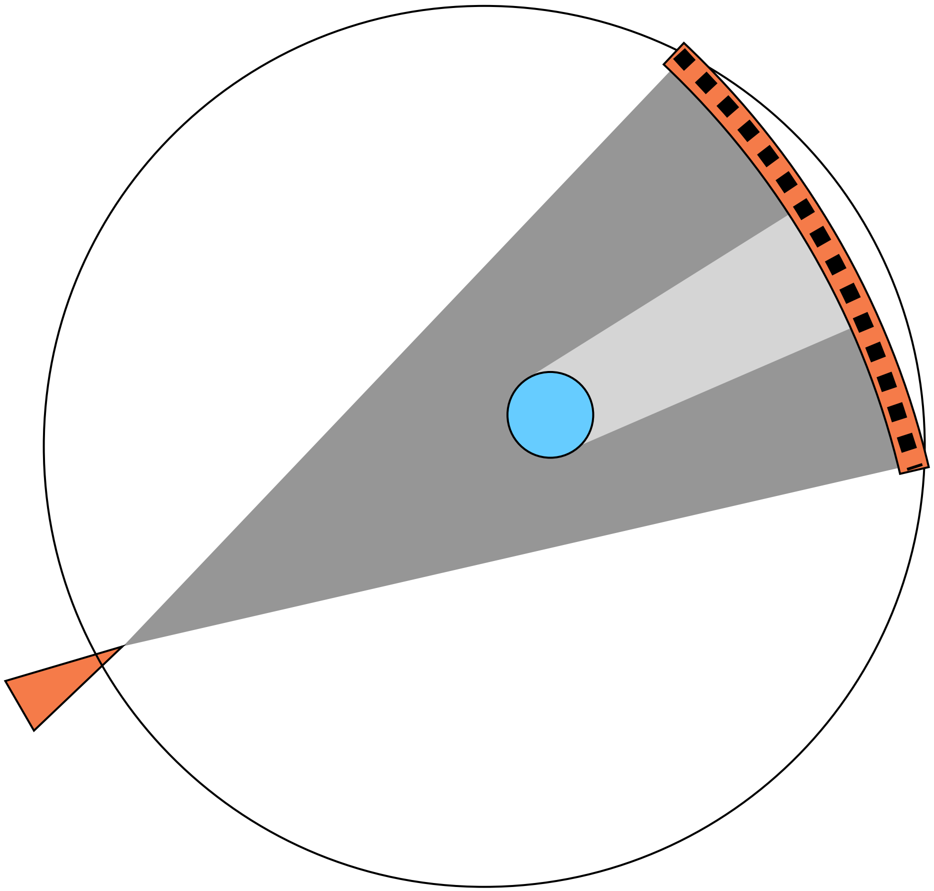
Nobel prize in Medicine, 1979



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

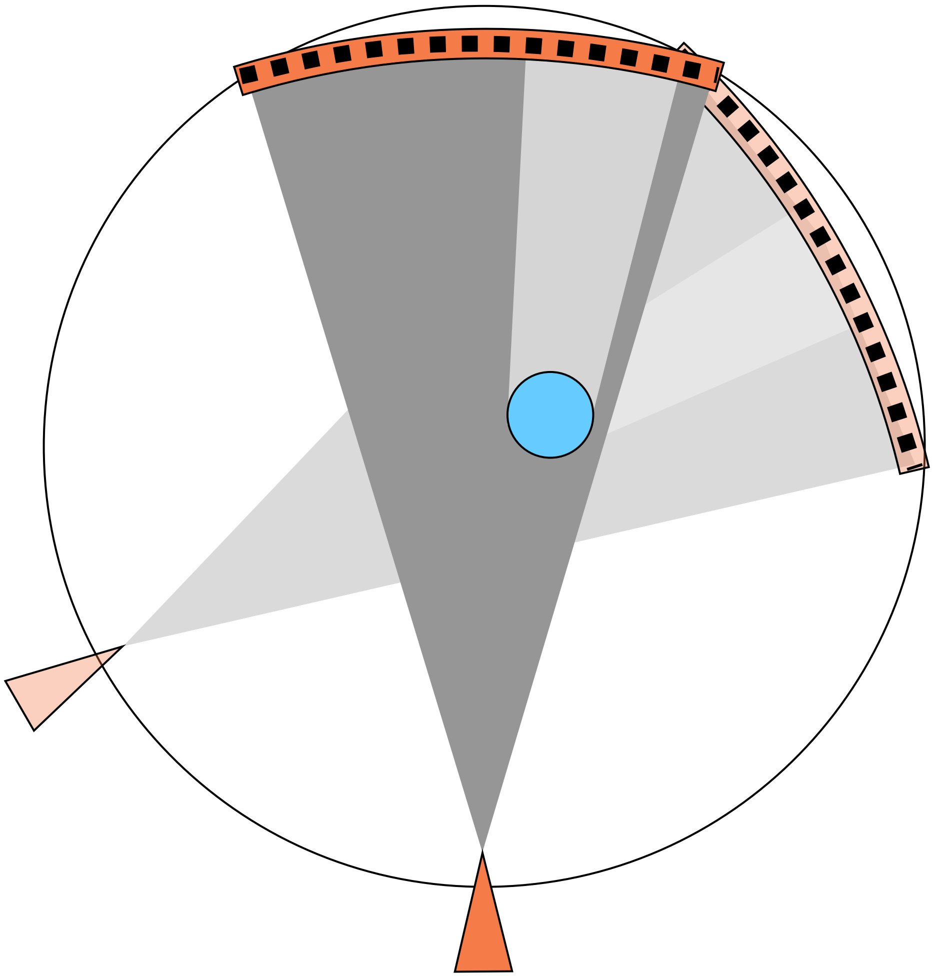

detectors
x-ray source

acquisition



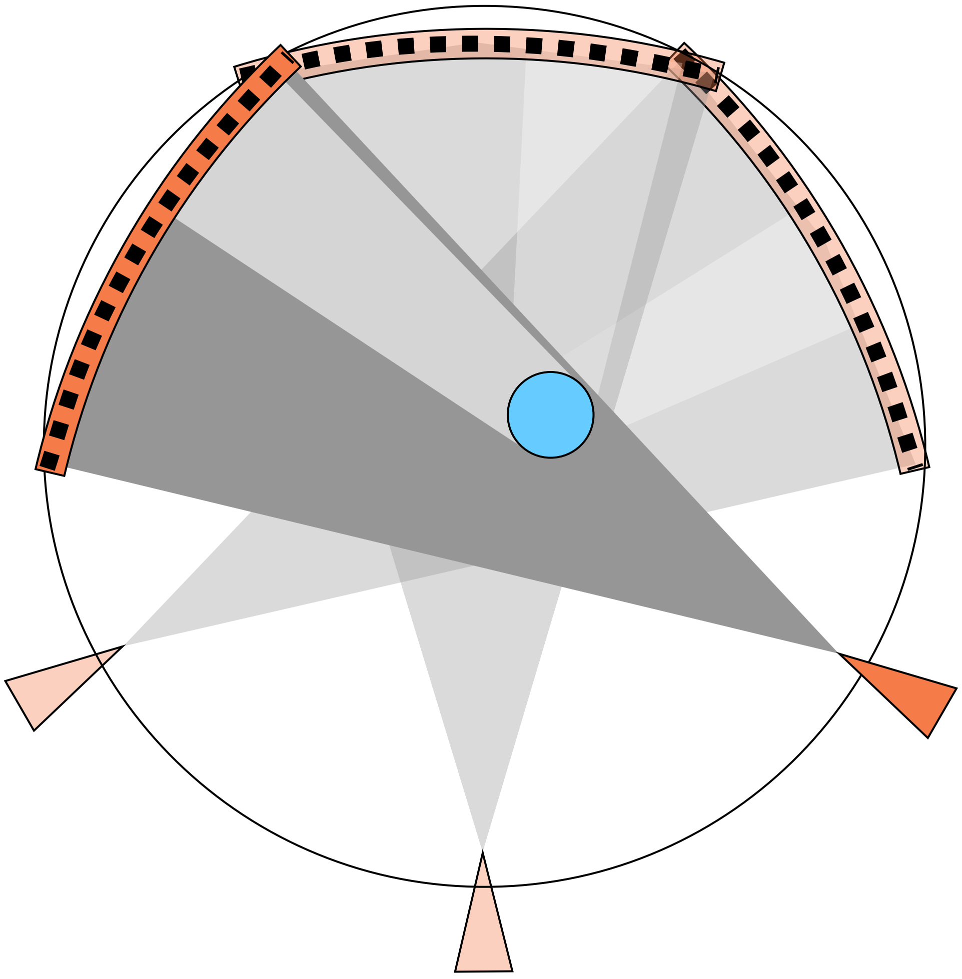
Animation courtesy of
Demetrios J. Halazonetis

acquisition



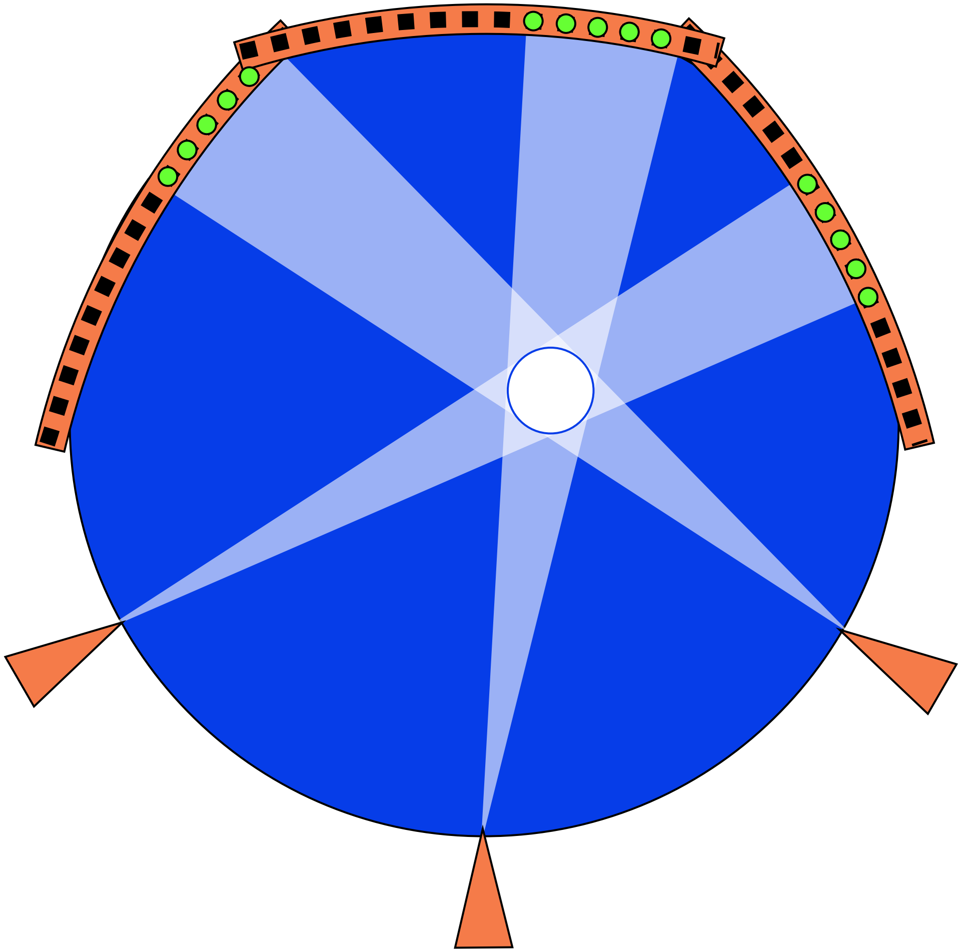
Animation courtesy of Demetrios J. Halazonetis

acquisition



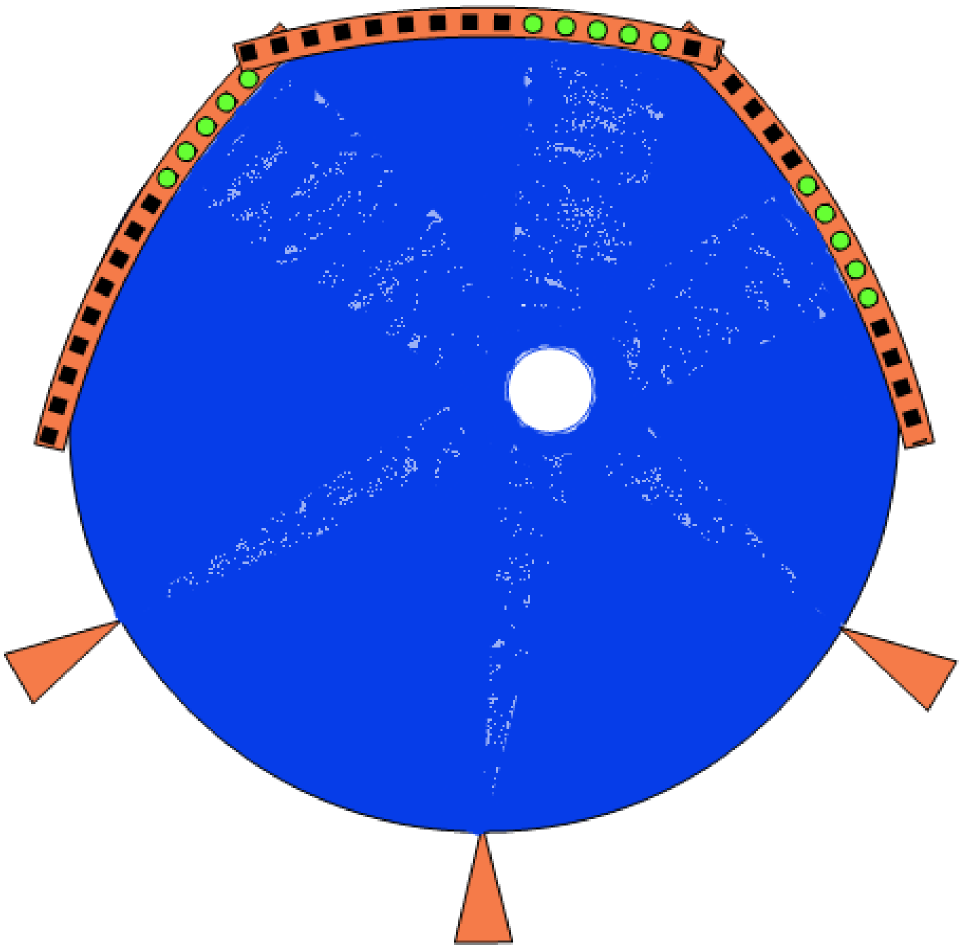
Animation courtesy of
Demetrios J. Halazonetis

Reconstruction – filtered backprojection



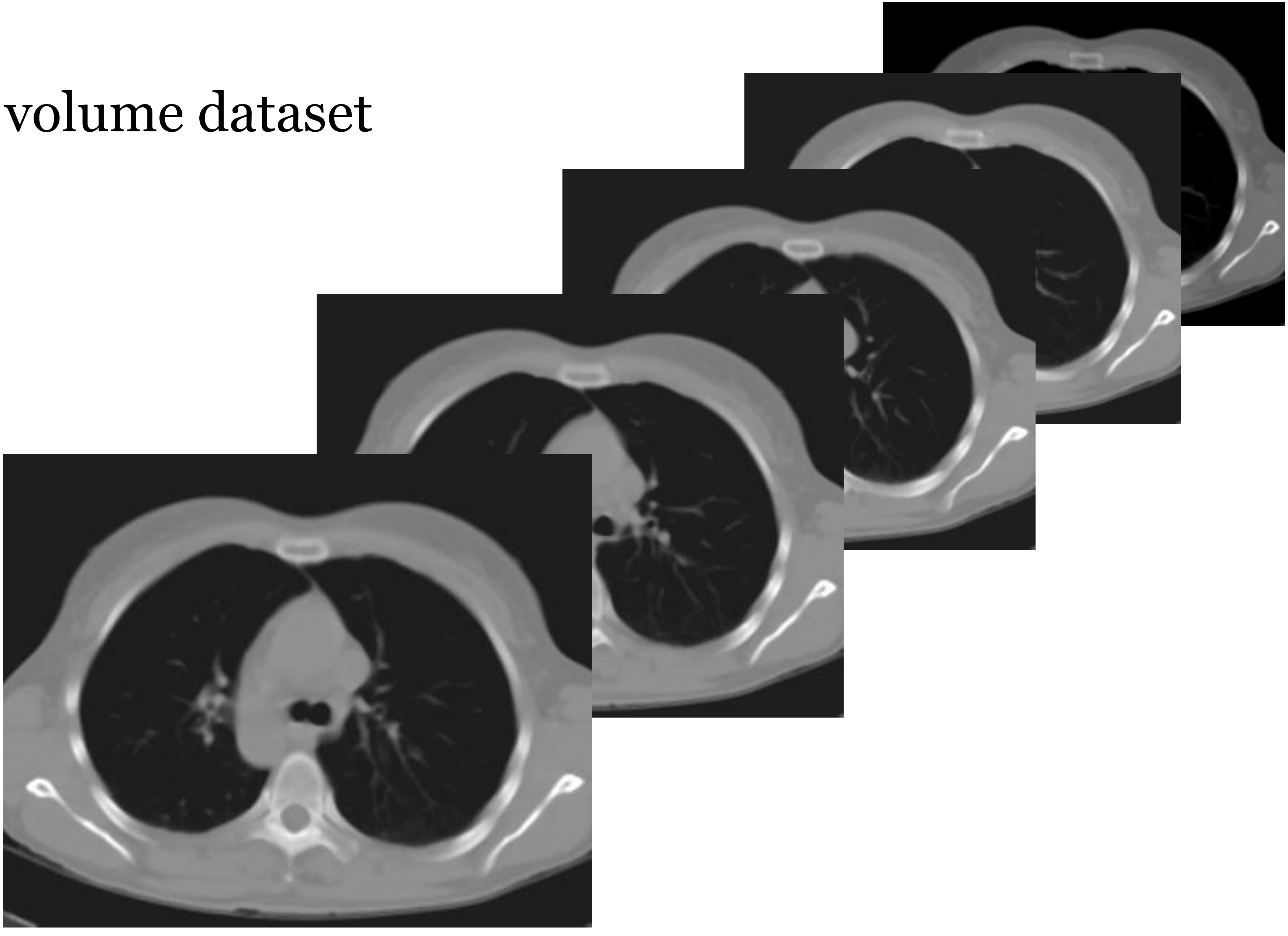
Animation courtesy of Demetrios J. Halazonetis

Reconstruction – filtered backprojection

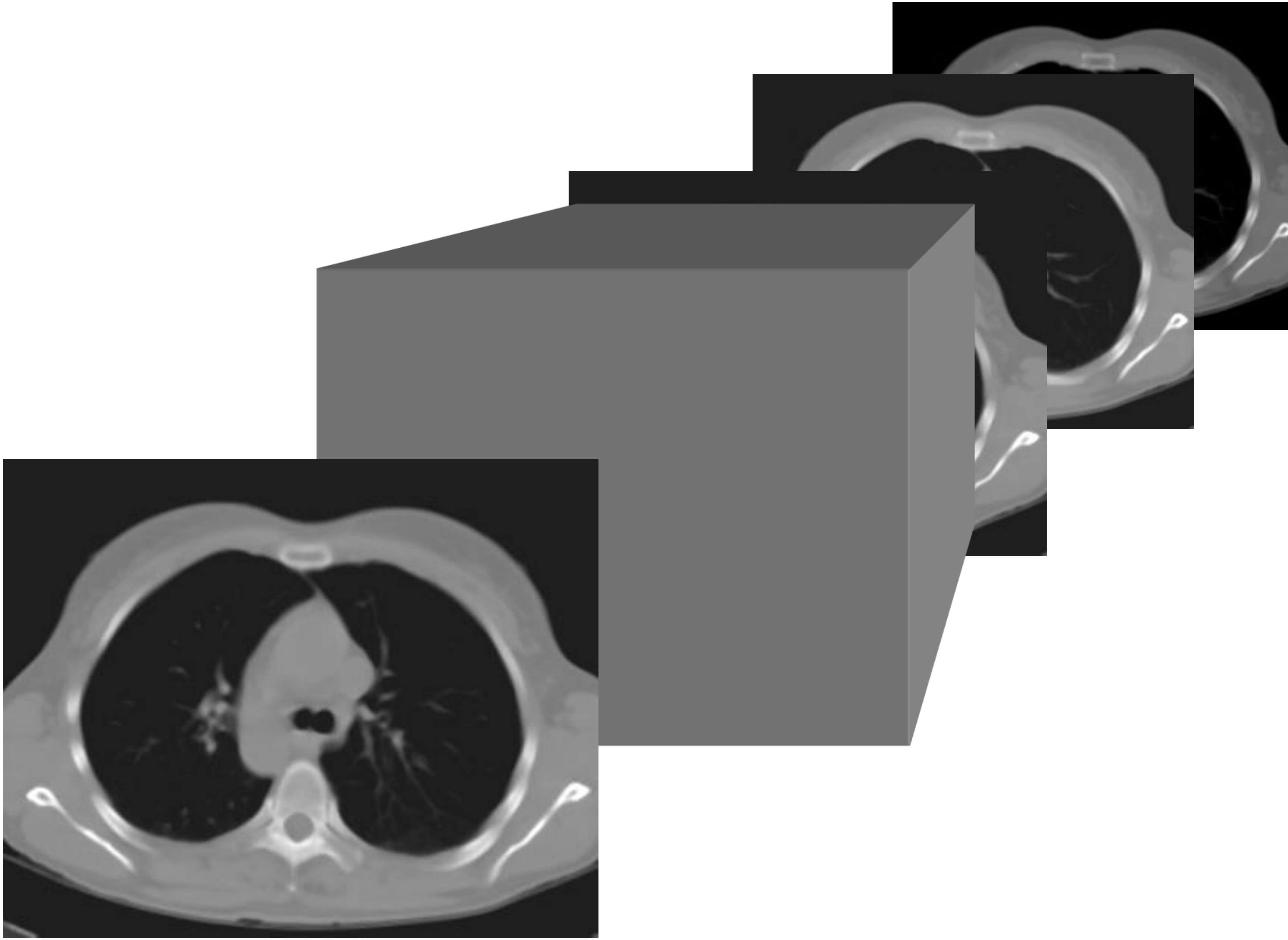


Animation courtesy of Demetrios J. Halazonetis

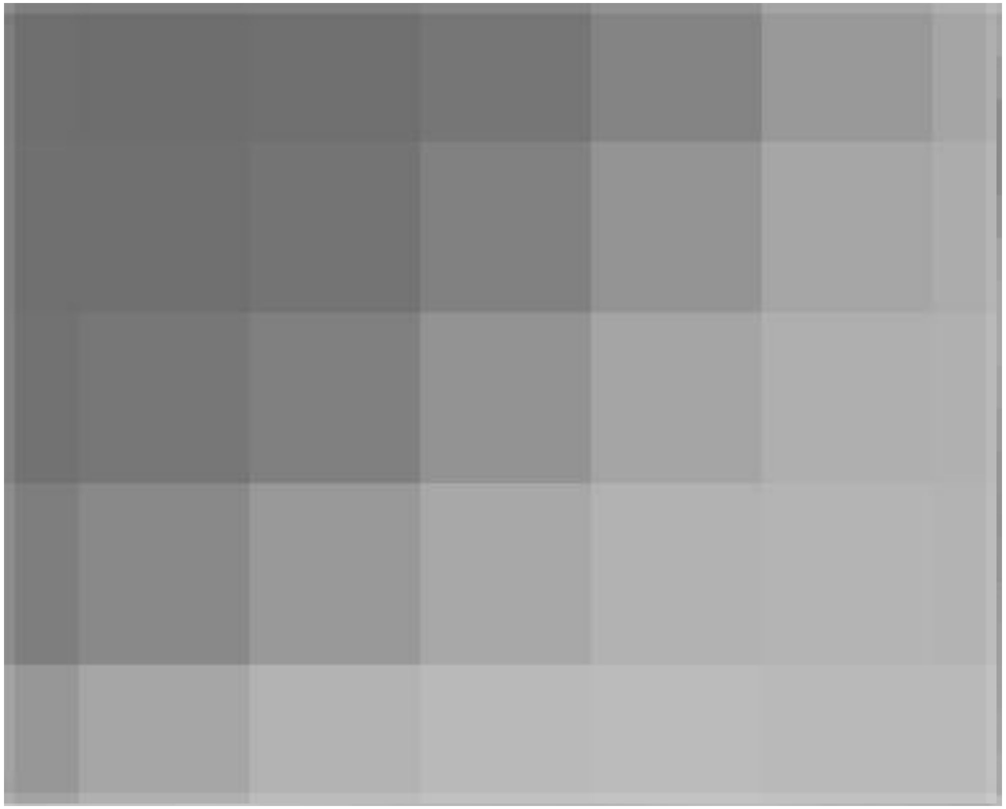
volume dataset



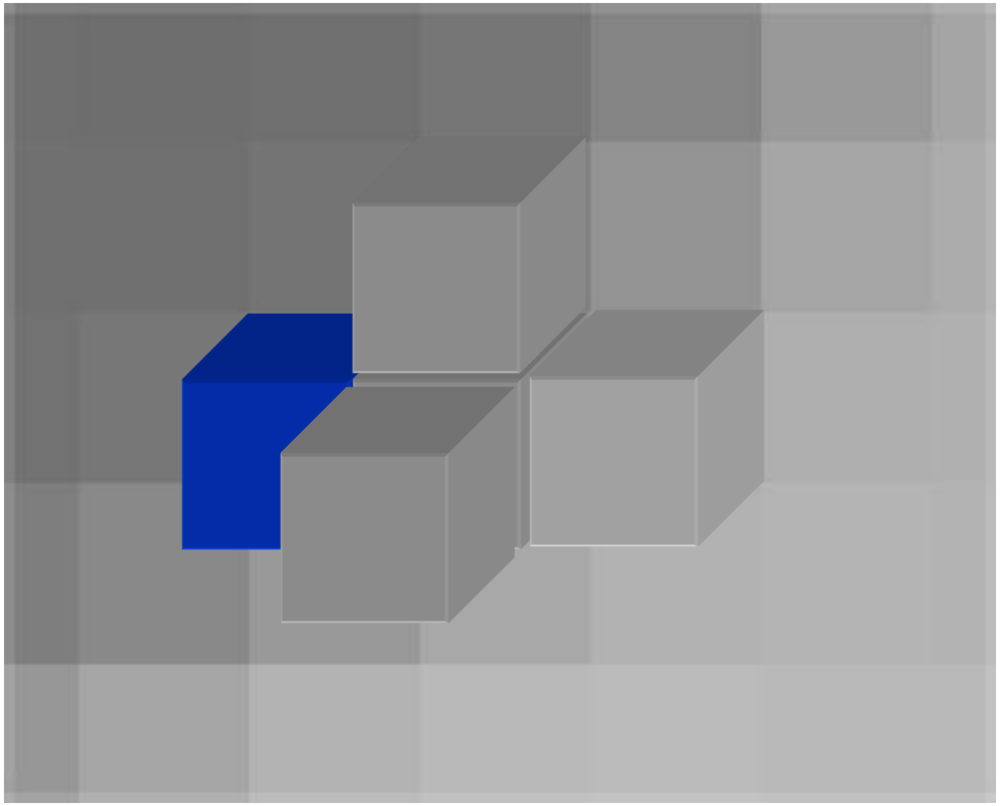
Animation courtesy of
Demetrios J. Halazonetis



Animation courtesy of
Demetrios J. Halazonetis

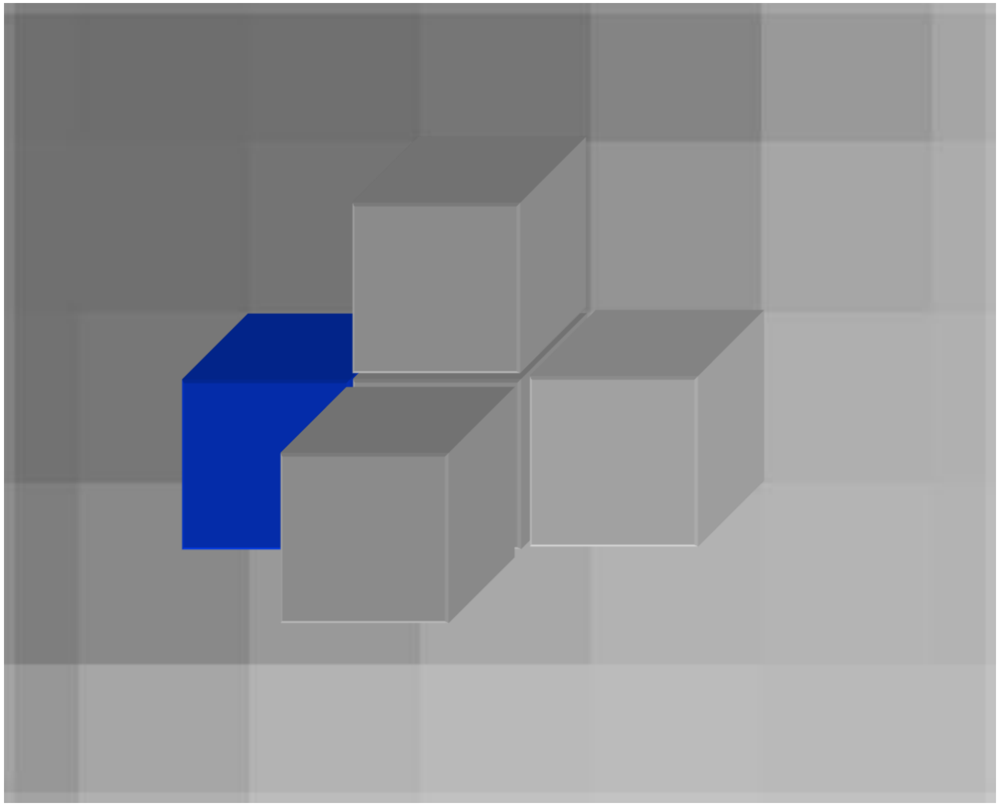


Animation courtesy of
Demetrios J. Halazonetis



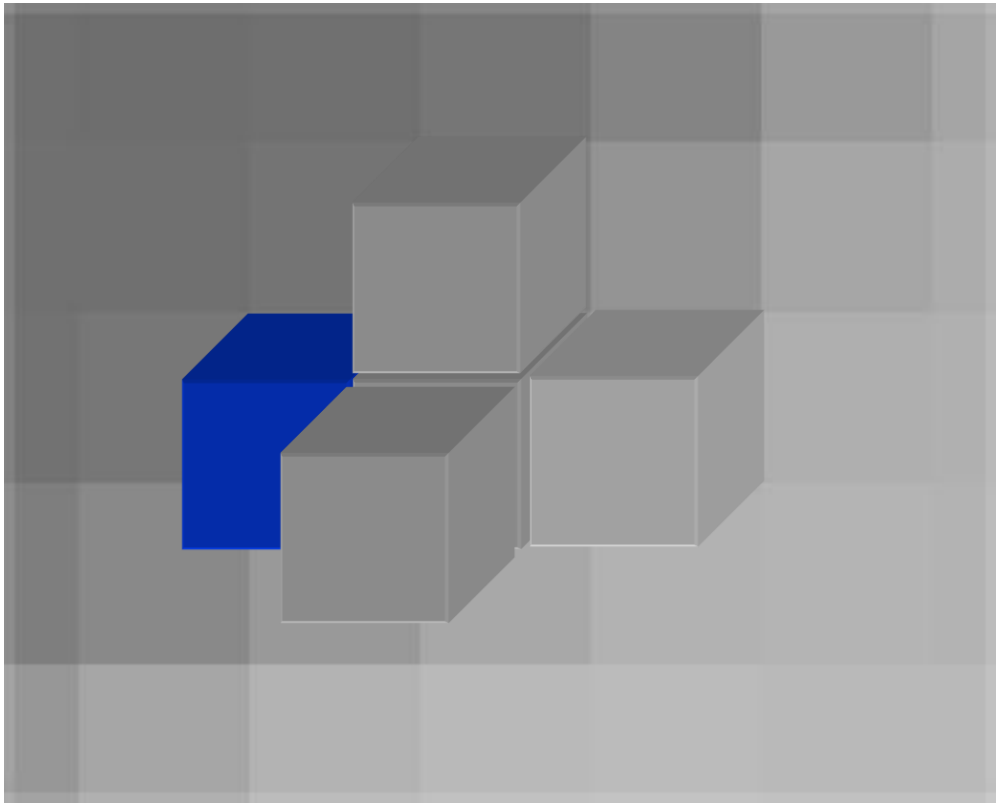
Animation courtesy of
Demetrios J. Halazonetis

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



Animation courtesy of Demetrios J. Halazonetis

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

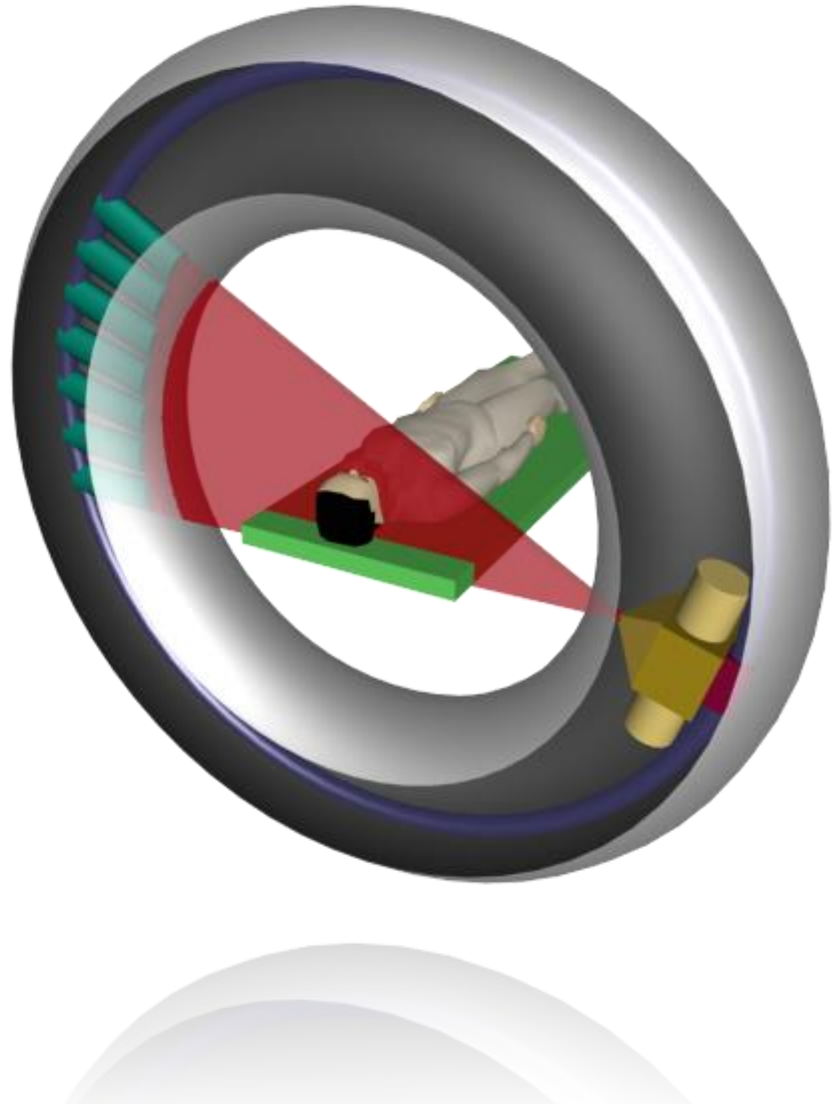


density:
0 - 4095

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

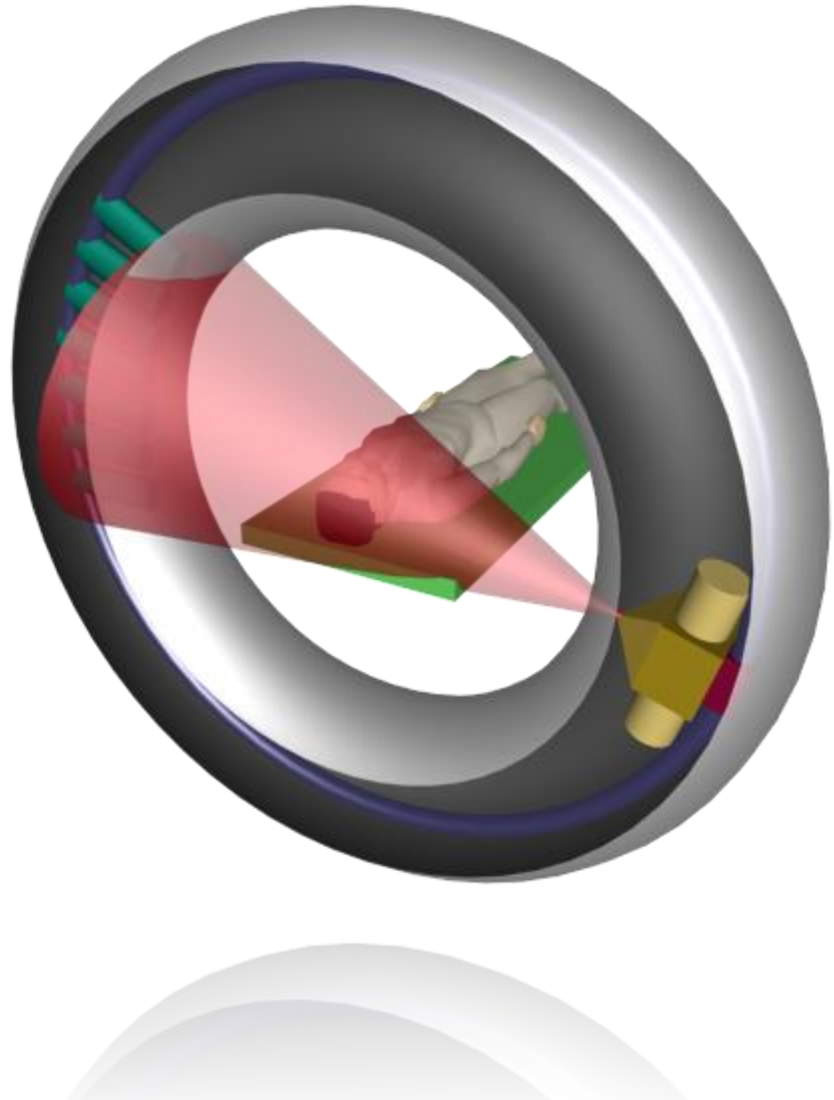
Animation courtesy of Demetrios J. Halazonetis

cone-beam CT (CBCT)



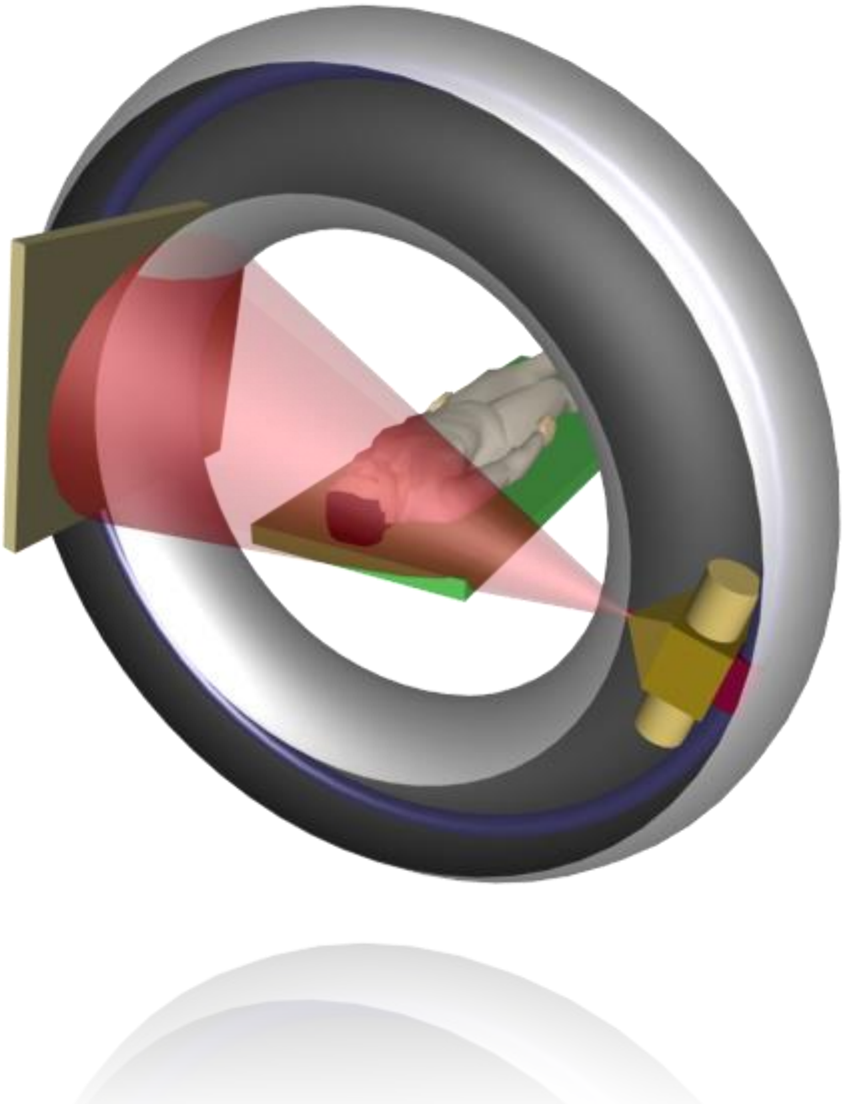
Animation courtesy of
Demetrios J. Halazonetis

cone-beam CT (CBCT)



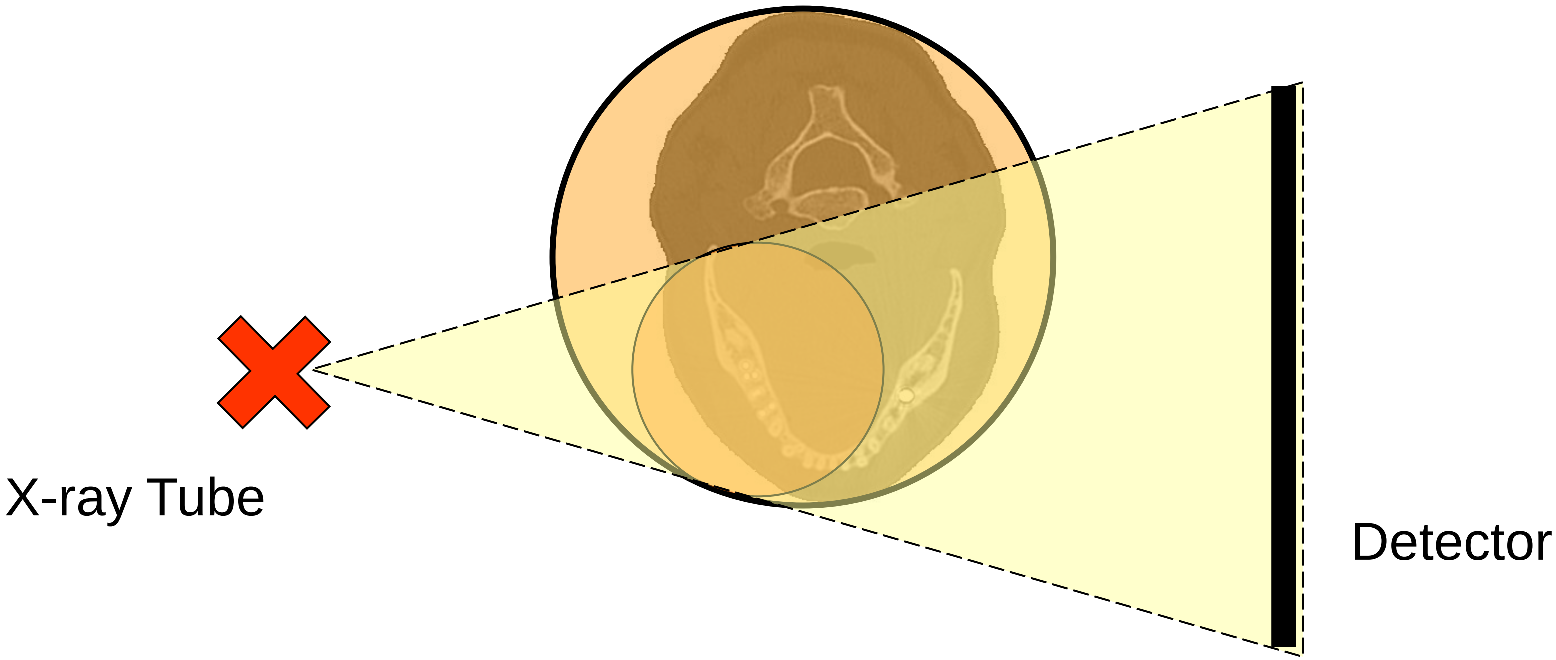
Animation courtesy of
Demetrios J. Halazonetis

cone-beam CT (CBCT)



Animation courtesy of
Demetrios J. Halazonetis

cone-beam CT (CBCT)

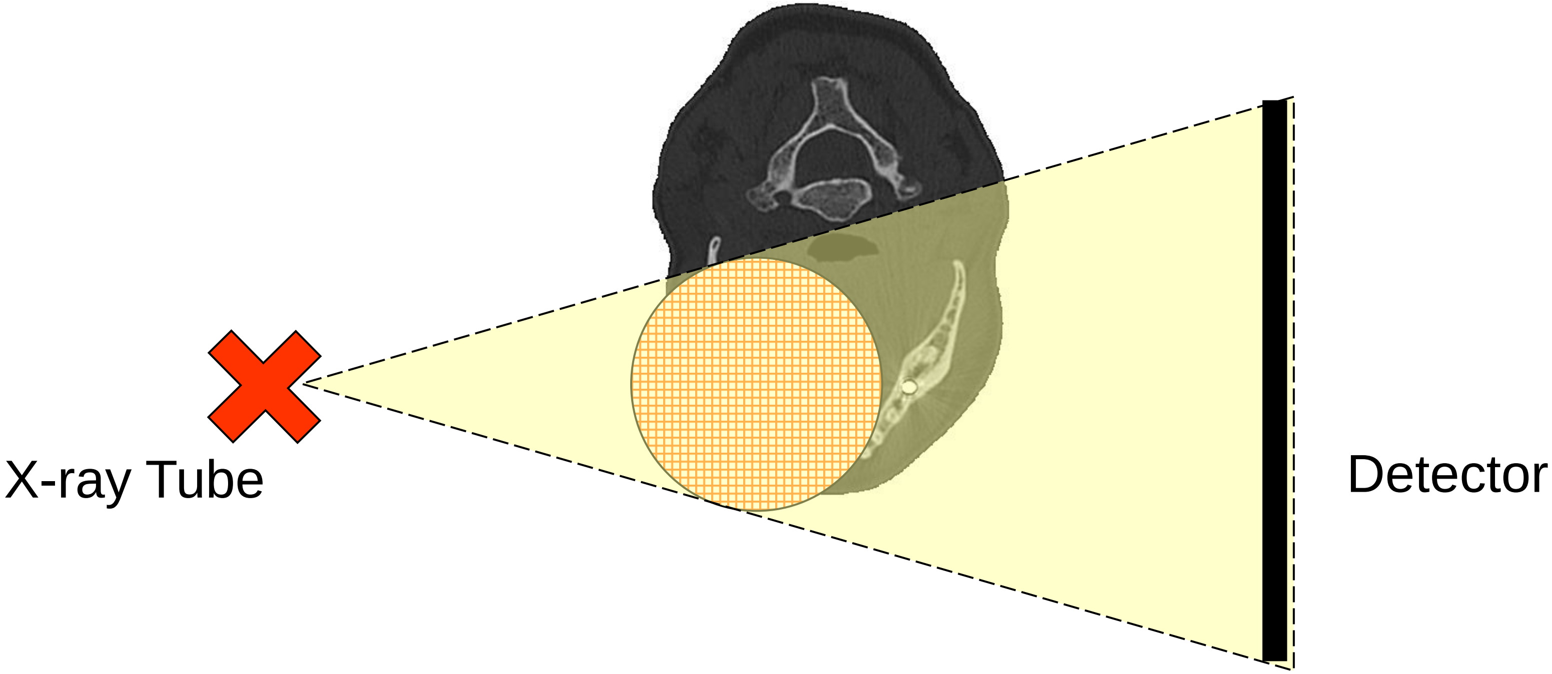


Notes e.g. specific imaging parameters / protocols / concerns

PLEASE AVOID SCANNING THE SPINE

“Sorry mate – no can do!”

Limitation of Small Field Of View CBCT



- CBCT measures the density within the Field Of View only
- Material outside the Field Of View has an unpredictable effect
- Software corrections means pixels may change with updates

4cm x 4cm

6cm x 4cm

8cm x 5cm

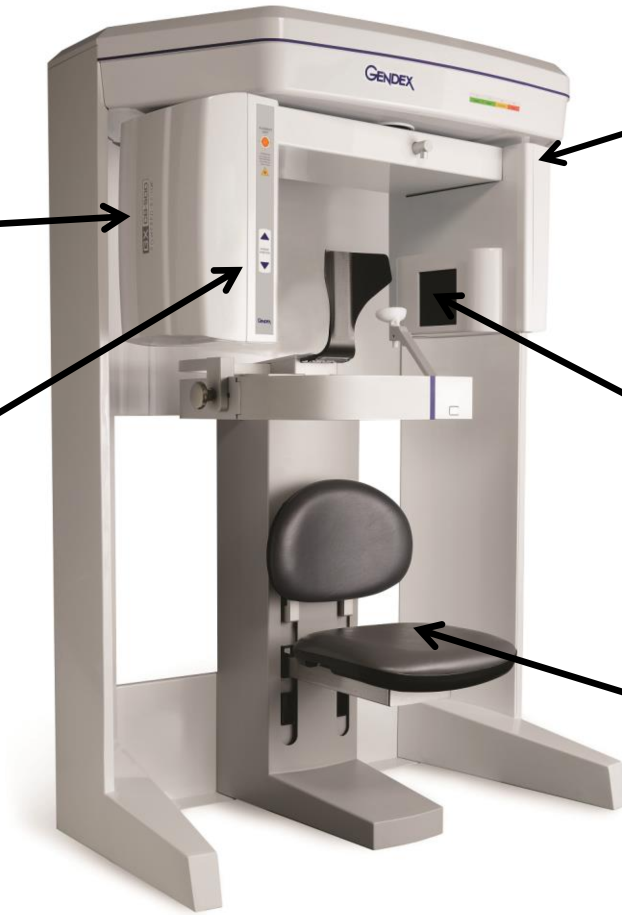
10cm x 6cm

Three reasons why CBCT pixel values don't lie on the Hounsfield scale:

- **The Hounsfield Scale is defined at 120kVp, but most CBCT scanners run at 80-90kVp**
- **The x-ray spectrum contains more low energy photons because of scattered radiation**
- **The voxel densities cannot be calculated accurately!**

CB-500 CBCT Scanner

Imaging Excellence Since 1893



pulsed x-ray tube

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

fast scan times
4.8s to 23s

low dose
typical Mx 35µSv
typical Mn 60µSv

large detector
8cm x 8cm

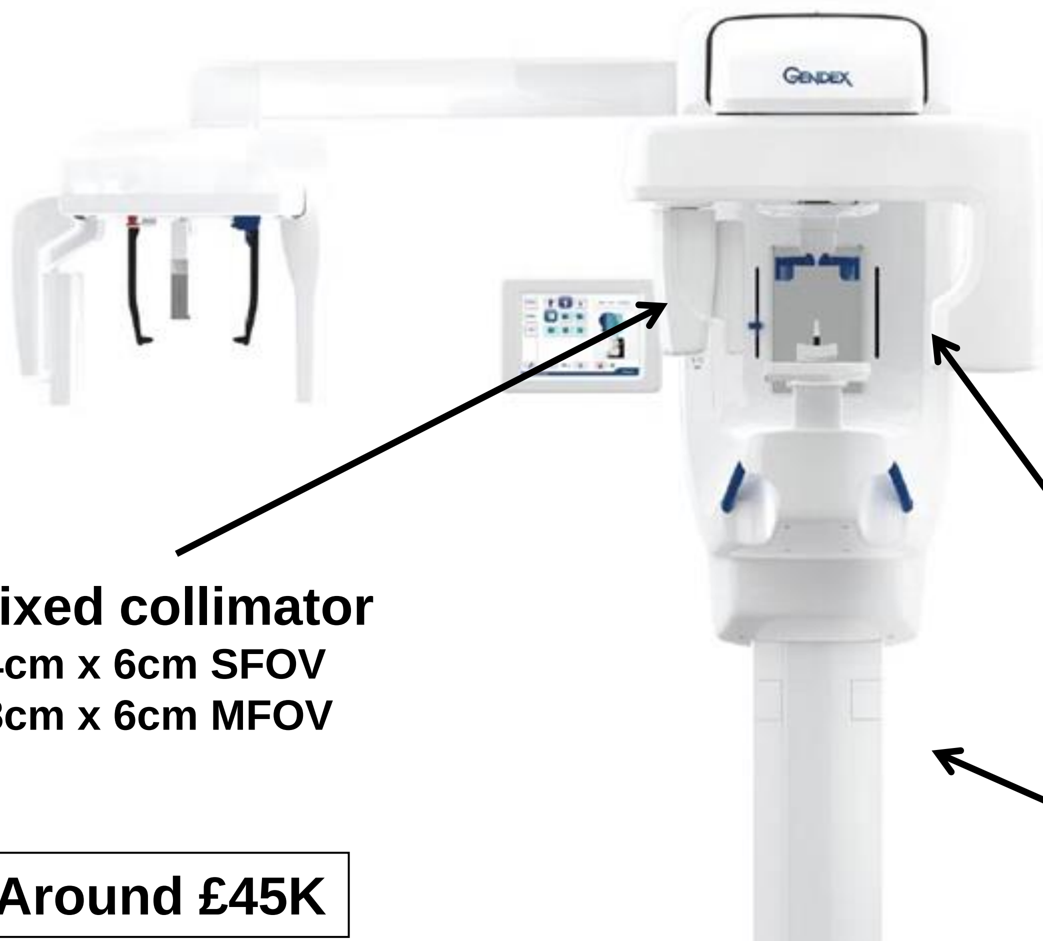
adjustable chair

Around £90K

Gendex™ is a trademark of Gendex Dental Systems of Lake Zurich, USA

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

Gendex™ is a trademark of Gendex Dental Systems of Lake Zurich, USA

The Best CBCT Scanner on the Market?

Aquilion ONE medical CT Scanner

160 detector rows
320 slices

operates in cone beam mode

0.5s scan time

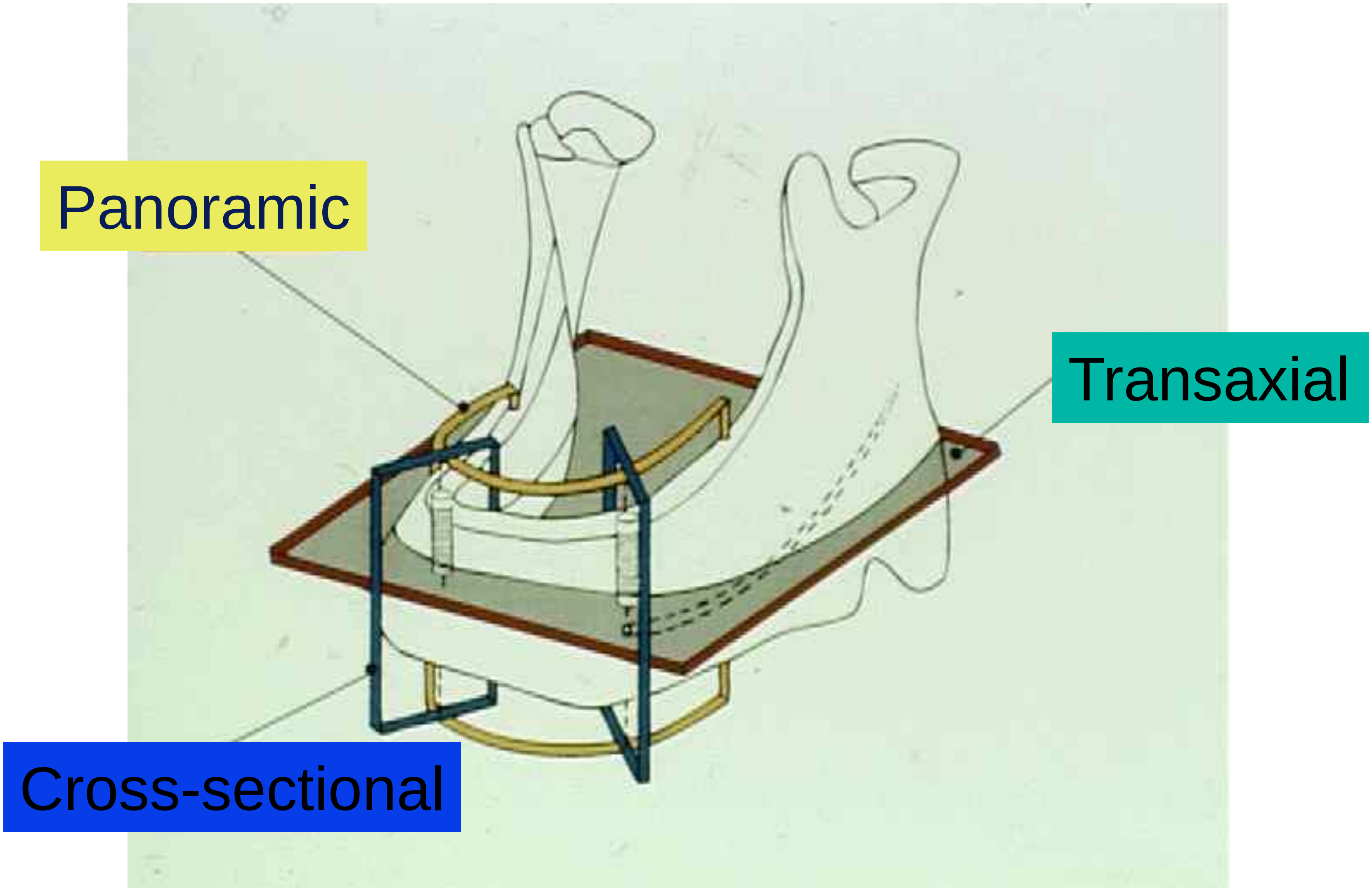
volume capture
24cm x 16cm max

Effective Doses
typical Mx 100μSv
typical Mn 150μSv

Around £1M

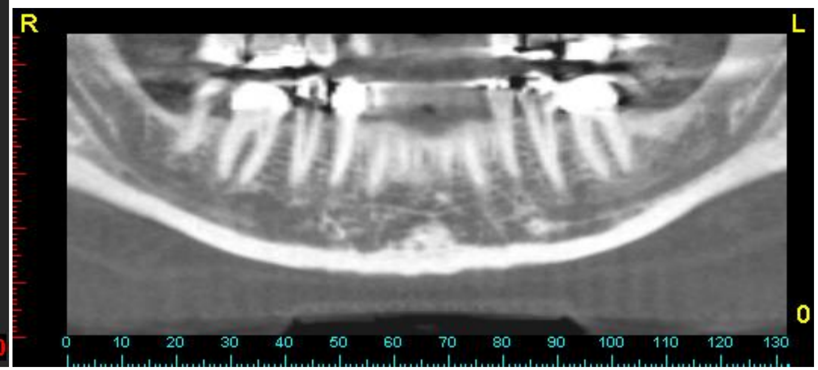
Aquilion™ is a trademark of Canon Medical Systems Corporation (formerly Toshiba)

Basic CBCT images



Basic CBCT images

Axials



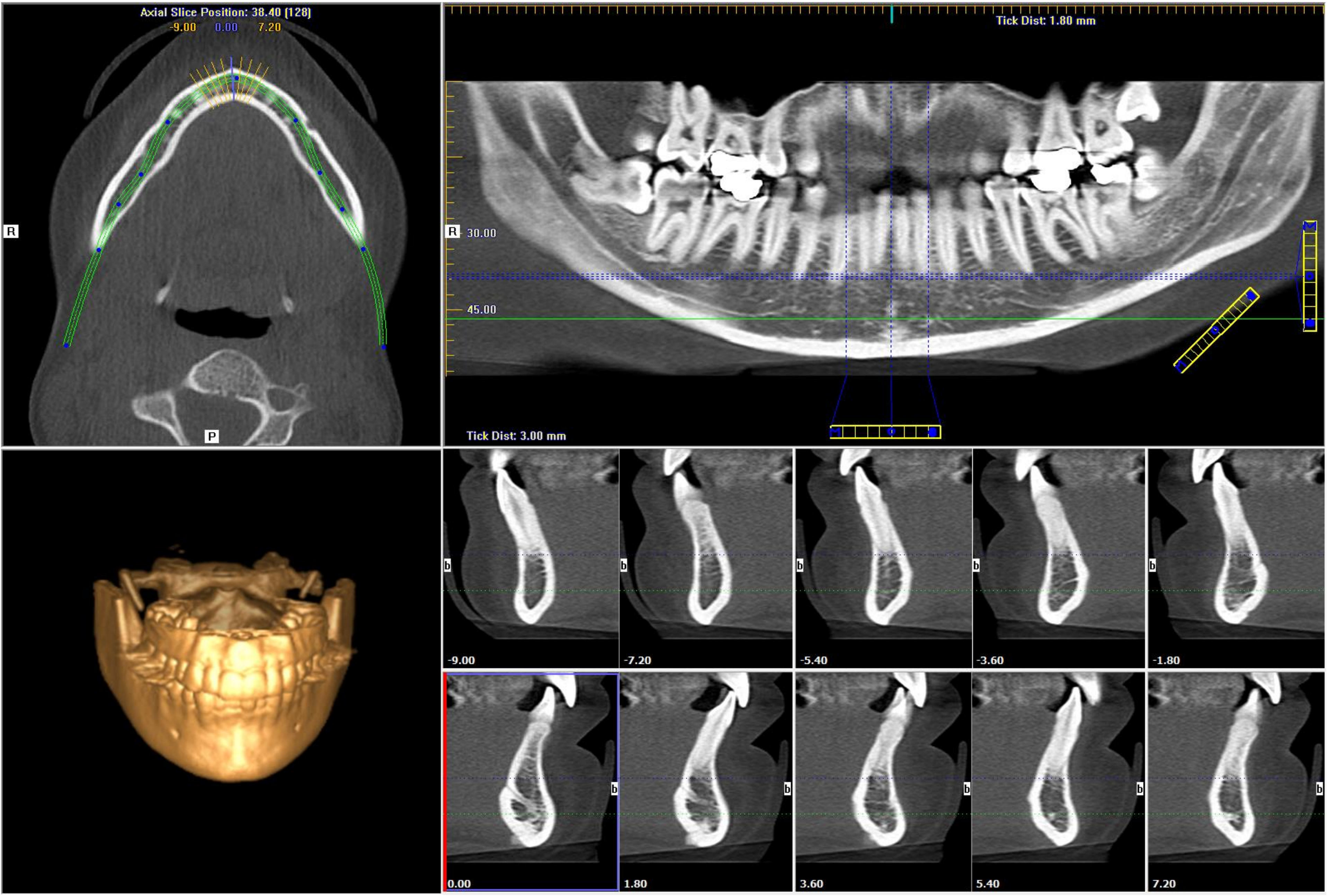
Panoramics

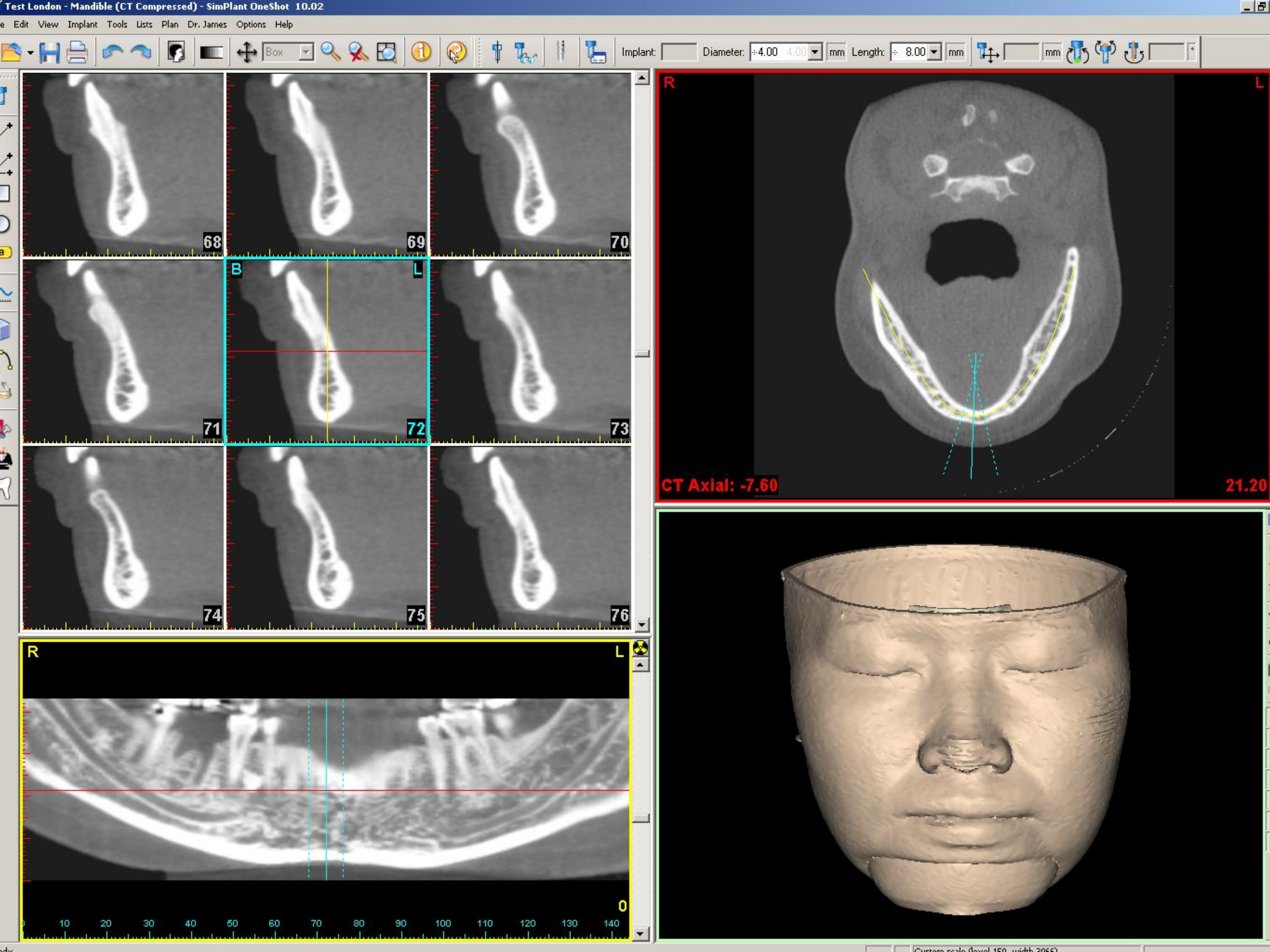
Cross Sections

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
b
-9.00
-7.20
-5.40
-3.60
-1.80
0.00
1.80
3.60
5.40
7.20



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
75
76
R
L
CT Axial: -7.60
21.20
R
L
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140

Image Quality in CBCT scans

- Noise

- ***electronic noise (dark current)***
- ***photon noise (not enough x-rays)***

- Artefact

- ***patient movement***
- ***metal objects within the patient***
- ***rings (machine calibration, poor operator technique)***

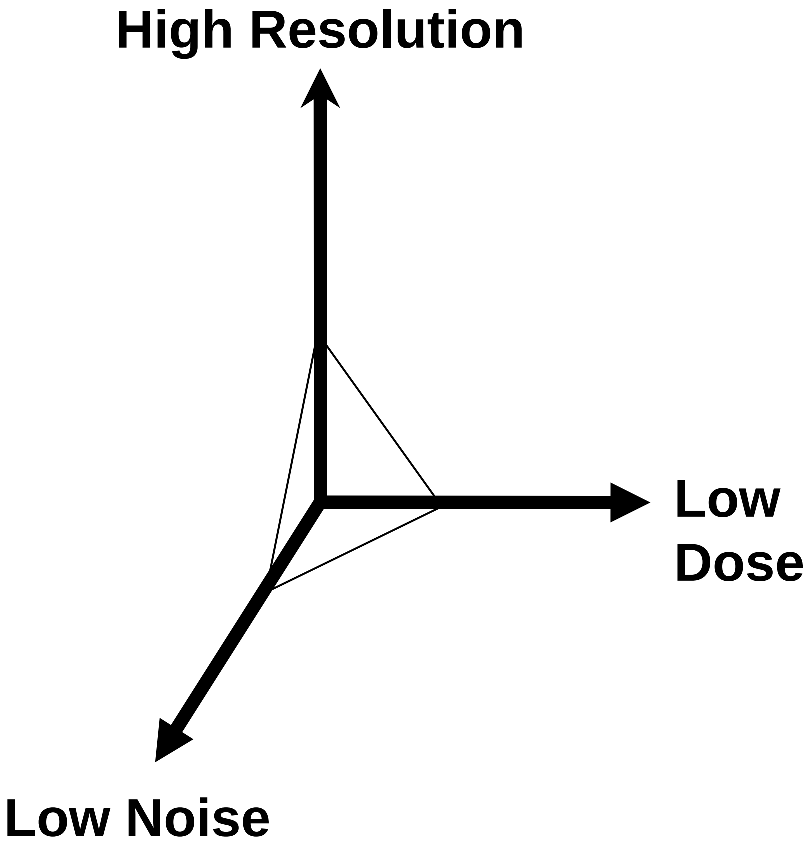
- Spatial Resolution (resolution at high contrast)

- ***depends on machine design***
  (focal spot size, detector elements, sampling, mechanical stability)
- ***voxel size can only limit the resolution – cannot increase it!***

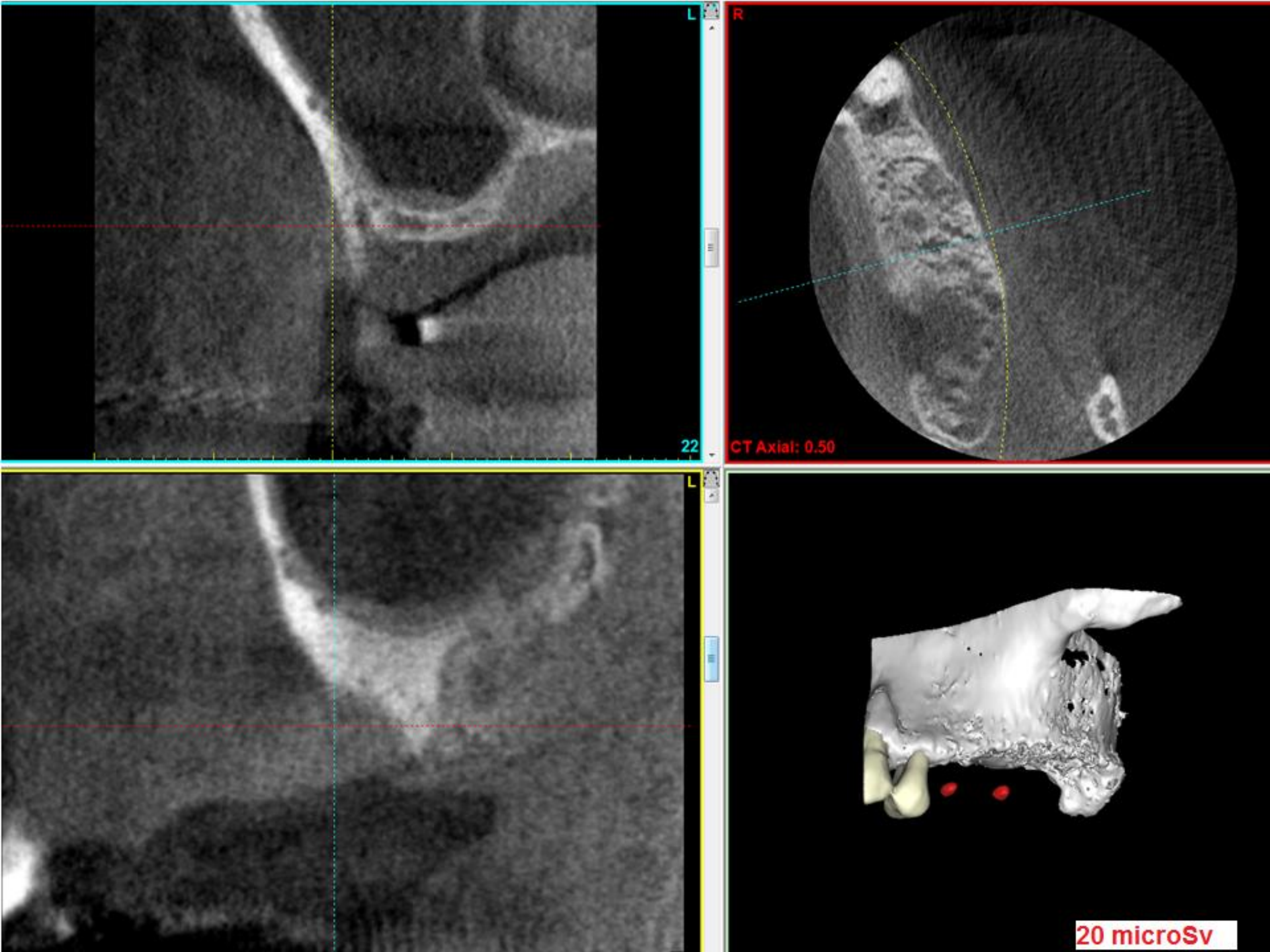
- Contrast Resolution (resolution at low contrast)

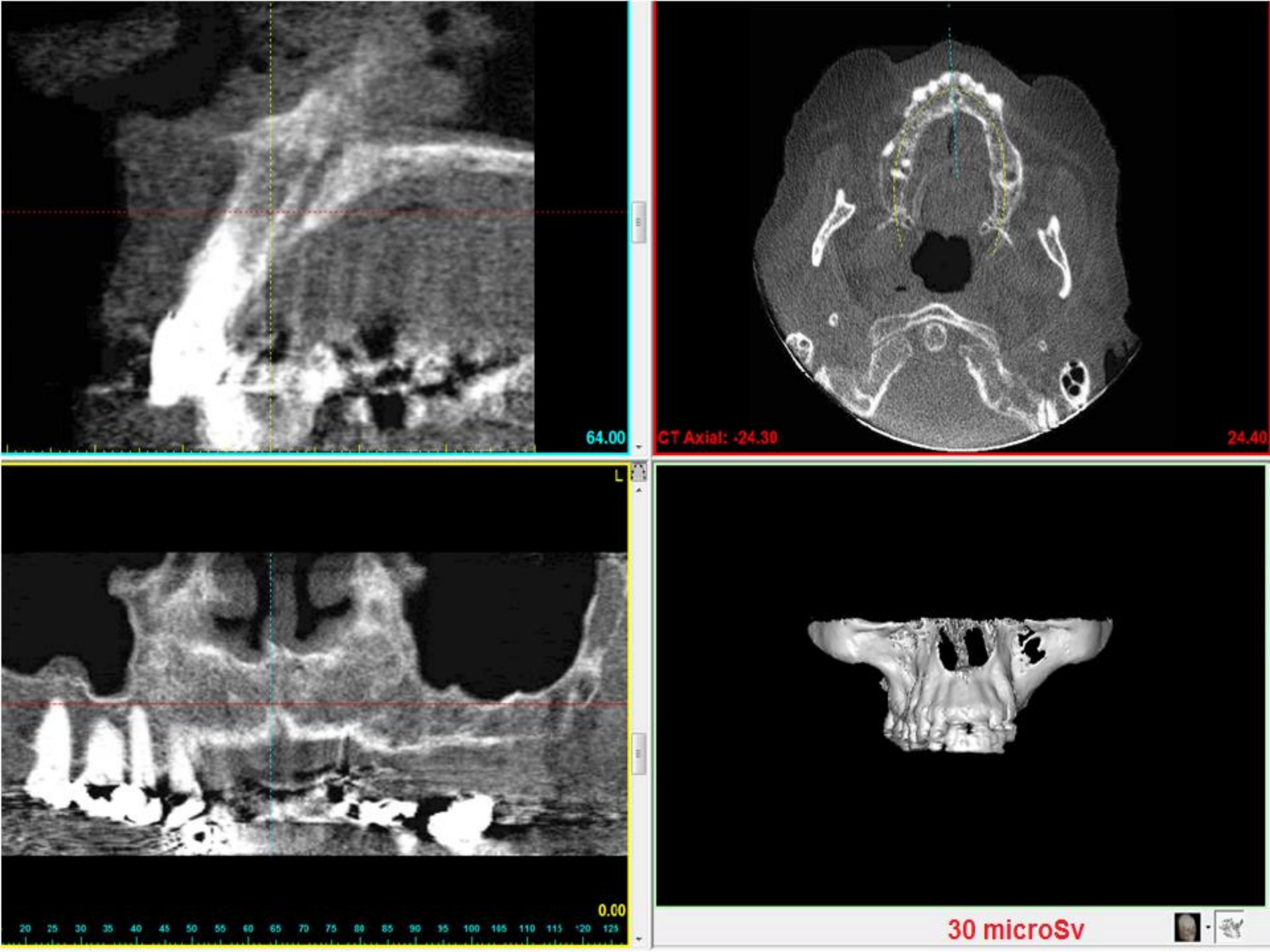
- ***depends on machine design (kVp, filtration, reconstruction algorithms)***

The impossible dream

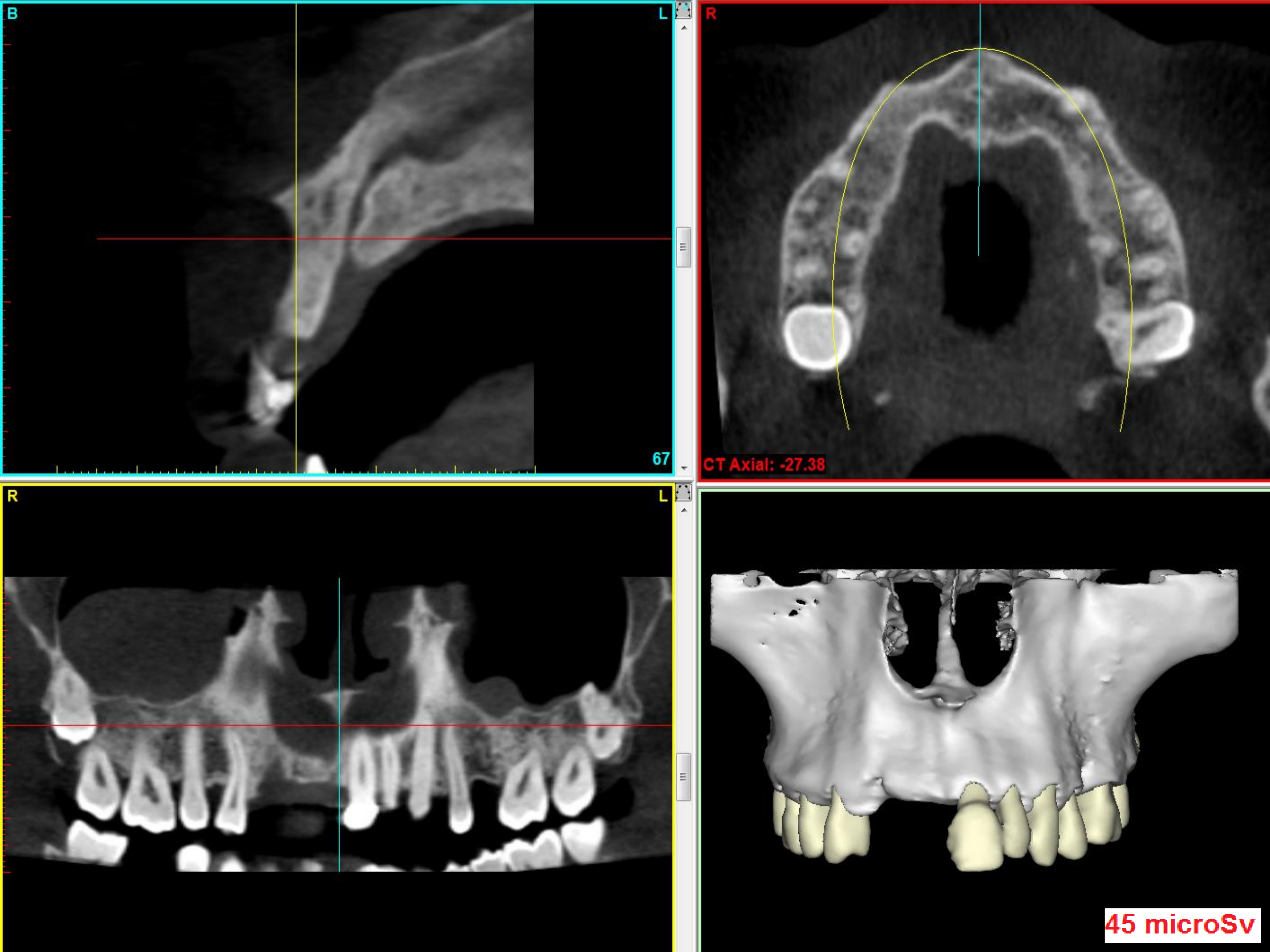


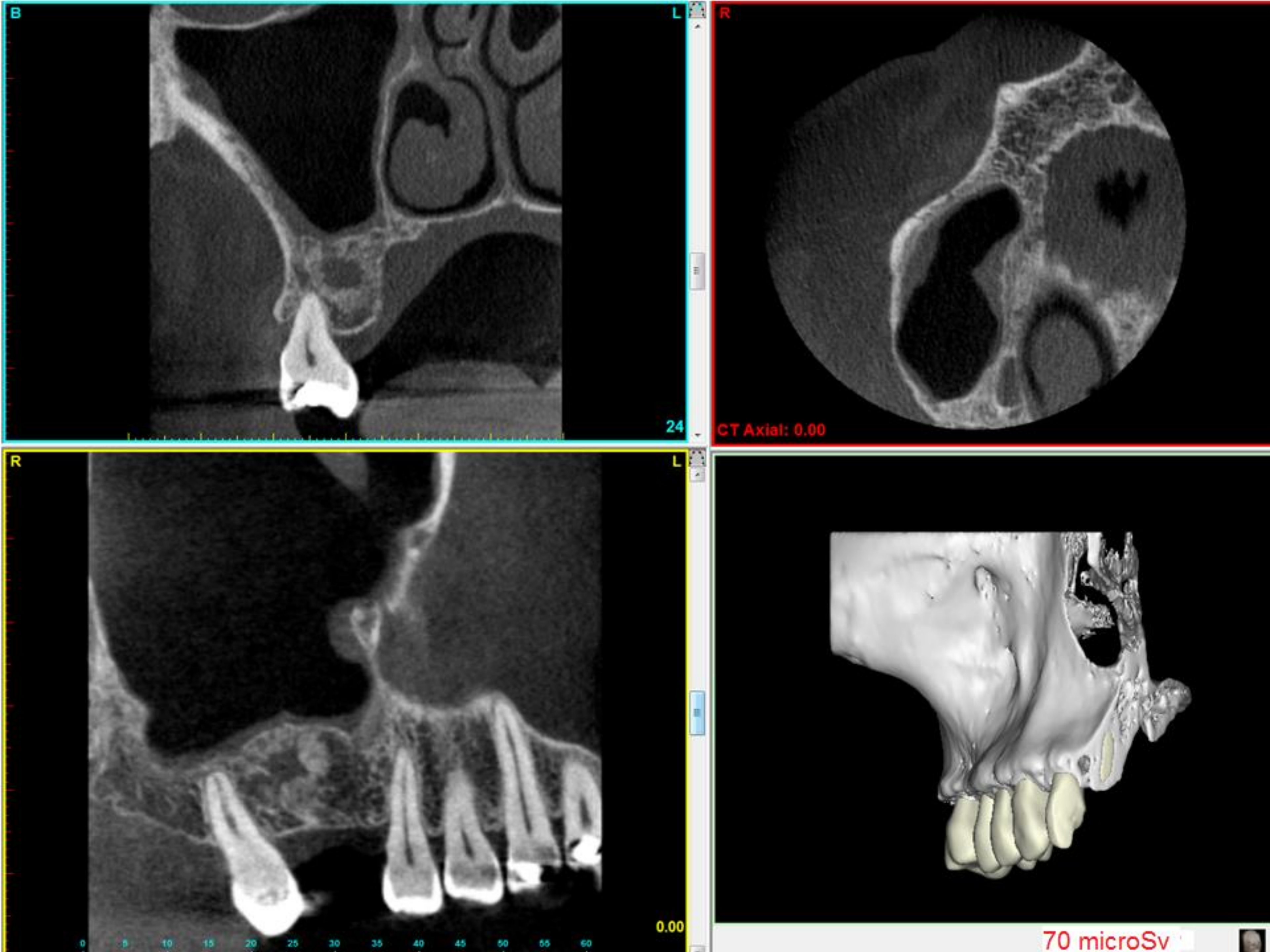
A good scanner will offer a range of voxel sizes, mAs and field sizes to suit the imaging task at hand.


L
22
R
CT Axial: 0.50
L
20 microSv



64.00
CT Axial: -24.30
24.40
L
0.00
20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100 105 110 115 120 125
30 microSv


B
L
67
R
CT Axial: -27.38
R
L
45 microSv



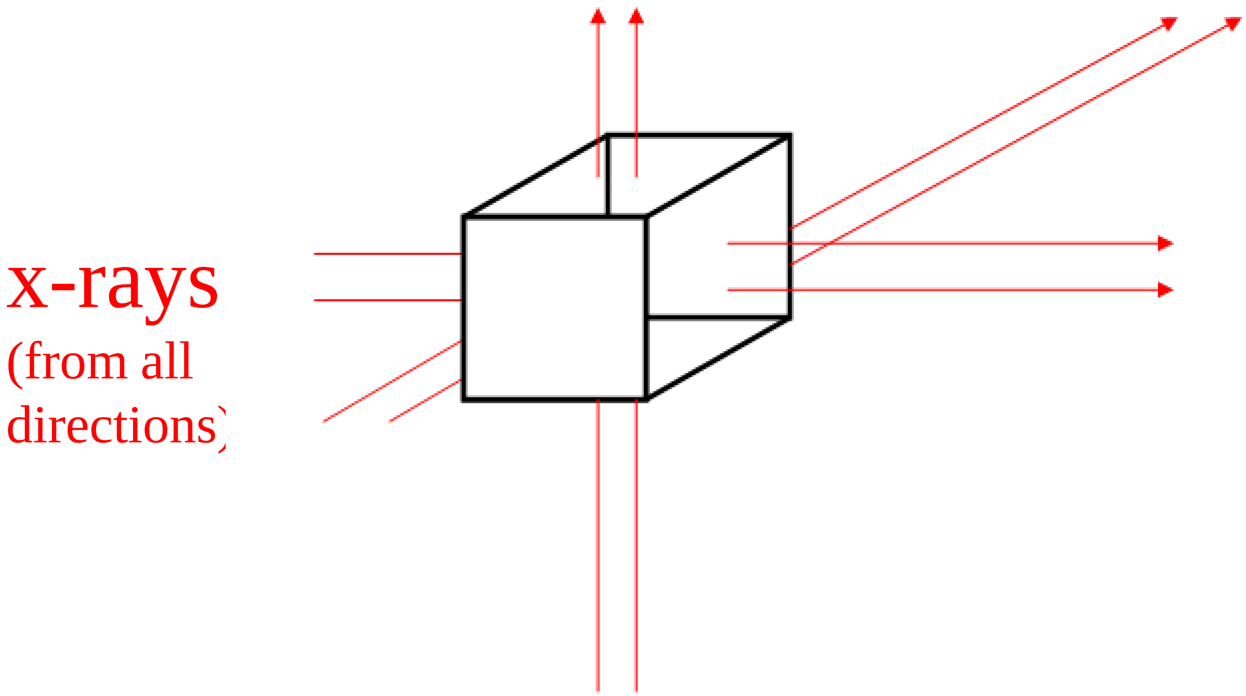
B
L
24
R
CT Axial: 0.00
R
L
0.00
0 5 10 15 20 25 30 35 40 45 50 55 60
70 microSv

Noise in CT / CBCT images

Noise = unstructured contribution to the image which has no counterpart in the object.

- **Electronic noise (dark current)**
- **Photon noise (not enough x-rays)**
  - **Signal-to-Noise Ratio is proportional to $\sqrt{n}$**
  - **Where n is the number of x-ray photons**

Noise depends on voxel size



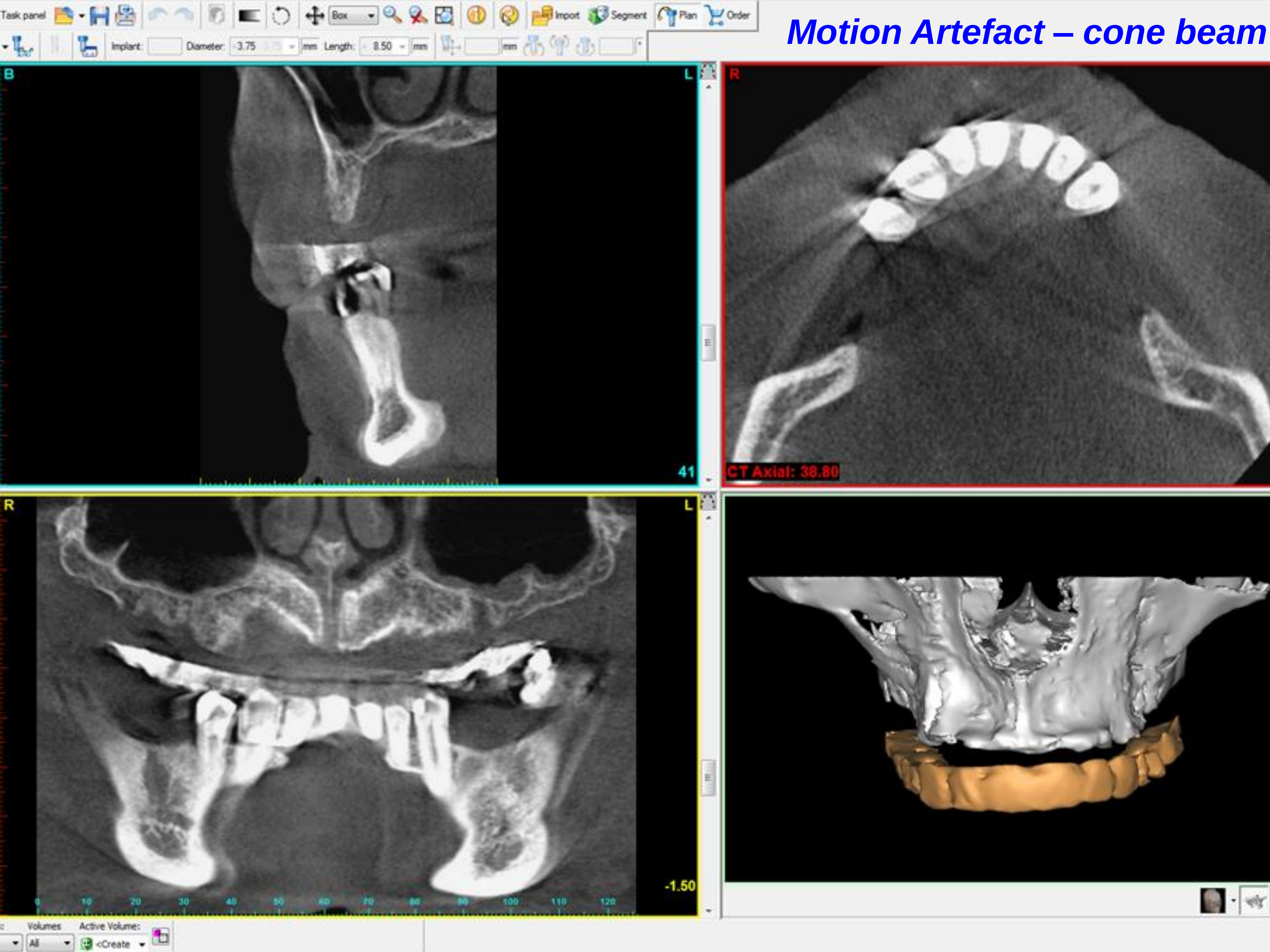
If you halve (1/2) each side of a cube e.g. from 0.4mm to 0.2mm
Number of x-ray photons passing through it goes down by 8 (i.e. 1/8)
Noise goes up by √8 = 2.83
mAs (dose) may have to be increased to compensate

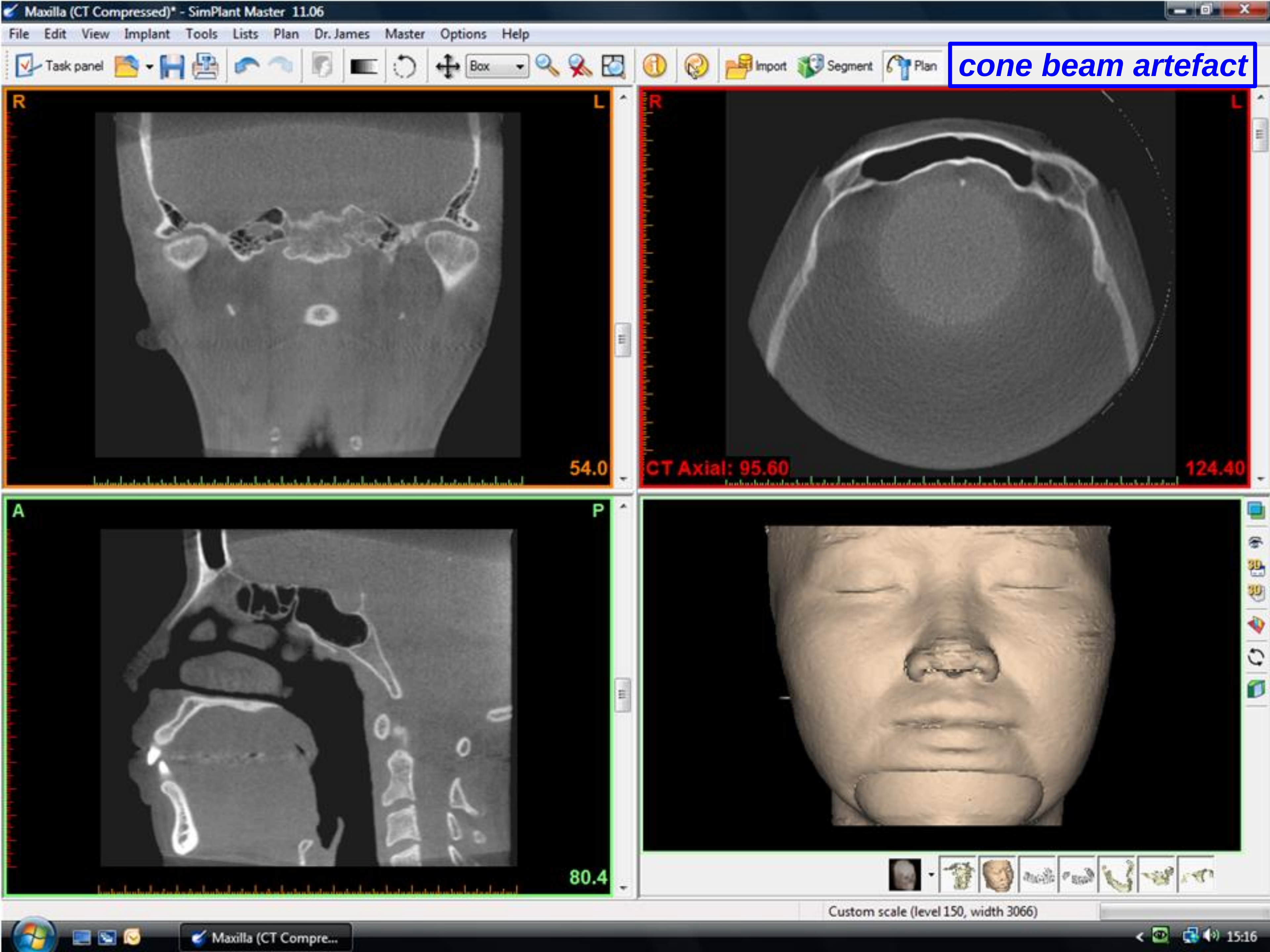
Artefacts in CT / CBCT images

Artefact = structured contribution to the image which has no counterpart in the object.

- **Motion artefact**
- **Cone beam artefacts**
- **Ring artefacts**
- **Starburst (streak) artefact**
- **Beam hardening**

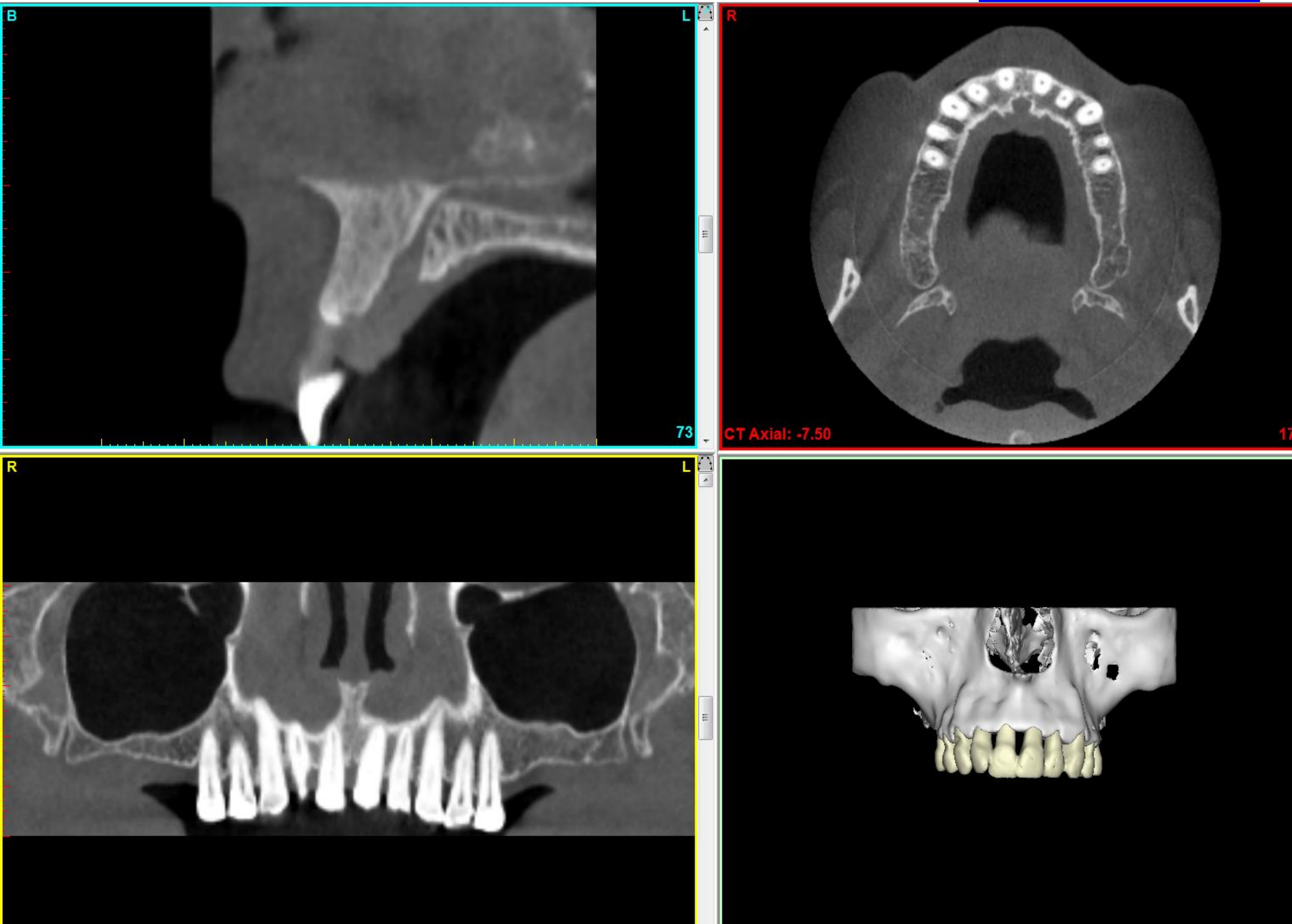
Motion Artefact – cone beam





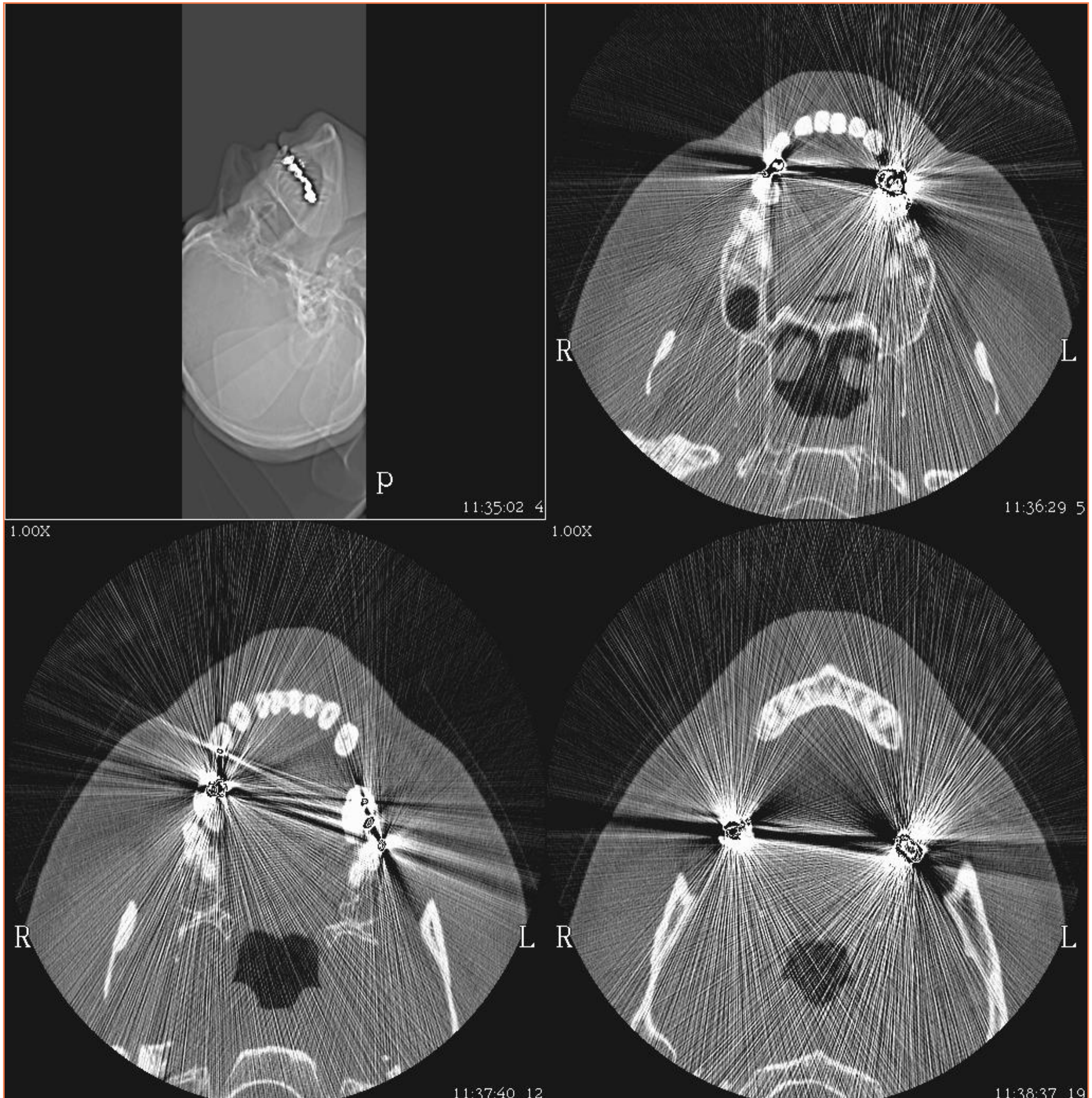
Maxilla (CT Compressed)* - SimPlant Master 11.06
File Edit View Implant Tools Lists Plan Dr. James Master Options Help
Task panel
Box
Import
Segment
Plan
cone beam artefact
R
L
54.0
CT Axial: 95.60
124.40
A
P
80.4
Custom scale (level 150, width 3066)
Maxilla (CT Compre...
15:16

ring artefact



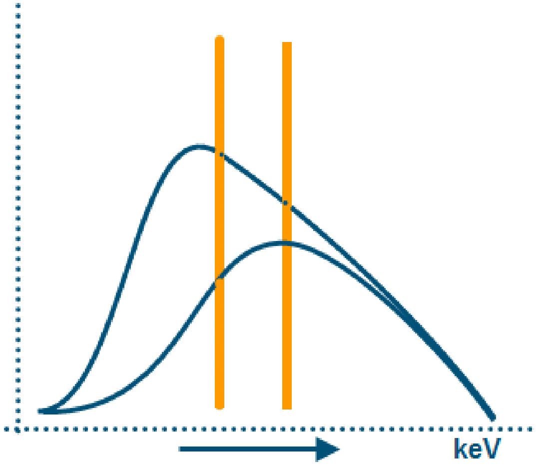
STARBURST ARTEFACT

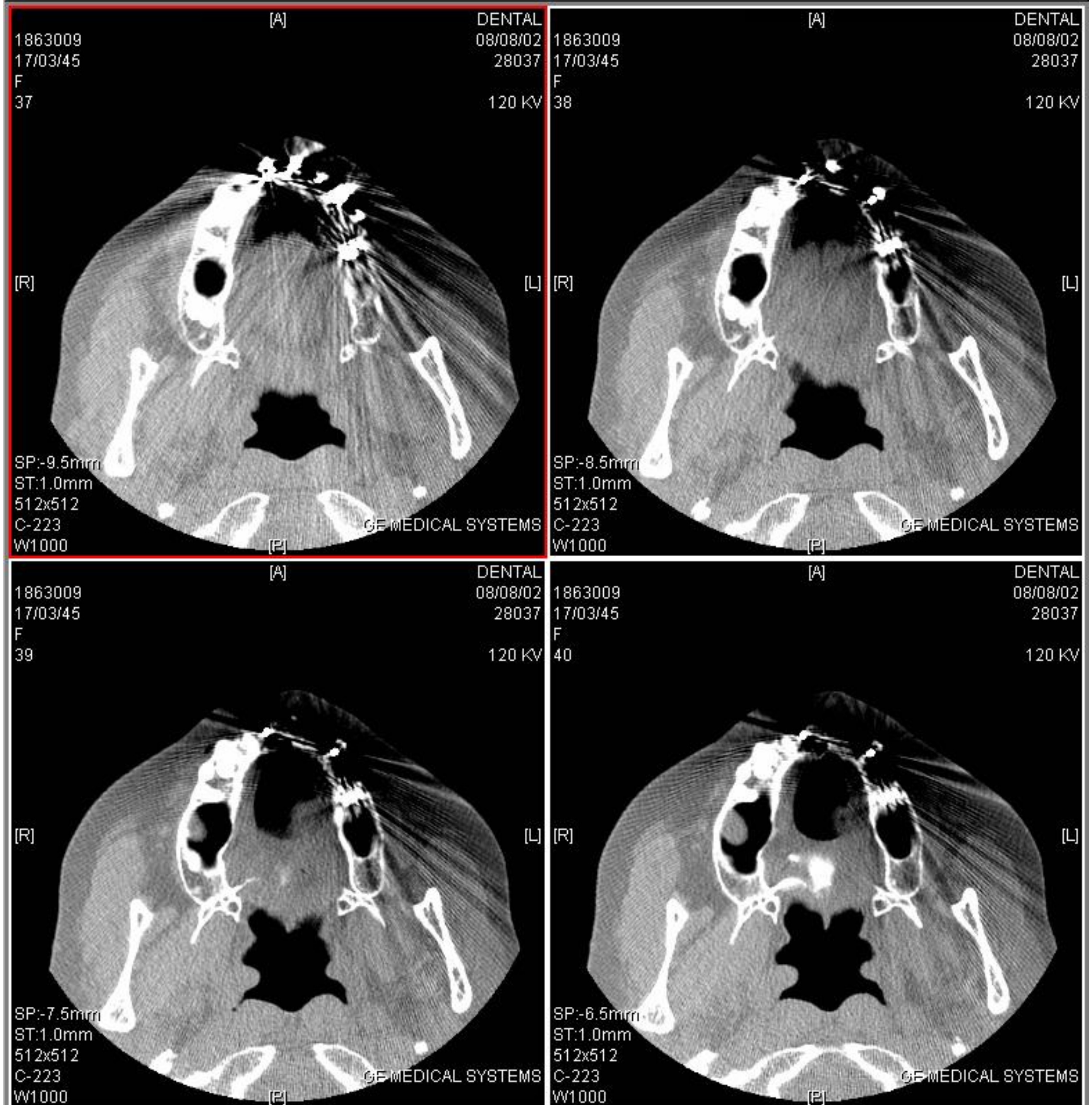
- **Starburst (streak) artefacts arise in CT scans when sharp changes in density are present, e.g. between air and bone or between bone and dense metals**
- **Starburst artefacts are caused by limitations in high frequency sampling**
  - **- partial volume effect**
  - **- beam hardening**
- **Starburst artefacts are not caused by scattered radiation**

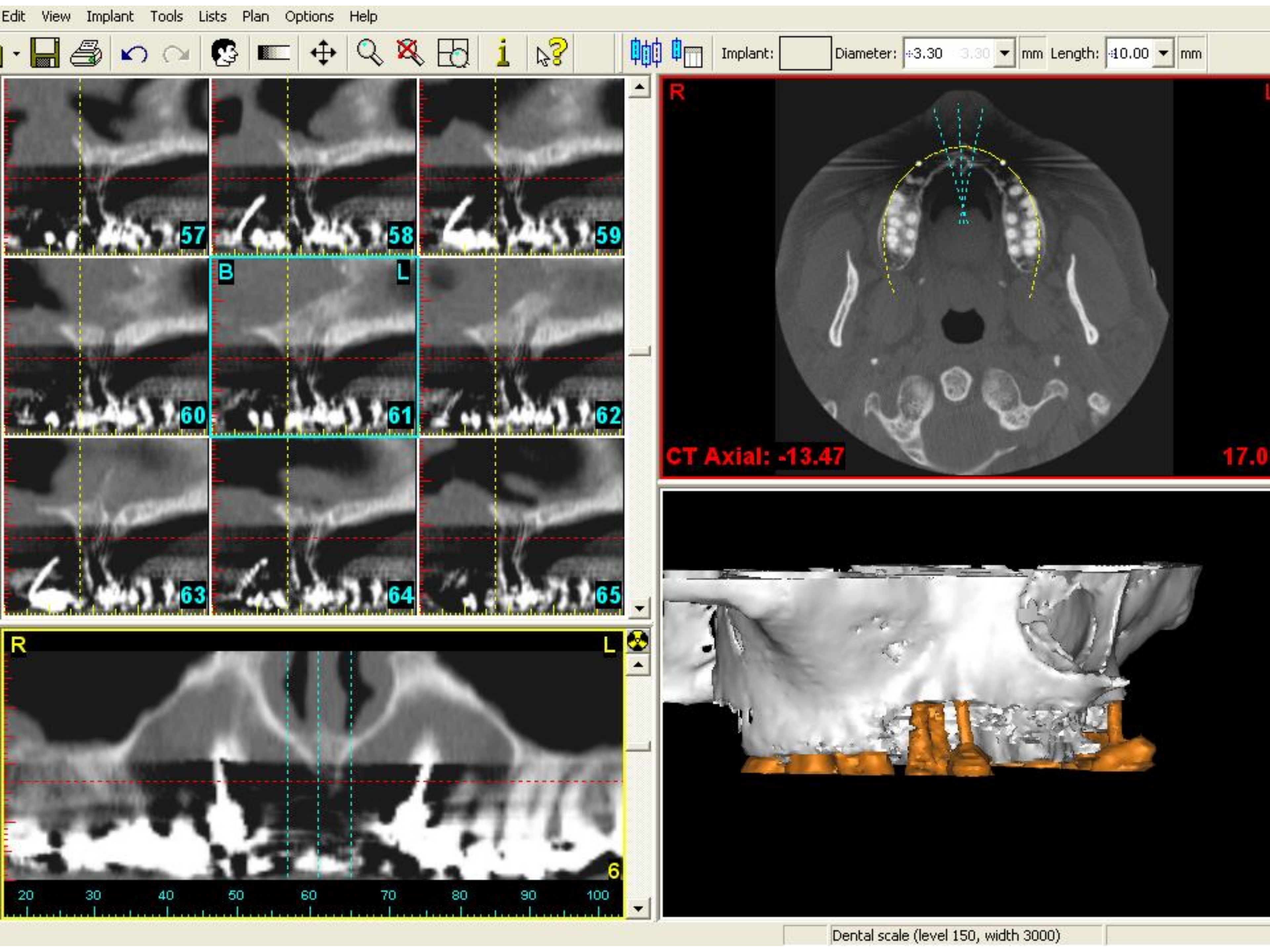

P
11:35:02 4
1.00X
R
L
11:36:29 5
1.00X
R
L
11:37:40 12
R
L
11:38:37 19

BEAM HARDENING ARTEFACT

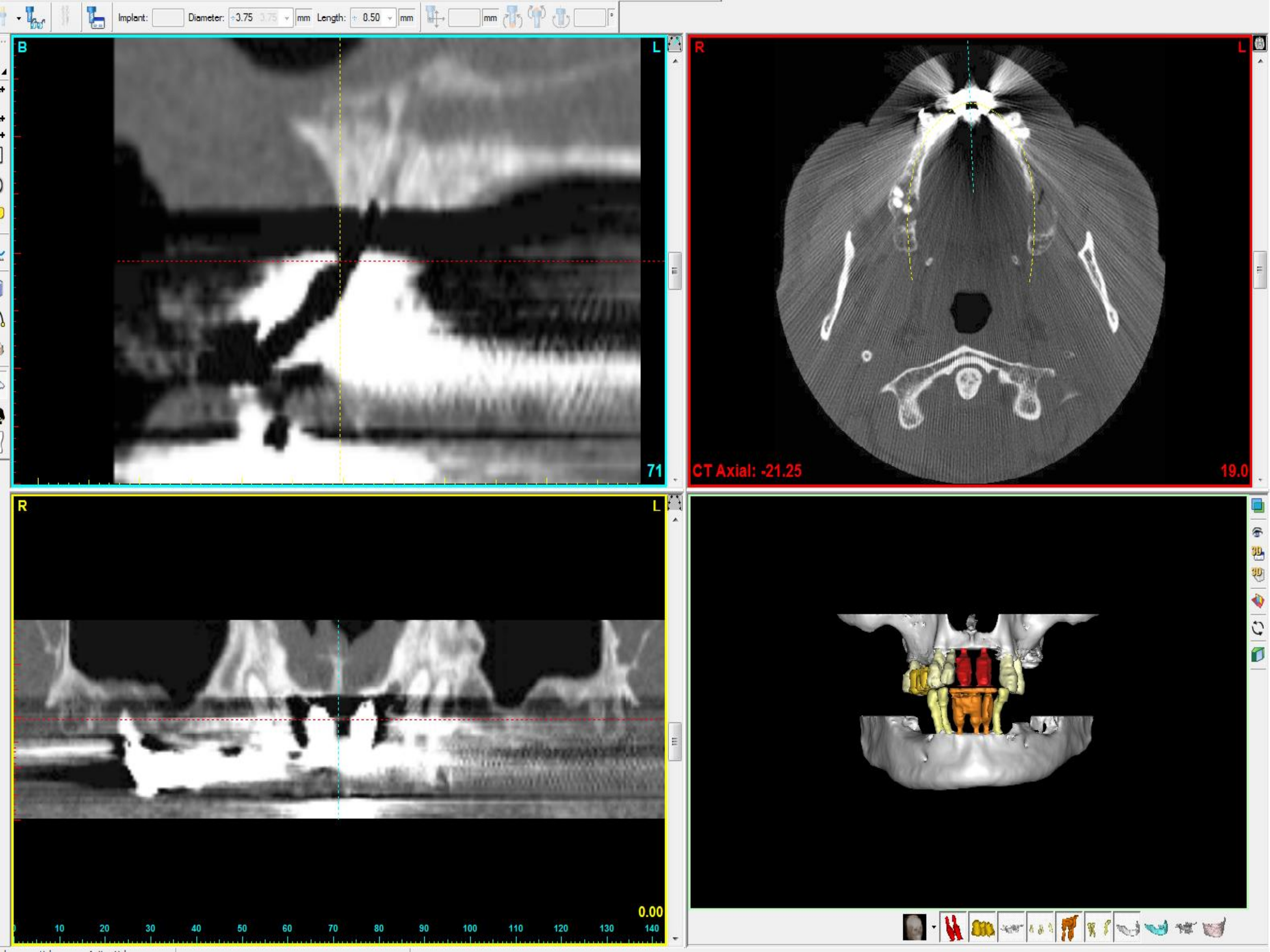
- **Beam Hardening artefacts occur in CT scans when metals are present**
- **Metals cause the low energy x-rays to be filtered out of the x-ray beam**
- **The average energy becomes higher**
- **The CT numbers become lower**
- **Parts of the image appear black**




[A]
DENTAL
1863009
08/08/02
17/03/45
28037
F
37
120 KV
[R]
[L]
SP:-9.5mm
ST:1.0mm
512x512
C-223
W1000
GE MEDICAL SYSTEMS
[P]
[A]
DENTAL
1863009
08/08/02
17/03/45
28037
F
38
120 KV
[R]
[L]
SP:-8.5mm
ST:1.0mm
512x512
C-223
W1000
GE MEDICAL SYSTEMS
[P]
[A]
DENTAL
1863009
08/08/02
17/03/45
28037
F
39
120 KV
[R]
[L]
SP:-7.5mm
ST:1.0mm
512x512
C-223
W1000
GE MEDICAL SYSTEMS
[P]
[A]
DENTAL
1863009
08/08/02
17/03/45
28037
F
40
120 KV
[R]
[L]
SP:-6.5mm
ST:1.0mm
512x512
C-223
W1000
GE MEDICAL SYSTEMS
[P]

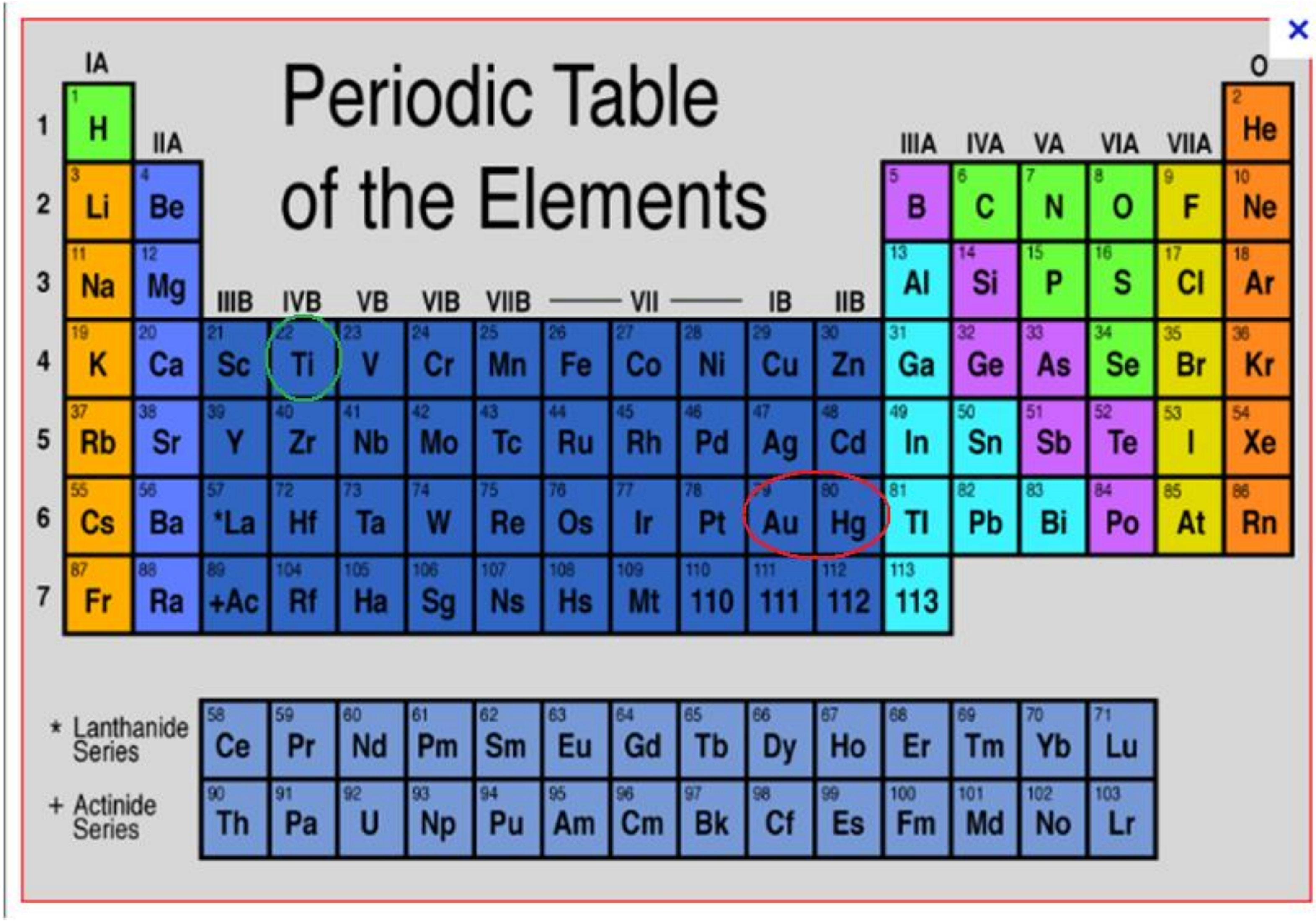


Edit View Implant Tools Lists Plan Options Help
Implant:
Diameter: 3.30
mm
Length: 10.00
mm
57
58
59
B
L
60
61
62
63
64
65
R
CT Axial: -13.47
R
L
6
20 30 40 50 60 70 80 90 100
Dental scale (level 150, width 3000)



Implant:
Diameter: 3.75
mm
Length: 0.50
mm
B
L
71
R
L
CT Axial: -21.25
19.0
R
L
0.00
10 20 30 40 50 60 70 80 90 100 110 120 130 140

High-Z materials cause the worst artefacts

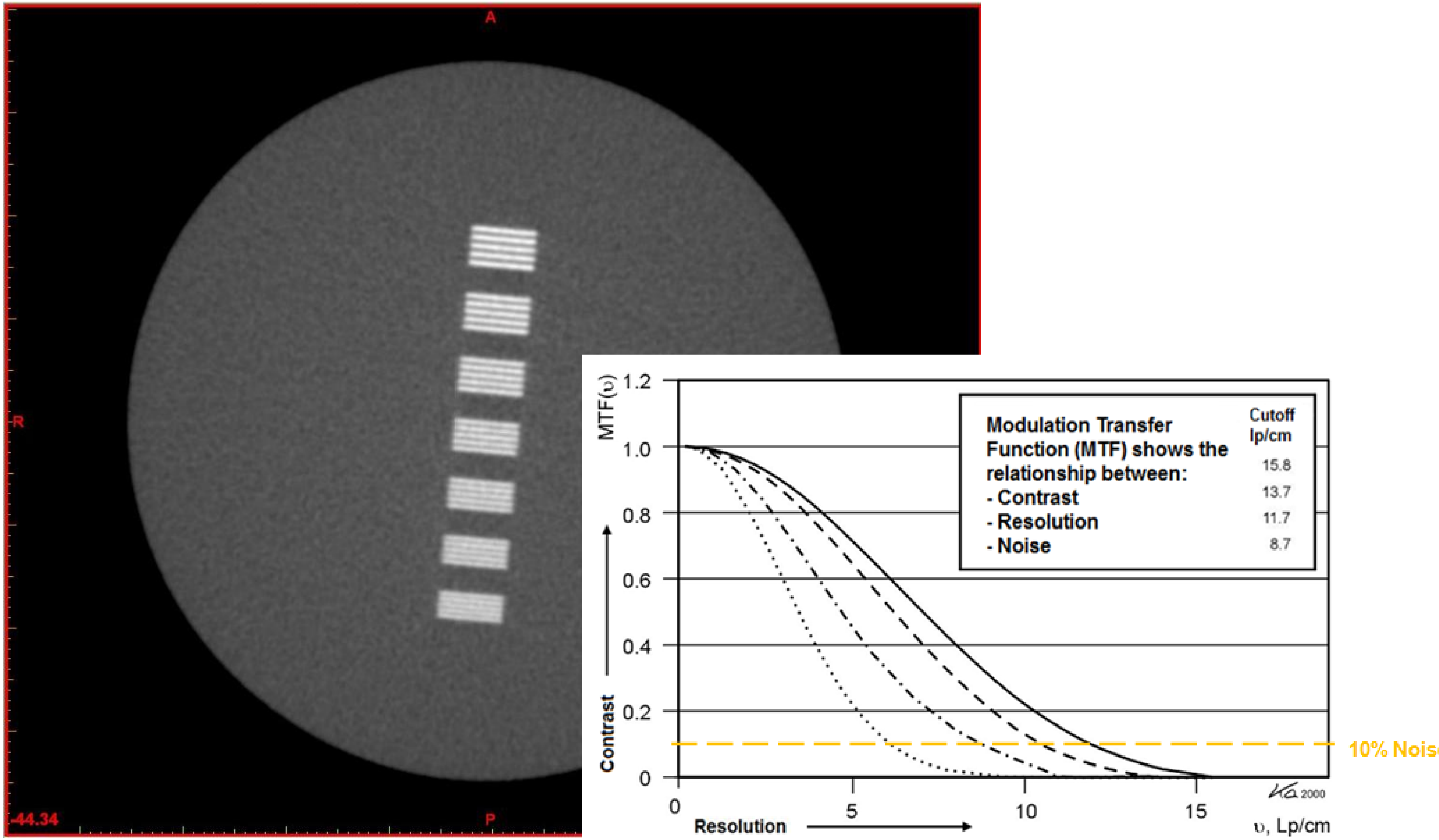


HOW TO AVOID ARTEFACTS

- **Titanium implants produce little artefact, gold produces a lot**
- **Remove dentures or other fixtures that include metal**
- **Consider replacing amalgam with composites**
- **Consider extracting teeth that will be sacrificed anyway.**

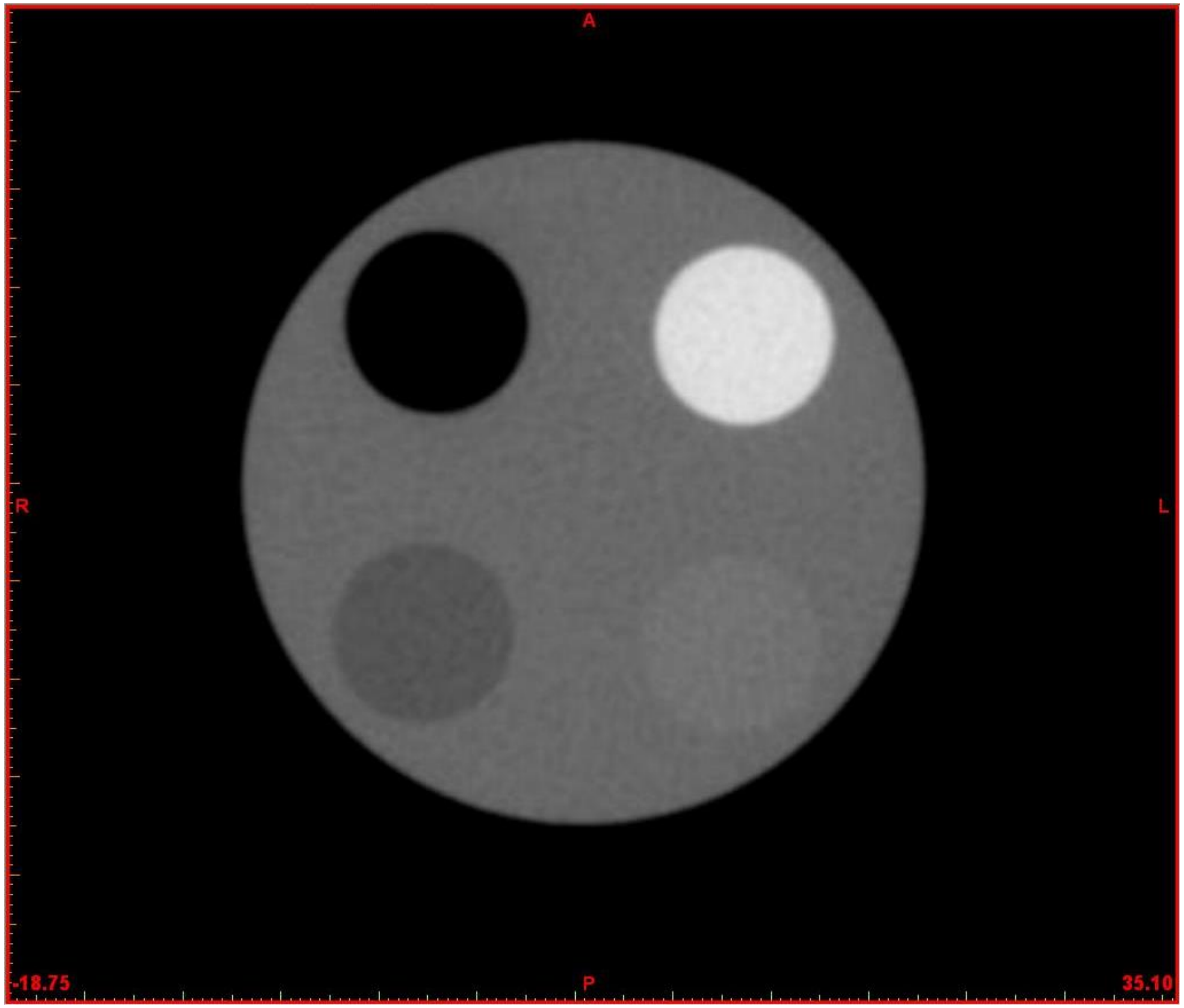
Spatial Resolution

Detail at high contrast



Contrast Resolution

Detail at low contrast



Spatial and Contrast Resolution

Optimisation

Want to Optimise

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

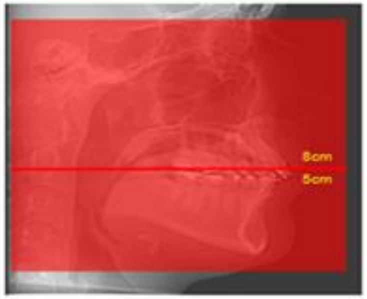
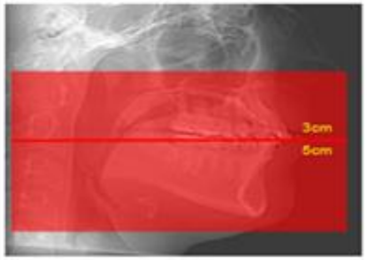
*** not to the dentist!**

Practical ways to Reduce the ~~Risk~~ Dose

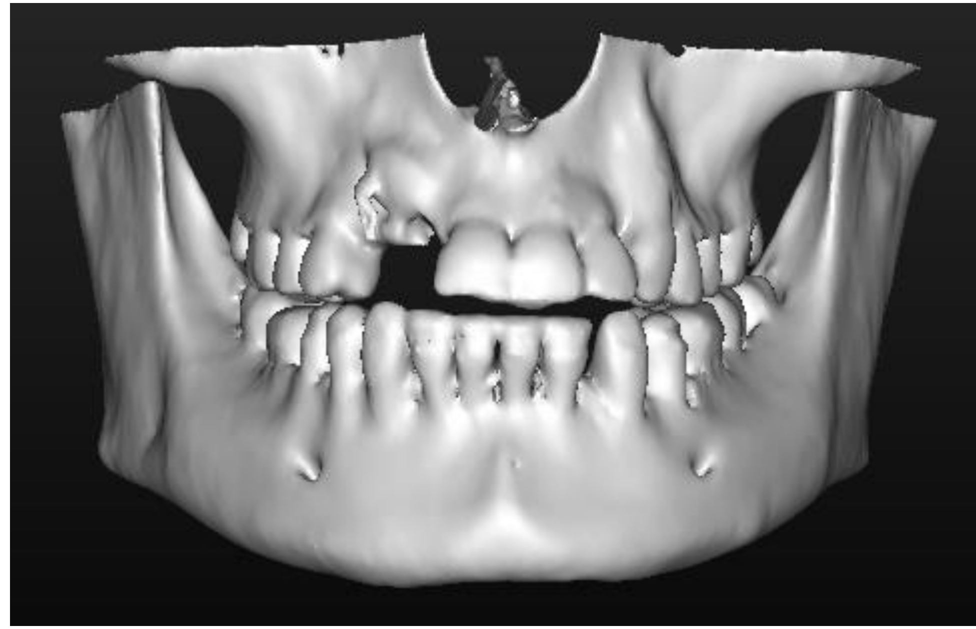
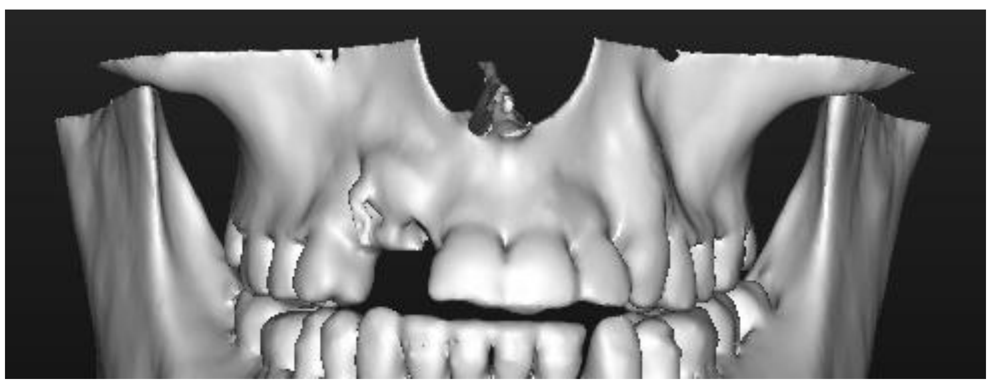
CBCT Scans:

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

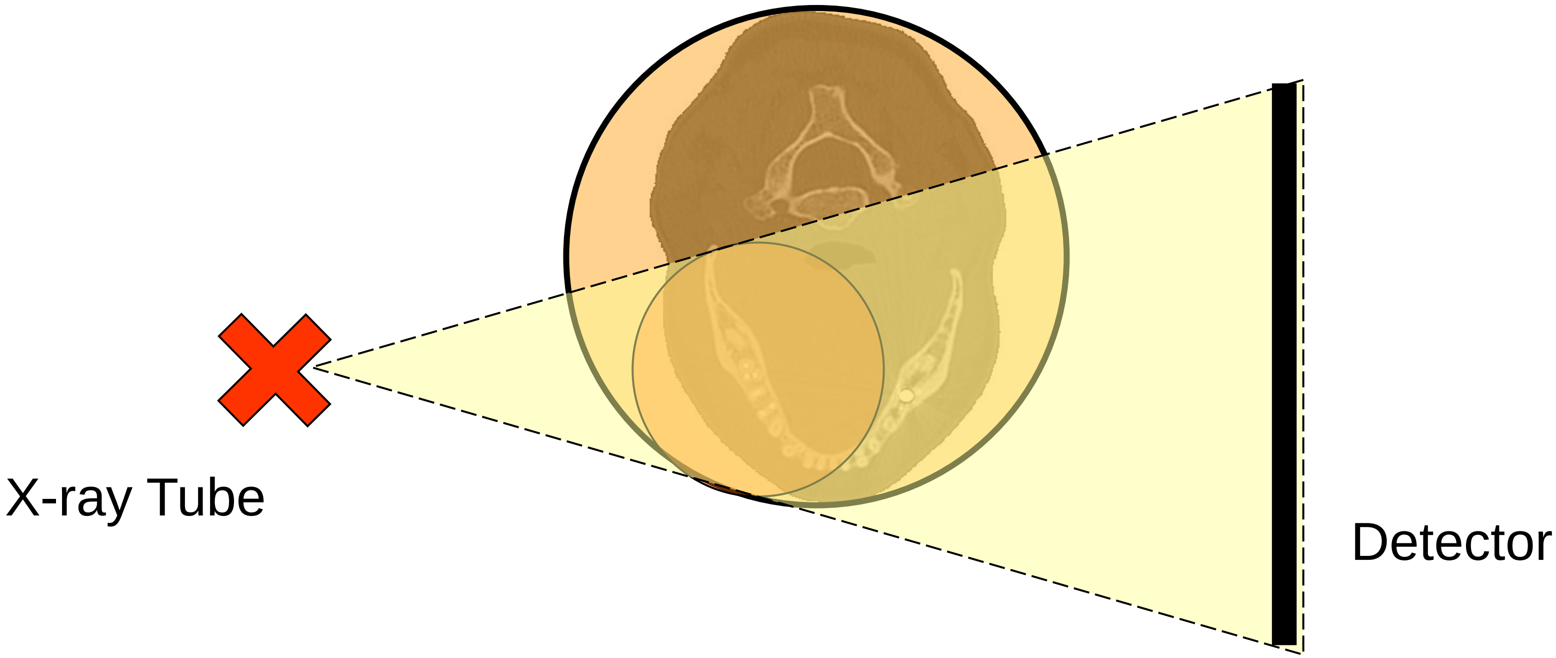
   Reduces the risk without loss of benefit in most cases.

	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

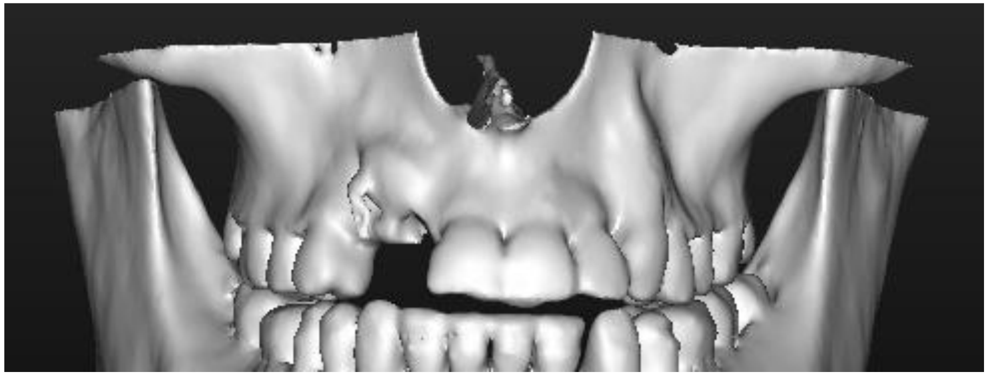




2. Reduce the Width (horizontal collimation)

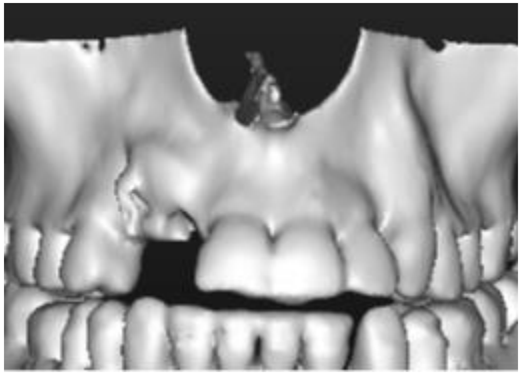


- **Absorbed Dose outside primary beam is not zero (about 50% from SEDENTEXCT measurements)**

- **There may be some loss of benefit**



16cm diameter



8cm diameter

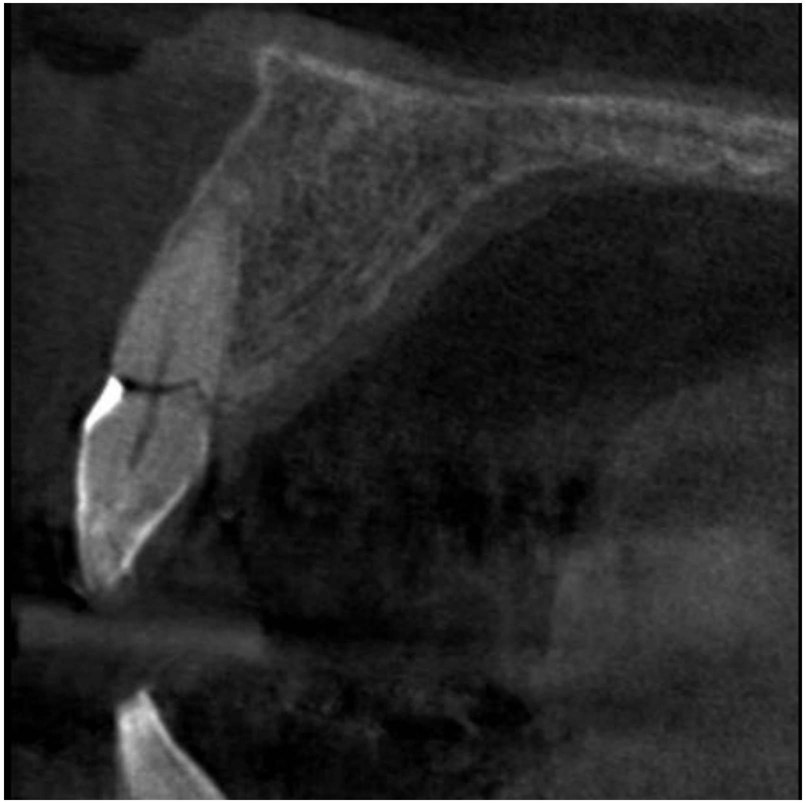
4cm diameter

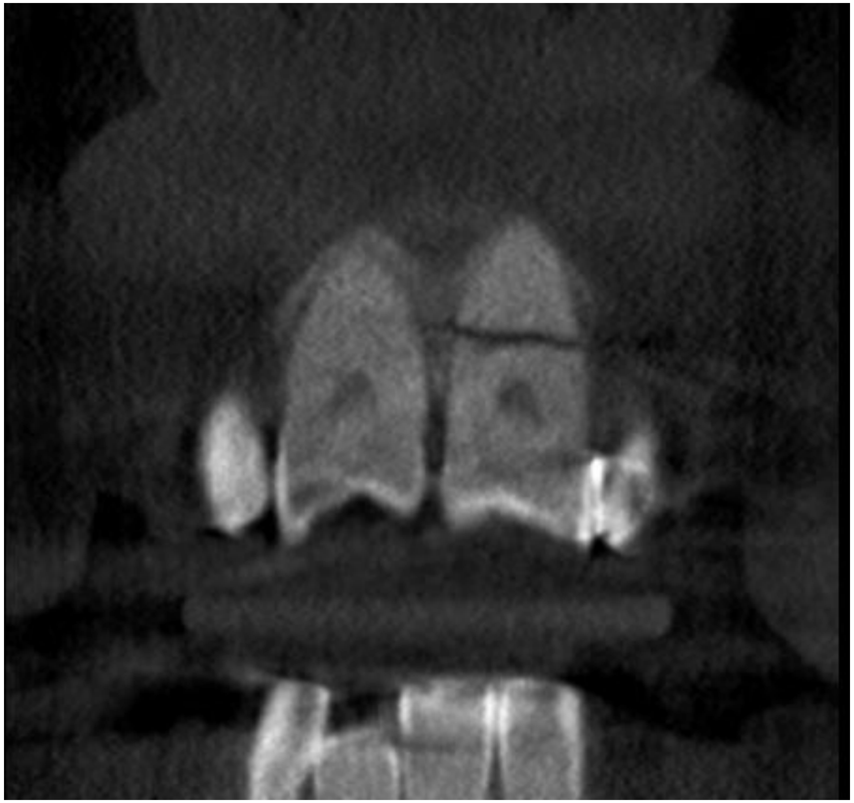
CBCT Scans

3. Reduce the mAs (tube current, scan time)

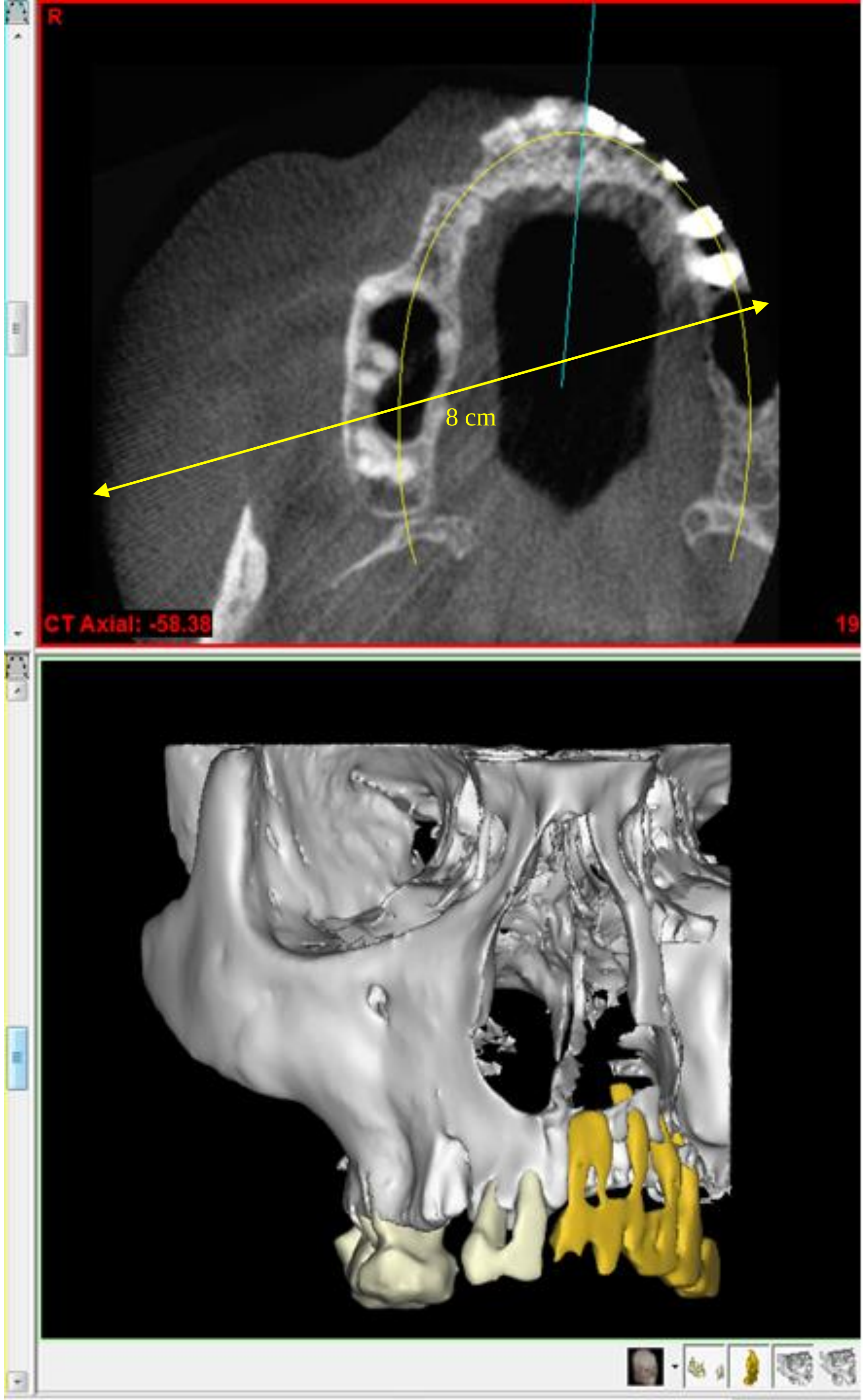
- **Reducing the mAs will have a negative impact on image quality**
  - **more noise**
  - **less angular samples**

- **On some scanners, the voxel size is linked to the mAs**





5cm x 5cm DAP 113 mGy.cm2
Effective Dose 15 microSv approx.



Is this optimal patient positioning?

Centre the patient to get the maximum information for the same radiation dose.

Outline of Lectures

- ✓ **Introduction / Disclosures**
- ✓ **Diagnostic Imaging in Dentistry**
  - – **CT / CBCT Scans**
  - – **Conventional Radiography**
- **Radiation Dose and Risk**
  - – **Compliance with the Legislation**
  - ✓ **Optimisation of CBCT Scans**


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)

- **2200 microSievert per year**
- **0.25 microSievert per hour**

Flight from the UK to Chernobyl

- **3 hours x 5 μSv/hr = 15 μSv**

Dental x-ray (intraoral)

- **1 microSievert**

CBCT scan (both jaws)

- **100 microSievert**

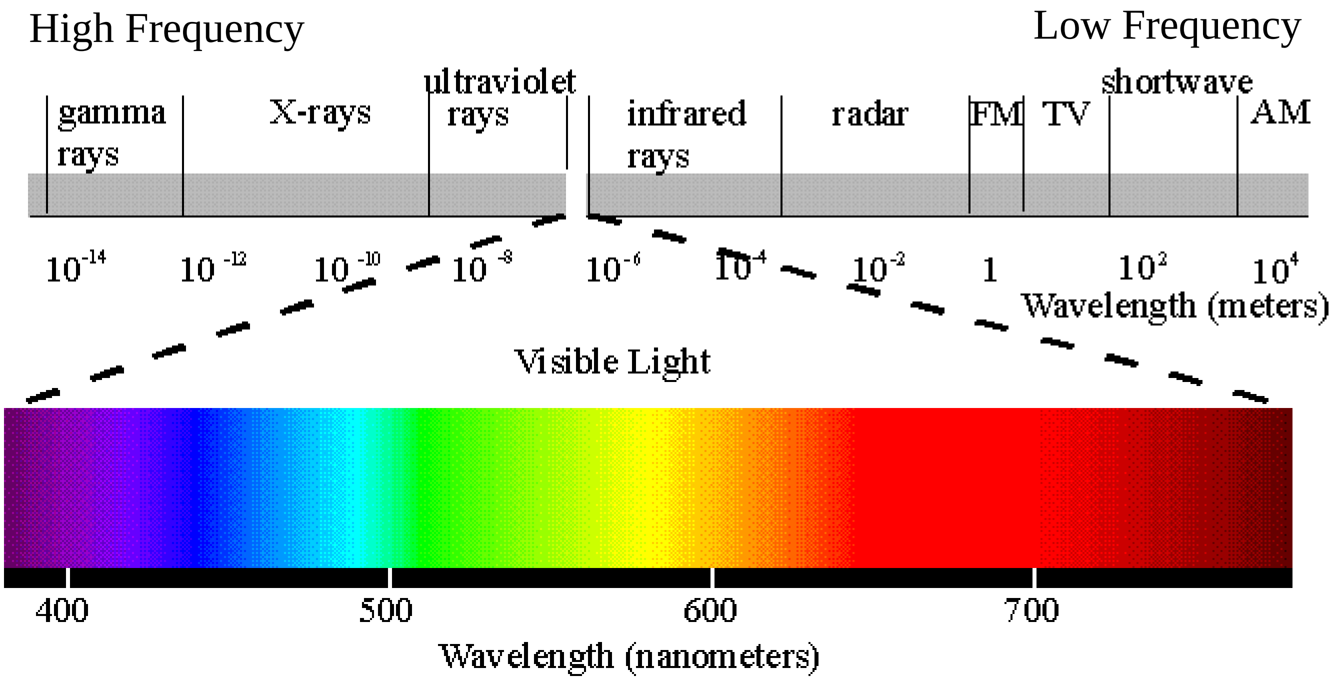
Topics

- **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

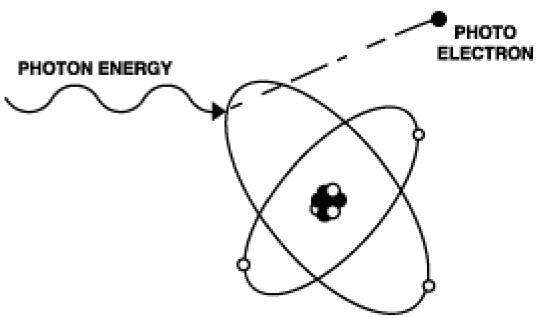


from **http://www.yorku.ca/eye/spectru.htm**

Energy depends on the frequency E = hν

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.**

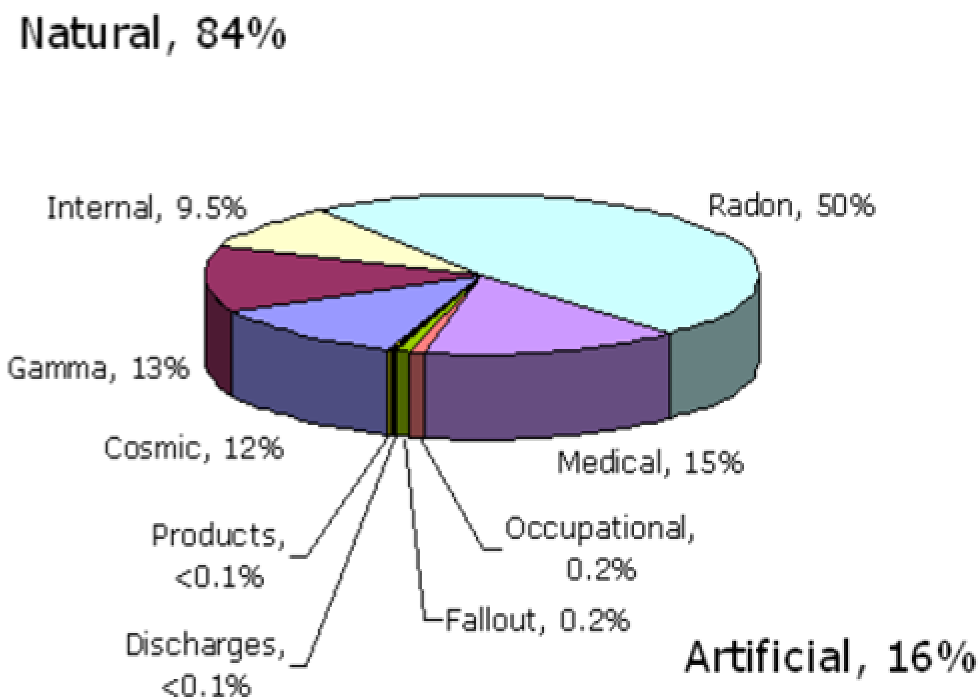


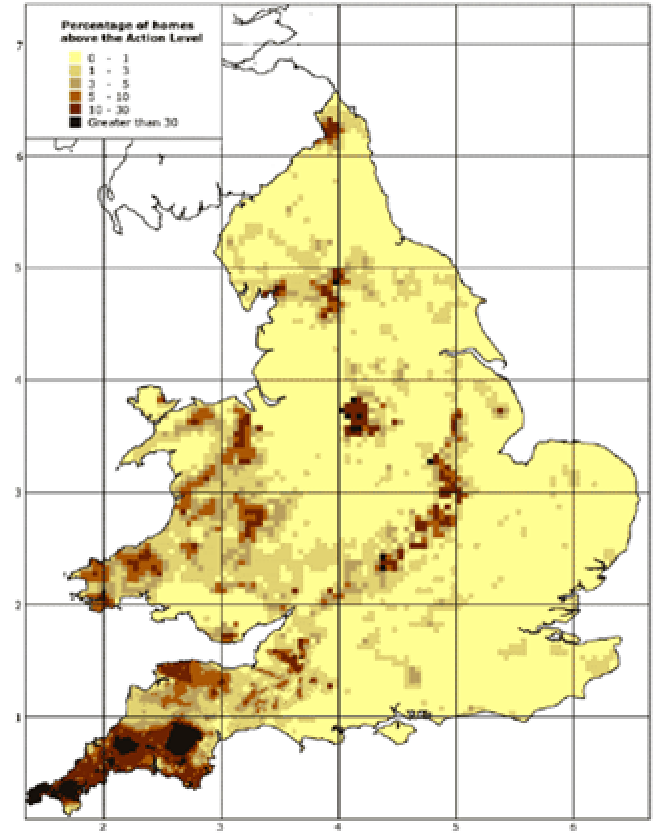
Sources of Ionising Radiation

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**

Topics

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

Don’t Try This At Home!

What is radon - and how does it work?

In short - Gastein radon therapy stimulates the ability of your own cells to repair themselves. While you swim in thermal water, sweat in a radon vapor bath or relax in the Gastein Healing Gallery, your body absorbs radon through your respiratory passages and skin. In the process, the noble gas emits mild alpha radiation in your body, which in turn activates a special messenger substance, **reducing inflammation** and promoting **natural healing processes**. The result: The number of free radicals in your body drops and you have **less pain**.

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

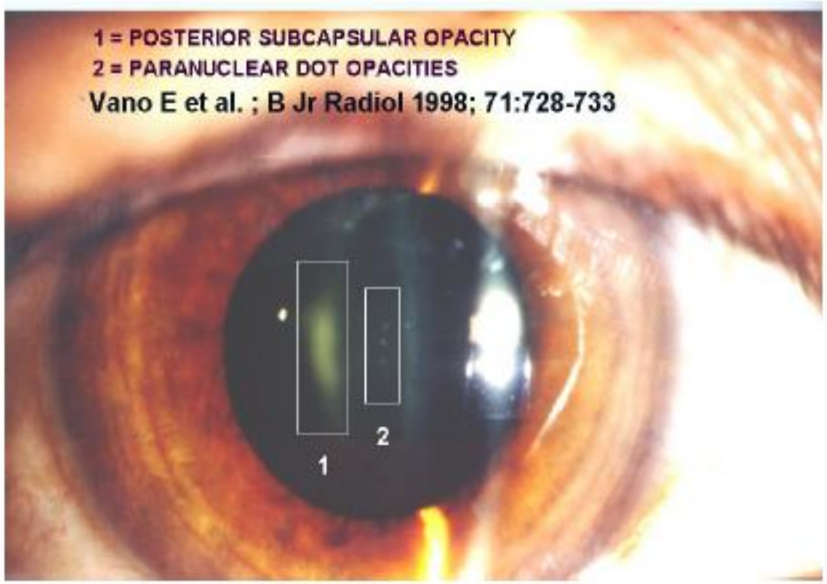
For a high dose of radiation received over a short period of time, we know that the following effects will occur:

- **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

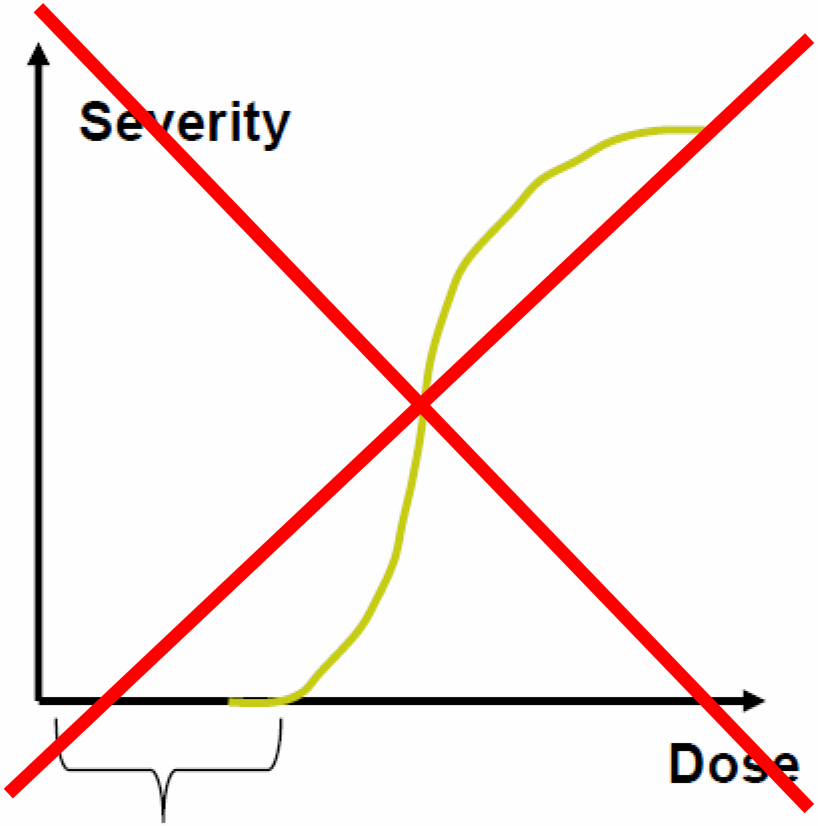
(averaged over 5 year, with not more than 50 mSv/year)

Eye Lens Limit is 15 mSv/year for trainees and members of the public

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.**

Deterministic Effects

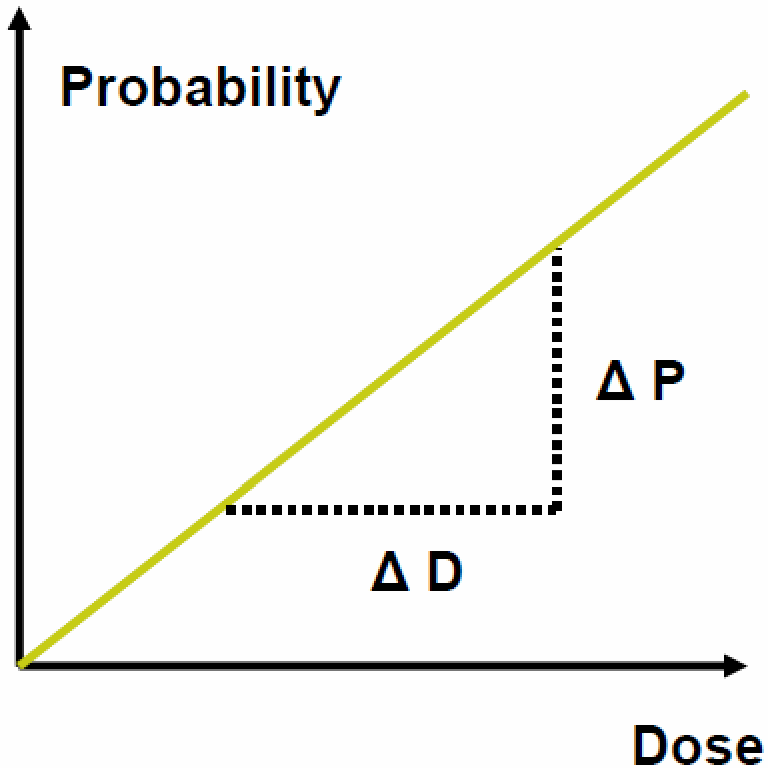


Threshold Dose

(about 500 mSv)

Should not see in dental practice!

Stochastic Effects



Risk Factor = Δ P / Δ D

(about 5% per Sievert)

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 other 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/

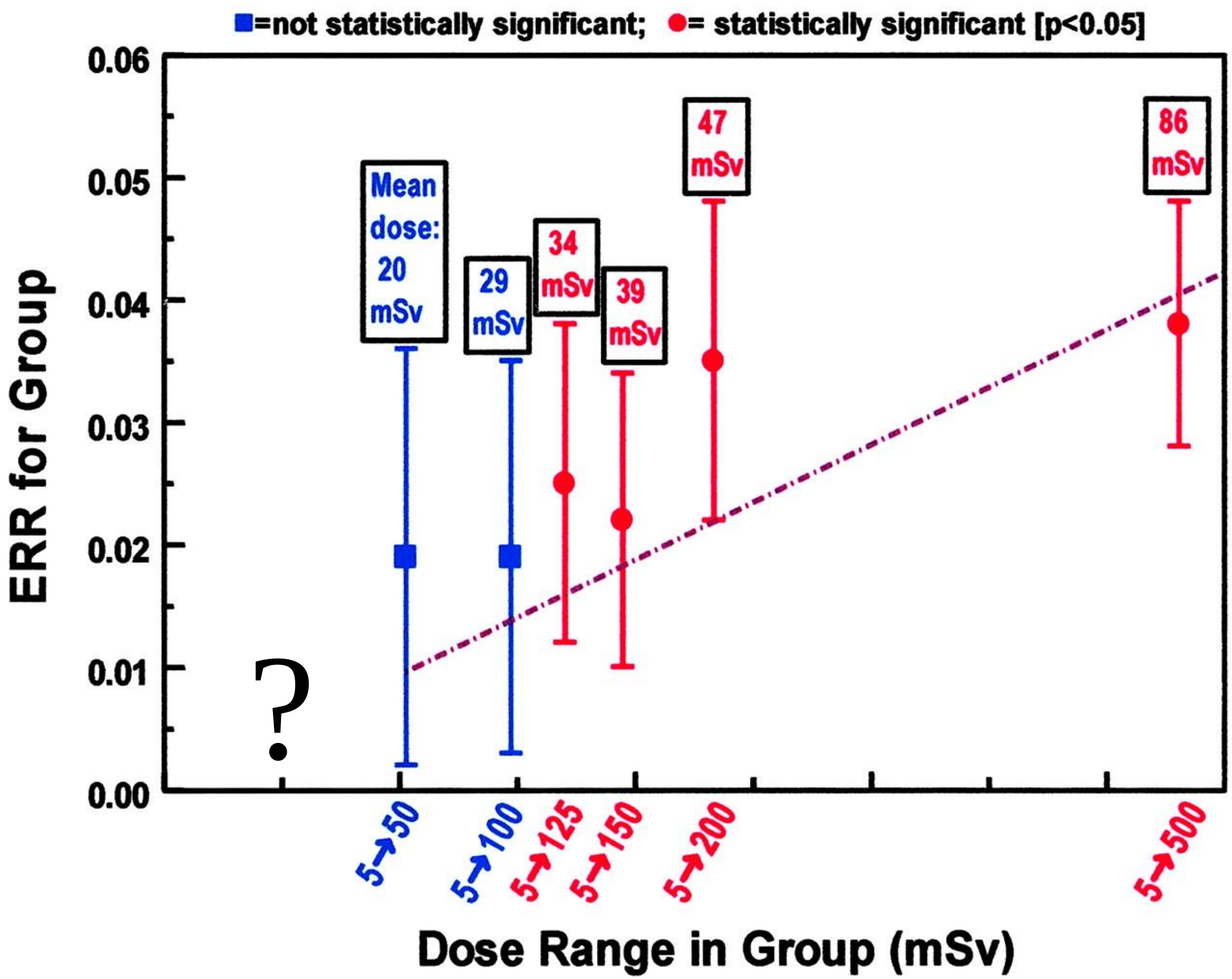
PNAS
Proceedings of the National Academy of Sciences of the United States of America

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]

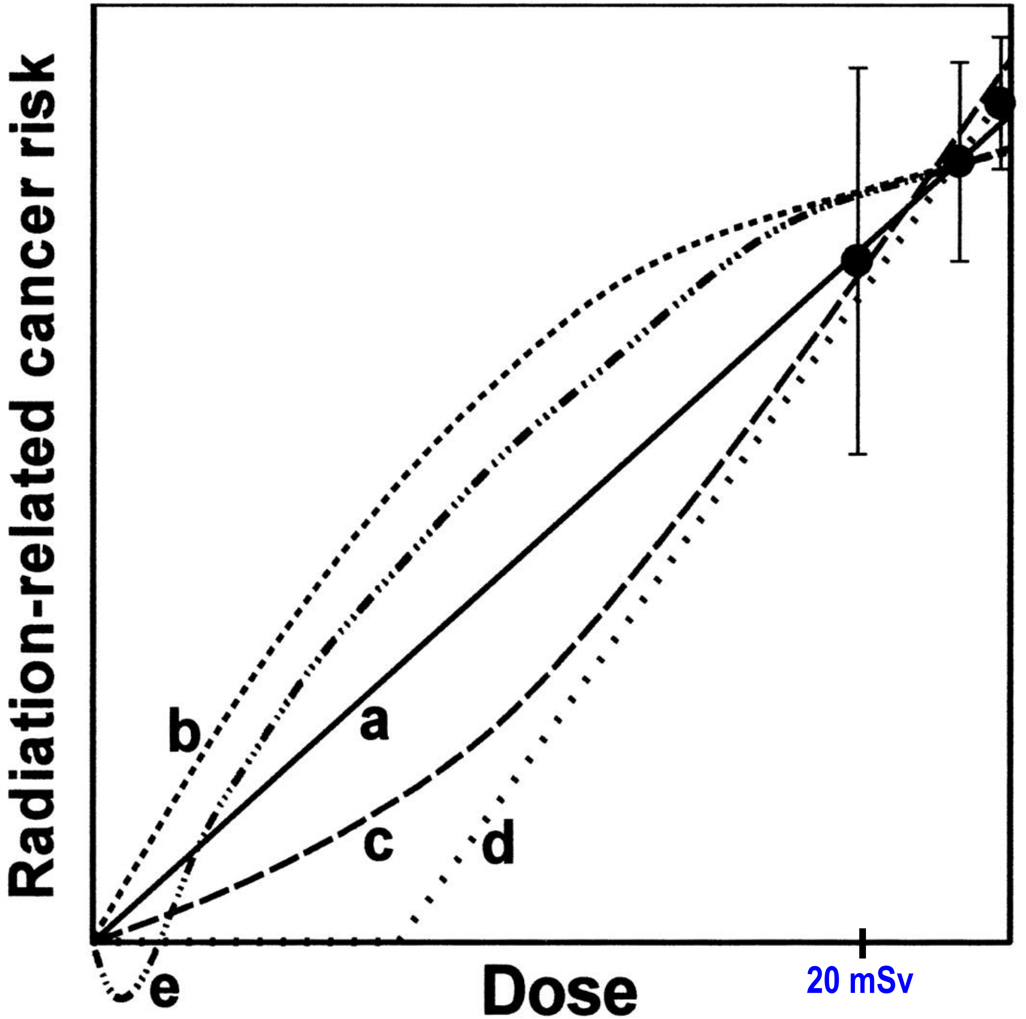
Contributed by Richard Doll, August 29, 2003

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

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.



a = LNT model
d = threshold model

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

PNAS

The Linear No-Threshold (LNT) Model

Puts a straight line through the origin

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

Criticism of the LNT Model

Doesn't take dose rate into account

Doesn't take cellular repair mechanism into account
(if it 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 **takes the size of the region and the body parts irradiated into account.**

Dose Terminology

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"

Annals of the ICRP

PUBLICATION 103

The 2007 Recommendations of the International Commission on Radiological Protection

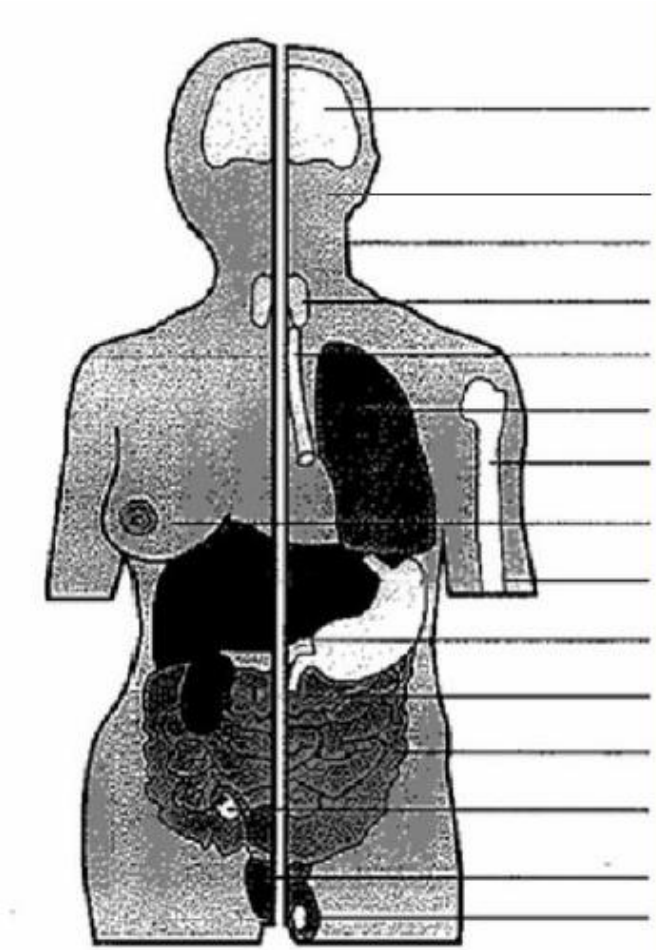
Editor
J. VALENTIN

PUBLISHED FOR

The International Commission on Radiological Protection

by

ELSEVIER



	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

Tissue Weighting Factors from ICRP 103

To obtain the Effective Dose:

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.

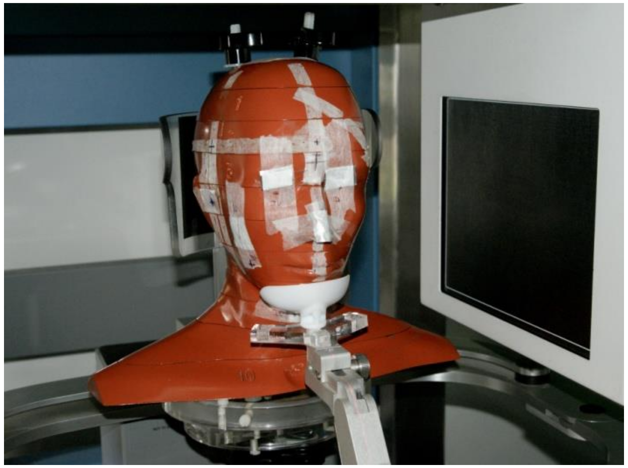
Effective Dose (E)

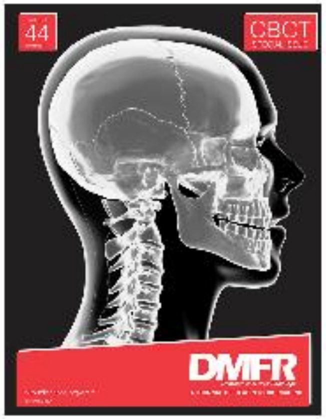
$$E = \sum_T H_T w_T$$

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





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

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]

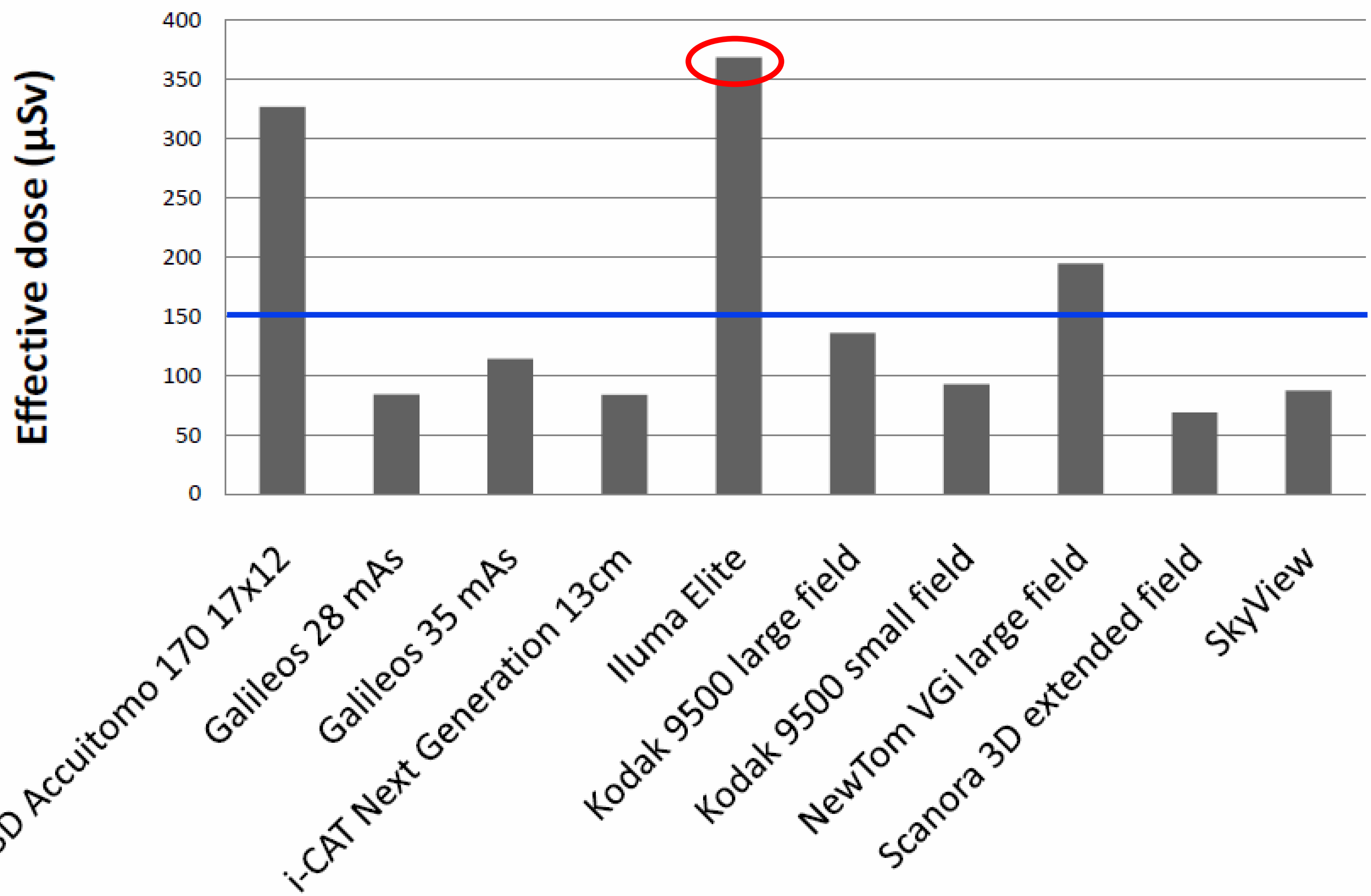
[a] *Oral Imaging Center, School of Dentistry, Oral Pathology and Maxillofacial Surgery, Faculty of Medicine, Catholic University of Leuven, Belgium*
[b] *Center for Periodontology and Implantology, Heverlee, Belgium*
[c] *North Western Medical Physics, The Christie NHS Foundation Trust, Manchester Academic 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)

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

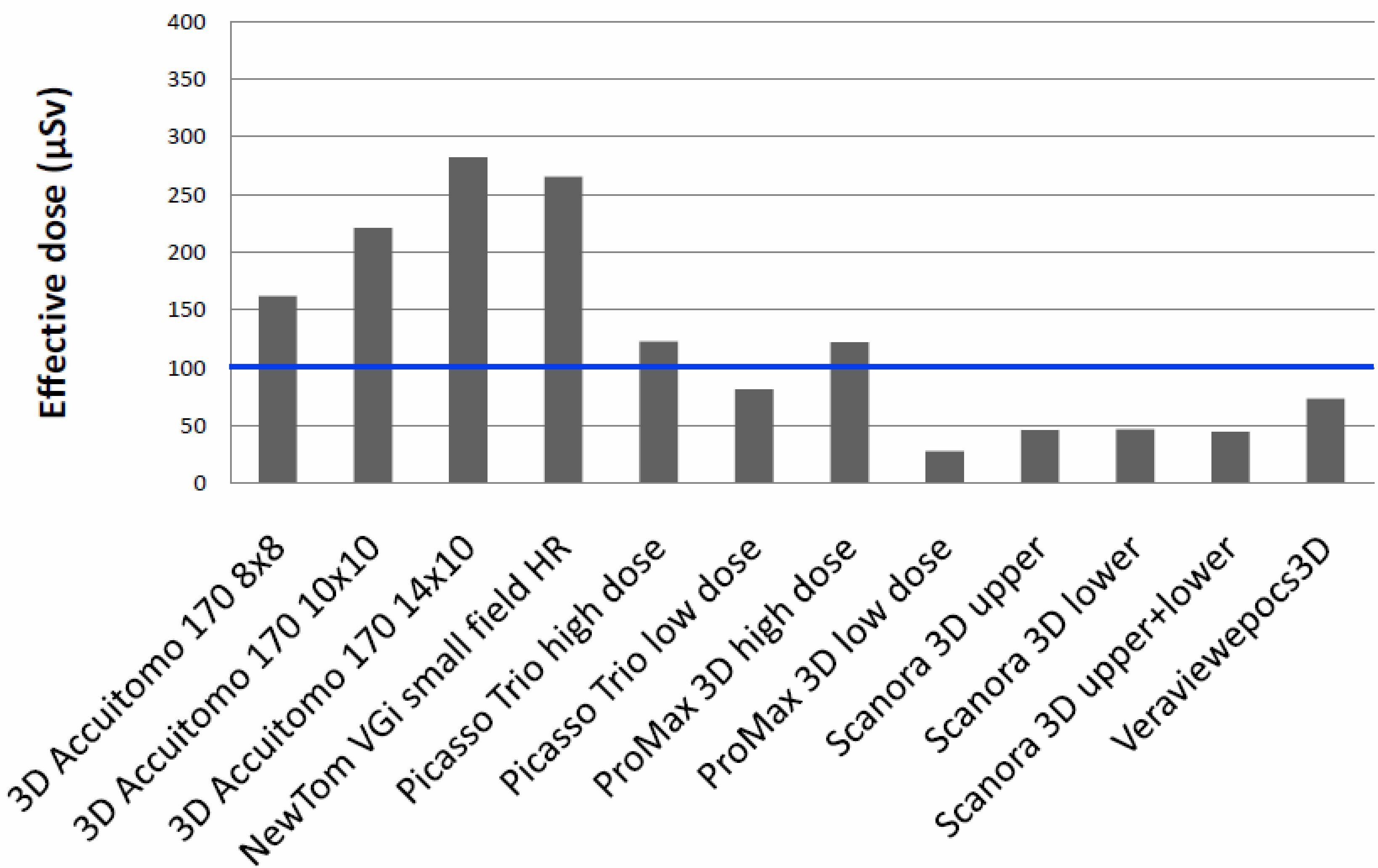
20 microSieverts to 370 microSieverts

Effective dose for large field CBCTs



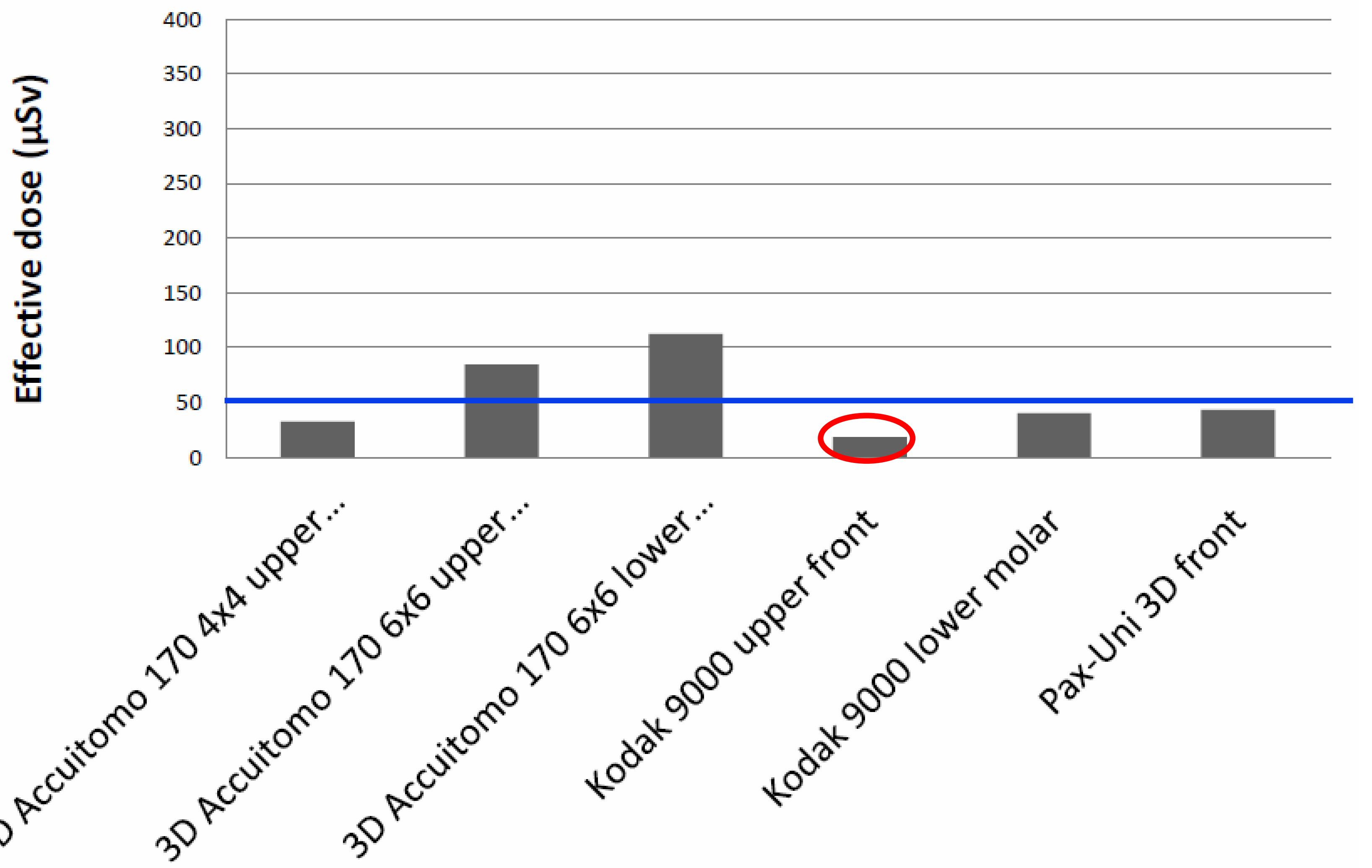
Prof. Ria Bogaerts, Katholieke Universiteit Leuven, March 2011

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

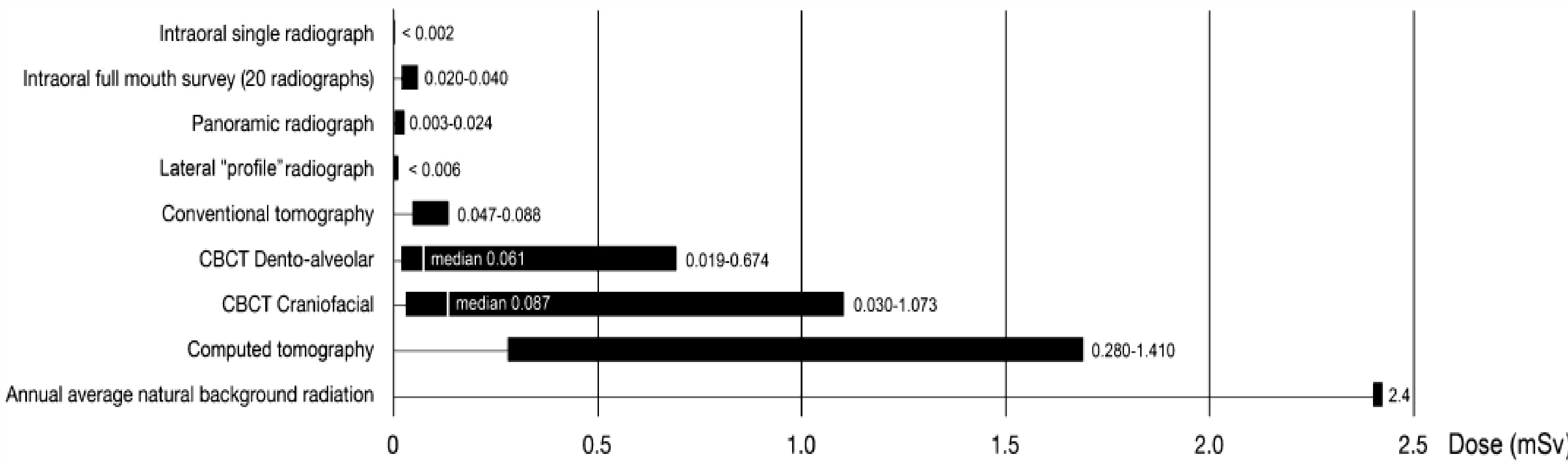


Fig. 1. Ranges of effective dose for the imaging modalities used in implant dentistry.

Source of exposure	Dose
Dental x-ray	0.005 mSv
100g of Brazil nuts	0.01 mSv
Chest x-ray	0.014 mSv
Transatlantic flight	0.08 mSv
Nuclear power station worker average annual occupational exposure (2010)	0.18 mSv
UK annual average radon dose	1.3 mSv
CT scan of the head	1.4 mSv
UK average annual radiation dose	2.7 mSv
USA average annual radiation dose	6.2 mSv
CT scan of the chest	6.6 mSv
Average annual radon dose to people in Cornwall	7.8 mSv
CT scan of the whole spine	10 mSv
Annual exposure limit for nuclear industry employees	20 mSv
Level at which changes in blood cells can be readily observed	100 mSv
Acute radiation effects including nausea and a reduction in white blood cell count	1000 mSv
Dose of radiation which would kill about half of those receiving it in a month	5000 mSv

https://www.gov.uk/government/publications/ionising-radiation-dose-comparisons/ionising-radiation-dose-comparisons

Can we estimate Effective Dose from Dose Area Product (DAP) ?

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

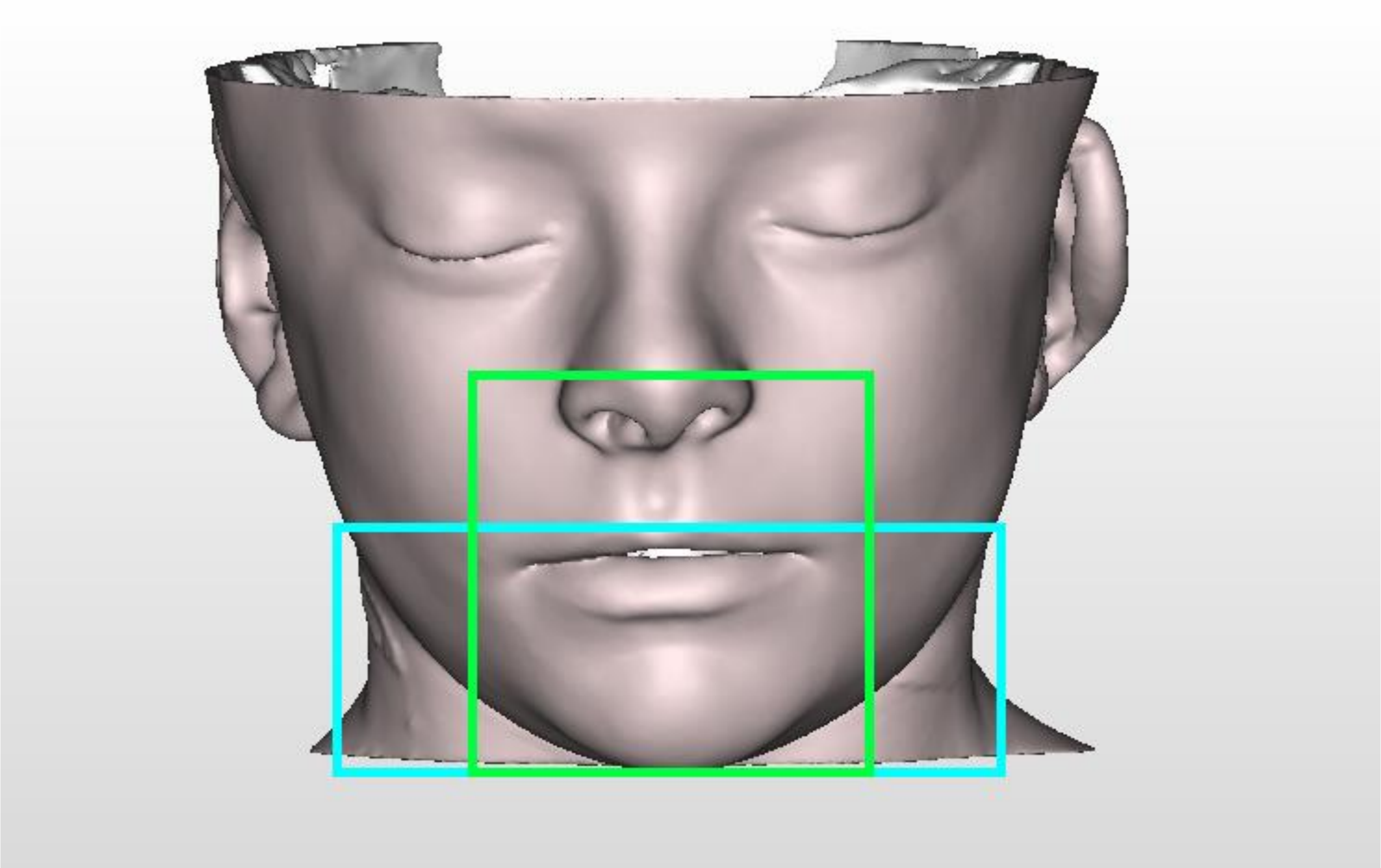
Table 5. Most commonly used exposure parameters in three specified regions and corresponding dose-are product (DAP) value and effective dose according to ICRP 60 (1991)

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**

Multiply the DAP by 0.1 to 0.15 to get a VERY ROUGH estimate of the Effective Dose

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 "Very Low"

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

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
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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**

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		(D) Release of radiation by nuclear power station[9]	1:10 000 000

Typical Risks from Dental X-Rays

	Effective Dose (μSv)	Risk
Intraoral (F speed, rect coll)	1 to 2	
Intraoral (E speed, round coll)	3 to 6	
Lateral Ceph	5 to 10	
Panoramic	3 to 25	
Cone Beam CT	20 to 370	
Medical CT (using dental protocol)	150 to 1500	

Typical Risks from Dental X-Rays

	Effective Dose (µSv)	Risk	
Intraoral (F speed, rect coll)	1 to 2	< 1 in 10 million	Negligible
Intraoral (E speed, round coll)	3 to 6	< 1 in 3.3 million	Negligible
Lateral Ceph	5 to 10	< 1 in 2 million	Negligible
Panoramic	3 to 25	1 in 6.7 million to 1 in 800 thousand	Negligible to Minimal
Cone Beam CT	20 to 370	1 in 1 million to 1 in 50 thousand	Mimimal to Very Low
Medical CT (using dental protocol)	150 to 1500	1 in 130 thousand to 1 in 13 thousand	Very Low

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

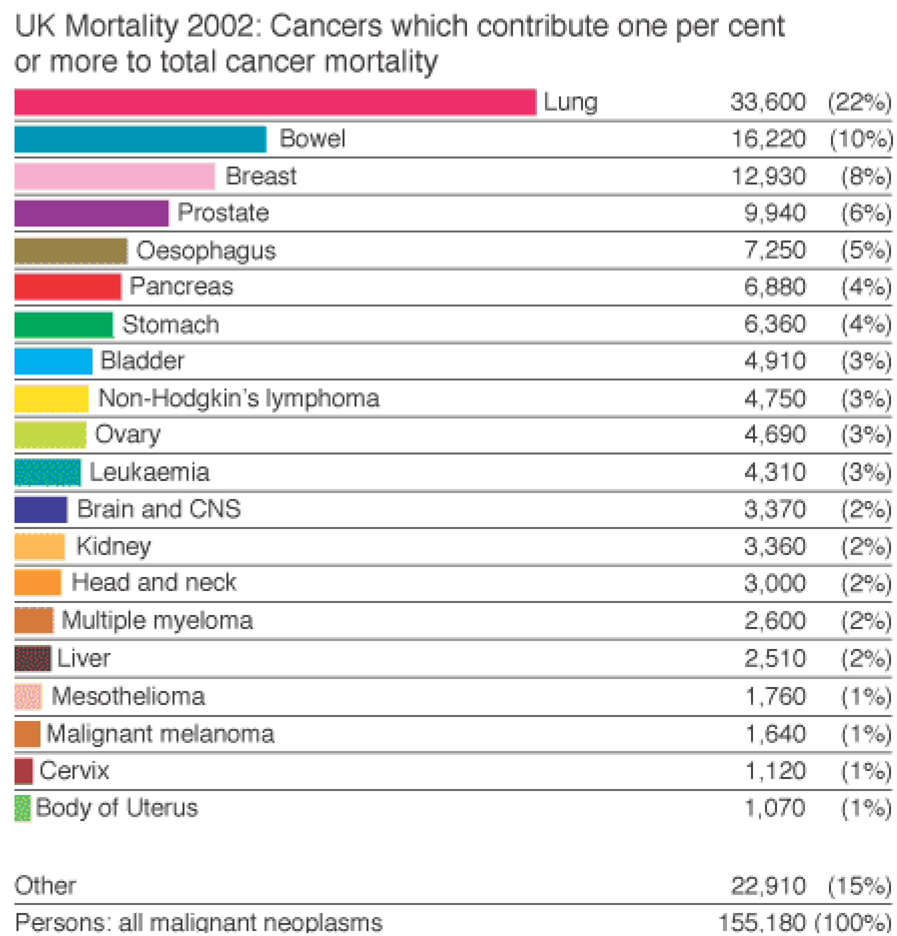
www.sedentexct.eu

Risks from Dental x-rays

- **Zero risk of Deterministic Effects**
- **Negligible to Very Low risk of radiation induced cancers**
- **Negligible risk of serious hereditary disease in an individual's descendants**

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

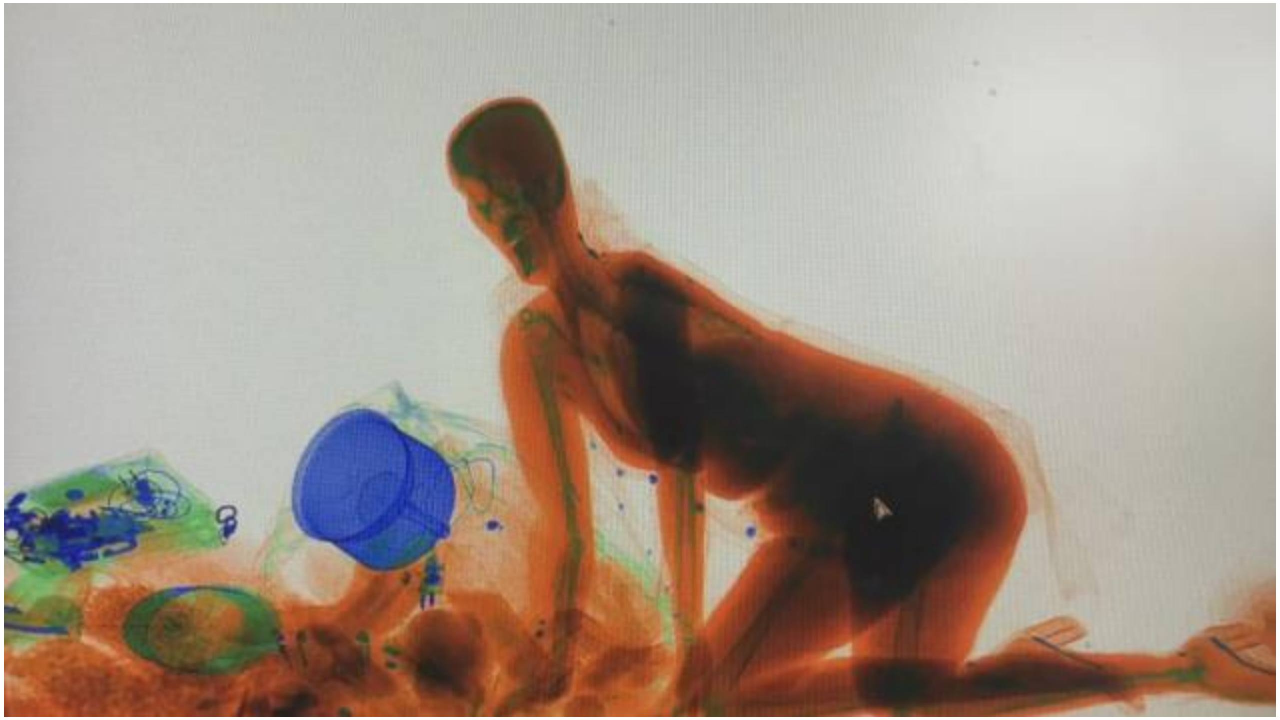
- ***There might be 160 extra cancer deaths per year*** ***(if LNT is correct)***
- ***Compared to 155,000 cancer deaths from other causes***



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

Benefit versus Risk

Not Recommended!



Risk of losing your luggage: about 6 per thousand
Risk of fatal cancer: about 1 per 10 million

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

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

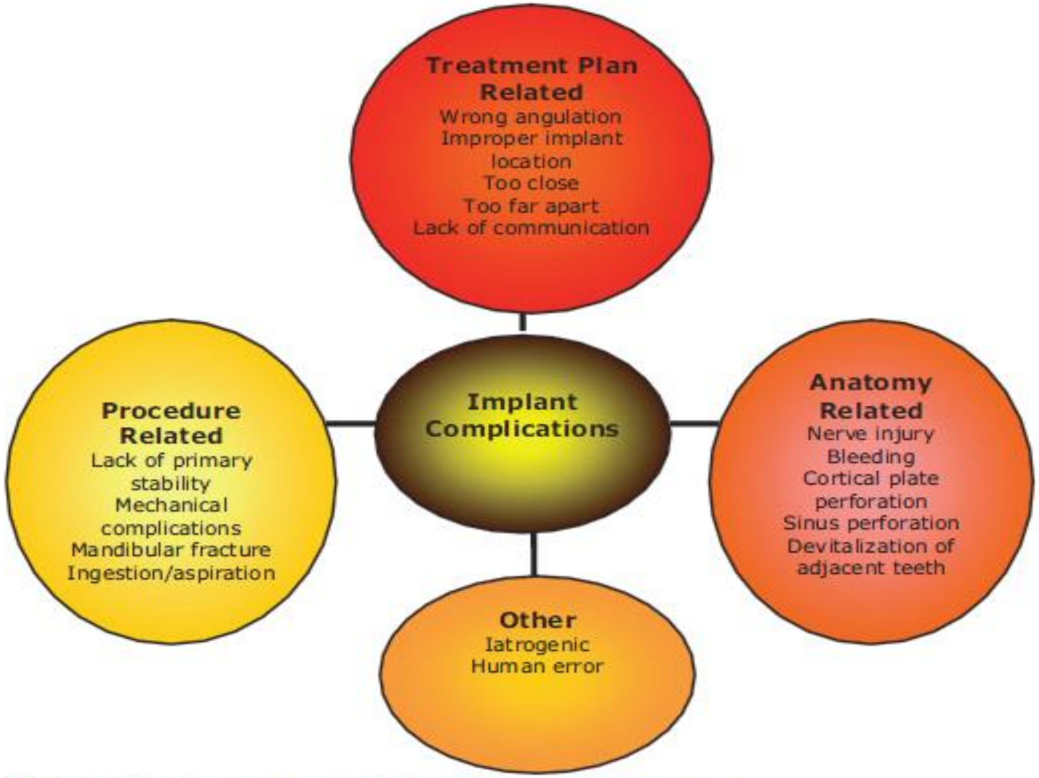
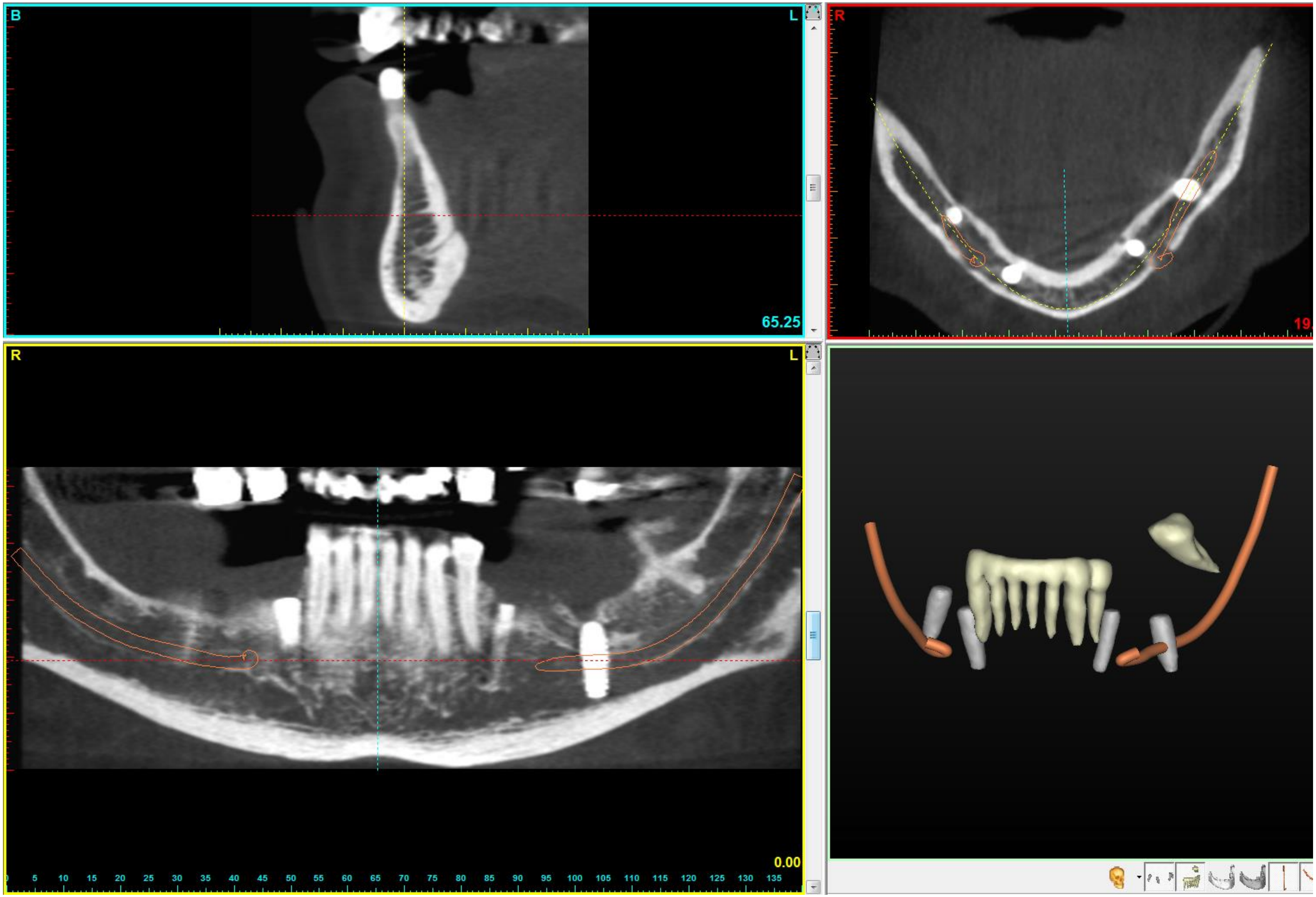


Fig. 1. Outline of common complications during implant surgery.

The Risk of Not Having a CBCT Scan



Take the CT Scan first, do the surgery second (not the other way around)!

Outline of Lectures

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

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

Framework for Radiation Protection

- **Based on the Recommendations of the International Commission for Radiation Protection (ICRP)**
  - **an advisory body with no formal powers**
- **European Directives for Radiation Safety**
- **National Legislation**
  - **England, Scotland, Wales, Northern Ireland (all slightly different)**
- **Local Rules / Written Procedures at each hospital or dental practice**
- **Each healthcare professional has an individual responsibility**

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**

Both Replaced by

- **Basic Safety Standards Directive (revised)**
  - **2013/59/Euratom of 5 December 2013**
  - **National legislation to be enacted by 5 February 2018**

Transposition of BSSD into UK Law

Two separate bodies of legislation:

Radiation Safety for Workers and the Public

- **Ionisation Radiations Regulations 1999 – "IRR99"**
- **Enforced by Health and Safety Executive**
- **Revised legislation "IRR 2017" came into force on 1 January 2018.**

Radiation Safety for Patients

- **Ionising Radiation (Medical Exposure) Regulations 2000 (amended in 2006 and 2011) – "IR(ME)R 2000"**
- **Enforced by Care Quality Commission (CQC)**
- **Revised legislation "IR(ME)R 2017" came into force on 6 February 2018.**

Legislation versus Guidelines – what's the Difference?

"Legislation" refers to Criminal Law

- **Example: it is an offence to start taking x-rays in your clinic without registering with HSE first.**

"Guidelines" refer to Best Practice and are often relevant in Civil Law

- **Can I defend myself if a patient sues me?**
- **What if I'm investigated by the GDC?**

You won't go to jail for not complying with the Guidelines, but compliance puts you in a stronger position.

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 (that comes under IR(ME)R 2017)**
- **Regulated by Health and Safety Executive (HSE) not Department of Health or Care Quality Commission.**

IRR 2017 - New System of Authorisation

- **Employers (e.g. dental practice owners) had to register with HSE and pay £25 fee by 5 February 2018.**
- **Must re-register (and pay a new fee) after a material change (such as change of Employer's name or address)**
- **Associates (working at someone else's practice and following the owner's rules and regulations) don't have to register.**
- **Dental Practices also have to register with the Care Quality Commission (CQC) as part of IR(ME)R 2017.**

New Dose Limits for Workers and Members of the Public

Annual Dose limits (mSv)	Radiation Workers: Adults (over 18 yrs) — Category A	Radiation Workers: Trainee (under 18 yrs) — Category B	Public: Other persons
Whole body	20	6	1
Lens of the eye	~~150~~ 20	~~50~~ 15	15
Skin	500	150	50
Hands etc.	500	150	50

IRR 2017: Dose Limit to Lens of Eye is now 20mSv/year for Adults and 15mSv/year for Trainees/Other Persons

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

- **Personal dosimetry and monitoring**
- **A radiation passbook if they work in another Employer's controlled environment.**

People who work in dental practices are not normally "Classified"!

Risk Assessments

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

- **usually your Radiation Protection Advisor (RPA) will help you with this**

1. **Look for the hazards (sources of radiation)**

2. **Decide who may be harmed and how (staff, public)**

3. **Decide if existing control measures (shielding, warning signs) 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.**

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.

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)**
  - **a mobile shield**
  - **Protective equipment (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.

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**

Controlled and Supervised Areas

An area is *Controlled* or *Supervised* (depending on the level of risk) if special procedures ("Local Rules") are needed to prevent significant exposure.

Intra-orals:

- **Within the primary x-ray beam until sufficiently attenuated**
- **Within 1.5m of the x-ray tube and patient in any other direction (operator should be at least 2m from the patient).**

Dental CBCT:

- **Usually the entire room is a Controlled Area while the power is on.**
- **Two-stage warning lights are recommended**
- **Cleaners etc should not enter 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

Local Rules should be brought to the attention of employees (e.g. sign an undertaking that they have been read)

Some dental practices put the Local Rules on their website.

Radiation Protection Advisor

- **Dental Practices must appoint a suitable RPA (in writing)**
- **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 Supervisor

- **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.**

Outside Workers

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

- **includes service engineers, contractors etc**
- **can be Classified or not, employed or self-employed**
- **an engineer who has to enter a controlled area to service a CBCT machine is an "Outside Worker" and falls under the responsibility of both their own employer and the employer who owns the CBCT machine.**
- **In the case of an engineer you can hand responsibility over temporarily through a Handover Procedure.**

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

Frequently Asked Questions

What are the current Radiation Safety laws in the UK?

- **Radiation Safety for Workers and the Public**
  - **IRR 2017**

- **Radiation Safety for Patients**
  - **IR(ME)R 2017 (as amended in 2018)**

- **IRR99 and IR(ME)R 2000 have been revoked.**

Are Film Badges required for Dental Practice staff?

- **Personal monitoring (using electronic dosimeters, or film badges) is recommended where a risk assessment indicates that staff are liable to receive doses in excess of 1 mSv per year.**

- **In practice, this would be for staff whose workload exceeds 100 intraoral or 50 extraoral per week (or some pro-rata combination).**

What about Lead Aprons?

- **There is no justification for the routine use of lead aprons for patients in dental radiography.**

- **There is no requirement to provide a lead apron to a pregnant patient.**

- **Lead aprons should be available for any person (comforters, carers or staff) who provides assistance by supporting a patient during a radiographic procedure.**

What About Handheld X-Ray Equipment?

- **Not prohibited in the UK (but not encouraged either)**
- **European guidance recommends that handheld X-ray equipment should only be used when fixed or semi-mobile units are impractical (e.g. in nursing homes)**
- **Should always be used with arms fully extended (about 40cm) and in the horizontal plane**
- **All X-ray equipment must be CE marked.**

Hand-held dental X-ray equipment: Guidance on safe use Public Health England PHE-CRCE-023. **Gulson and Holroyd (9 February 2016).**

Justification and good practice in using handheld portable dental X-ray equipment: a position paper prepared by the European Academy of DentoMaxilloFacial Radiology (EADMFR). **Berkhout et al, DMFR 44, 6 (July 2015).**

Where can I find a Radiation Protection Advisor (RPA)?

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

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**
- **In Northern Ireland: enforced by Regulation and Quality Improvement Authority www.rqia.org.uk**

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

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.**

Principles of Patient Protection

- **Justification** **(benefits must outweigh the risks)**
- **Optimisation (keep doses As Low As Reasonably Practicable)**
  (consistent with the intended diagnostic purpose)
- **Limitation**
  ~~(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 2017

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

The Employer is the legal person responsible for compliance with IRR 2017 and IR(ME)R 2017.

The Employer could be:

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

The Employer must create a framework for Radiation Protection through written policies and procedures.

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.**

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).

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.**

Diagnostic Reference Levels

- **DRLs are dose levels which are not expected to be exceeded for standard procedures (they are not Dose Limits – they are guidelines)**
- **Local DRLs should be set for each type of x-ray procedure**
- **Local DRLs should not normally exceed National DRLs.**

National DRLs

- **For intra-orals the National DRLs are 1.2 mGy for adults and 0.7 mGy for children (entrance doses)**

- **For DPTs the National DRLs are 81 mGy.cm^2 for adults and 60 mGy.cm^2 for children (Dose Area Product, DAP)**

- **For CBCT the National DRLs are 265 mGy.cm2 for adults (maxillary molar implant) and 170 mGy.cm2 for children (impacted maxillary canine) (Dose Area Product, DAP)**

Evaluating the Results

- **The Employer must take steps 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.**

Frequently Asked Questions

Can my nurse take the CBCT scan?

An "Operator" is anyone who is entitled by the Employer to carry out practical aspects of an exposure.

The rules are the same for

- **Intraoral radiographs**
- **Dental Panoramic Tomography (DPT)**
- **Cephalometric radiographs**
- **CBCT scans**
- **Any other type of dental X-ray**

If your nurse is entitled to take intraorals or DPTs then he/she can be entitled to take CBCT scans as well

Entitlement should be based on adequate training as spelled out in Schedule 3 of the legislation.

Who can be a Referrer?

A Referrer must be a Registered Health Care Professional.

Referrers can only refer patients for specific procedures in accordance with the Employer's referral criteria.

There is no formal requirement for Referrers to have received additional training, but it is good practice.

Who can be a Practitioner?

A Practitioner must be a Registered Health Care Professional.

Practitioners are entitled by the Employer to take responsibility for an individual exposure.

Practitioners must have received adequate training as spelled out in Schedule 3 of the legislation.

So who can press the button?

- **The Practitioner can either perform the procedure, or delegate it to a person who has received adequate training.**

- **Dental nurses, dental hygienists, etc may perform x-ray procedures provided that:**

    1. **they have completed appropriate training in radiation safety**
    2. **they have received practical training on operating the machine**
    3. **the procedure has been authorised by a Practitioner.**

- **The Practitioner retains clinical responsibility for the exposure, even though the practical aspects have been delegated.**

Are there Radiation Dose Limits for Patients?

- **While there are no specified dose limits for patients, there is a responsibility to ensure that all exposures are justified and optimised.**

- **All exposures must have a net benefit, and must be kept as low as reasonably achievable consistent with obtaining the required diagnostic information.**

What about Dose Constraints, are they Dose Limits?

Yes – but they are not for Patients!

- **Dose Constraints are a requirement for carers and comforters and for volunteers participating in research programs.**
- **Carers and comforters should be over 18 years old and must not be pregnant**
- **Staff members who assist the patient as part of their job are not considered "carers and comforters" and therefore are subject to the Dose Limit of 1mSv per year for members of the public**
- **Carers and comforters (and staff members who assist the patient) should be offered lead aprons.**

What About Diagnostic Reference Levels (DRLs), are they Dose Limits?

- **They are not Dose Limits – they are guidelines!**

- **DRLs are dose levels which are not expected to be exceeded for standard procedures when good and normal practice regarding diagnostic and technical performance is applied.**

- **DRLs may be exceeded if necessary but the reasons should be recorded.**

What about Pregnant Patients?

There are special regulations relating to exposure of patients who are or may be pregnant.

- **European Guidance indicates that special precautions are not indicated for low dose procedures or where the uterus is not in the primary beam (e.g. in dental radiography).**
- **There is a requirement to ask a female of childbearing age if she is pregnant, and record her reply.**
- **There is no requirement to use lead aprons for pregnant patients.**
- **Vertex occlusion projections (which might irradiate the foetus) are generally prohibited.**

What about Thyroid Collars?

- **Thyroid collars should be used in the few examinations where the thyroid may be in the main primary beam and the collar will not interfere with the image (e.g. cephalometric radiography but not panoramic radiography or CBCT).**

- **In practice, it is usually better to collimate so that the thyroid is outside the primary beam.**

- **The use of thyroid collars should also be considered when intraoral radiographs are taken with circular collimators on younger patients.**

- **The use of shielding which comes in contact with the patient is generally discouraged.**

What About Radiology Reports?

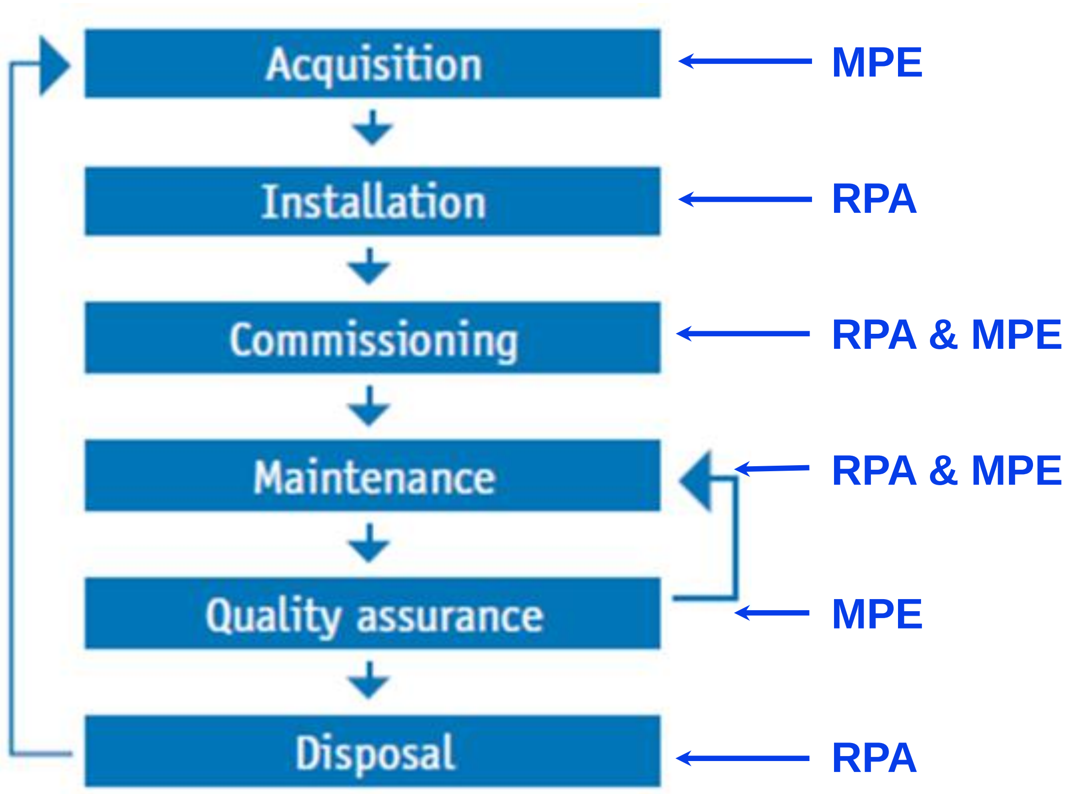
- **IR(ME)R 2017 requires a *clinical evaluation* of the outcome of each exposure (other than for carers and comforters) and that this must be *recorded.***
- **There is no legal requirement to send the images to a Radiologist for reporting**
- **If you have received sufficient training, it is good practice 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.**

What is the role of the Medical Physics Expert (MPE)?

The BSSD defines Medical Physics Expert as:

- **"An individual …having the knowledge, training and experience to act or give advice on matters relating to radiation physics applied to medical exposure, whose competence in this respect is recognised by the competent authority"**
- **RPAs are concerned with Radiation Safety for Workers and the Public**
- **MPEs are concerned with Radiation Safety for Patients, getting involved with Equipment Purchases, Quality Assurance and Optimisation**
- **MPEs are certified by the Department of Health & Social Care**
- **In many cases, the RPA and the MPE will be one and the same person.**

Equipment Life Cycle



Automatic Dose Reporting

Any equipment installed on or after 6 Feb 2018 must:

- **Display relevant parameters for assessing the patient dose**
- **Have the capacity to transfer these parameters to the patient's record.**

For CBCT, parameters such as kVp, mAs, DAP etc should be displayed to the operator and transferred to the patient's record (preferably automatically)

Storing these values in the DICOM image headers would be one way to comply with this.

Significant Accidental or Unintended Exposure (SAUE)

- **Accidental exposure:** **an individual has received an exposure in error, when no exposure of any kind was intended.**
- **Unintended exposure:** **although the exposure of an individual was intended, the exposure they received was significantly greater or different to that intended.**
- **These can happen for many reasons including procedural, systematic or human error, or equipment malfunction.**

http://www.cqc.org.uk/guidance-providers/ionising-radiation/saue-criteria-making-notification

Significant Accidental or Unintended Exposure (SAUE)

- **All events which might be significant (including near misses) must be investigated, analysed and recorded**
- **Some events have to be reported to CQC.**
- **Duty of candour to disclose "clinically significant" events to patient, referrer, practitioner**
- **If not in patient's best interests to inform patient then representatives must be informed instead.**

Incidents you don't have to report

- **Repeat exposures involving no procedural, human, systematic or equipment errors.**
  - **where original images are undiagnostic and need a technical repeat**
  - **undiagnostic images due to patient movement**
  - **incidents which don't meet the dose threshold criteria**
- **You should still record and document these incidents even though you don't have to report them.**

Dose threshold criteria

Exposures where none was intended (Accidental Exposure):

1 (England only)	All modalities including therapy	3 mSv effective dose or above (adult) 1 mSv effective dose or above (child)
1 (Northern Ireland, Scotland & Wales)	All modalities including therapy	All, regardless of dose

Dose threshold criteria

Exposures different from intended (Unintended Exposure):

2.1	Intended dose less than 0.3mSv	3mSv or above (adult) 1mSv or above (child)
2.2	Intended dose between 0.3mSv and 2.5mSv	10 or more times than intended

M	More than one individual exposed within the same incident/theme.	All cases regardless of dose
E	Equipment fault exposure	
V	Voluntary notification	
C	Clinically significant event	

To whom should you report them?

Exposures to patients:

England: The Care Quality Commission
www.cqc.org.uk/irmer-notification

Wales: Healthcare Inspectorate Wales
www.hiw.org.uk **email**: IRMERIncidents@Wales.GSI.Gov.uk

Northern Ireland: The Regulation and Quality Improvement Authority
www.rqia.org.uk

Scotland: Healthcare Improvement Scotland
www.healthcareimprovementscotland.org **email**: hcis.irmer@nhs.net

Device-related incidents:

England and Wales:

The Medicines and Healthcare Products Regulatory Agency (MHRA)
http://www.gov.uk/report-problem-medicine-medical-device

Scotland:
Health Facilities Scotland

Northern Ireland:
The Northern Ireland Adverse Incident Centre

Accidental exposures to staff or members of the public

Health and Safety Executive

http://www.hse.gov.uk/radiation/ionising/index.htm

Health and Safety Executive Northern Ireland
https://www.hseni.gov.uk/articles/ionising-radiation#toc-3

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

- **Every employee that works with ionising radiation must be given appropriate training in radiation protection**

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

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]

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Exams | Courses | For Regional and International Centres | Work with our Team | Our Surgical Training Facilities

Thursday 19 November 2020 £300

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, and aims to help participants fulfill 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.

Friday 20 November 2020 £400

Basics of Dento-alveolar 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.

KING'S College LONDON

Dental Cone Beam CT Radiological Interpretation PG Cert

Online Course

https://www.kcl.ac.uk/study/postgraduate/taught-courses/dental-cone-beam-ct-radiological-interpretation-pg-cert.aspx

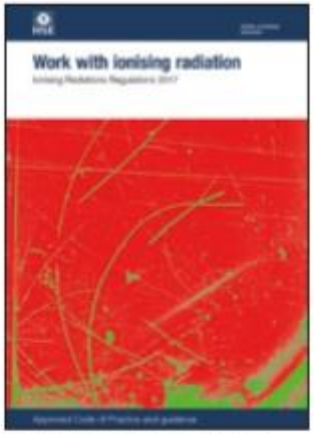
Guidance Documents (UK)

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

- **Revised Medical and Dental Guidance Notes (IPEM) to be published.**

- **Guidance Notes for Dental Practitioners on the Safe Use of X-Ray Equipment (PHE) updates planned.**

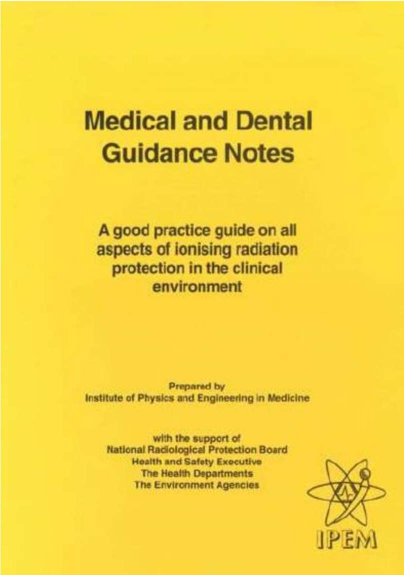
- **IR(ME)R 2017 legislation is available here:**
  www.legislation.gov.uk/uksi/2017/1322/pdfs/uksi_20171322_en.pdf



L121 (Second edition)
Published 2018

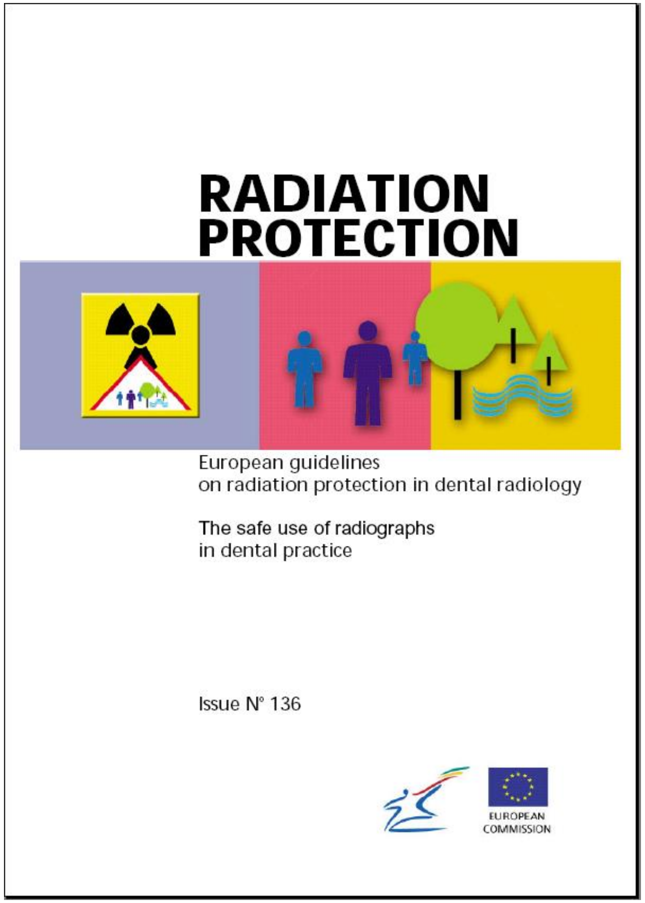
Medical and Dental Guidance Notes

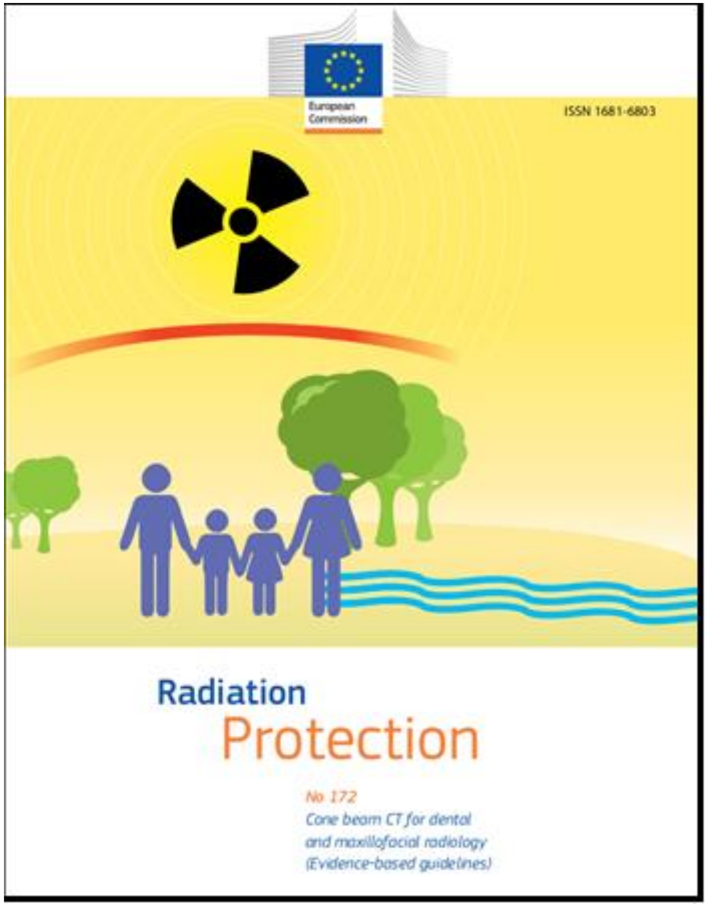
- **Provide general guidance on good practice**
- **Not an attempt to interpret legal requirements**
- **Following the guidance is not compulsory but should be sufficient to comply with the law**
- **Covers IR99, IR(ME)R 2000, equipment**
- **To be revised for IRR 2017 and IR(ME)R 2017**



IPEM 2002
Costs £20

Guidance Documents (Europe)





https://ec.europa.eu/energy/en/topics/nuclear-energy/radiation-protection/scientific-seminars-and-publications/radiation-protection-publications

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!**

The End

Thank you for listening.