Image Diagnostic Technology Ltd

Unit GC, Westpoint, 36 Warple Way, London W3 0RG

Tel: +44 20 8600 3540   www.simplantscans.com   email: info@ctscan.co.uk

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

Anthony Reynolds BA MSc PhD
Registered Clinical Scientist CS03469

Image Diagnostic Technology Ltd.

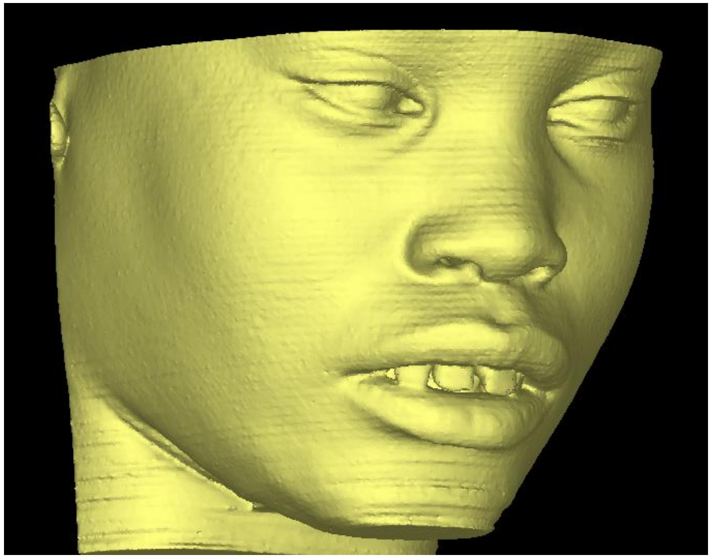
Who or what is IDT?

Three Companies:

Image Diagnostic Technology Ltd

specialises in arranging CT scans and 3D processing

since 1991



IDT Dental Products Ltd distributes

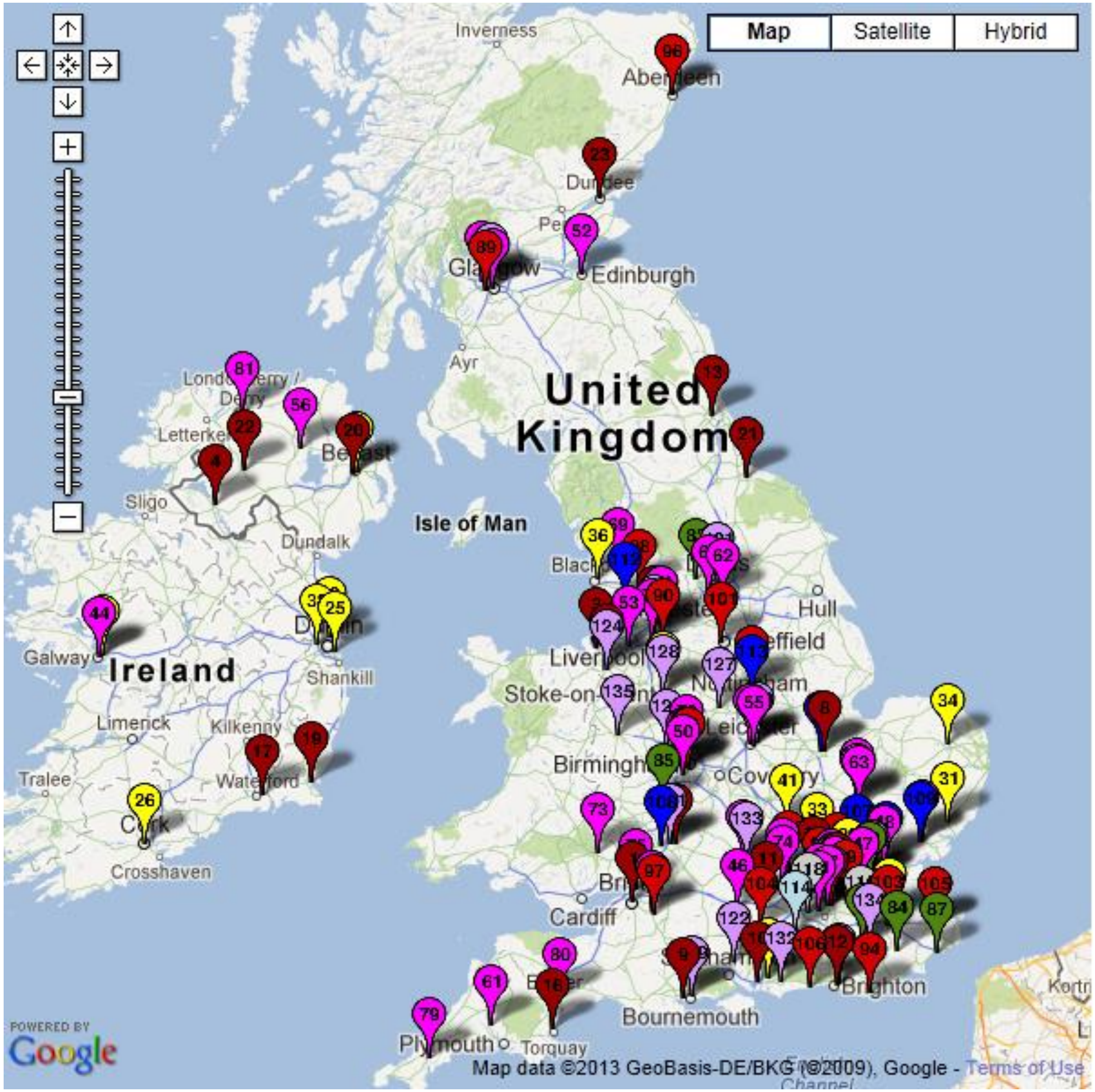
SimPlant Computer Guided Implantology

SurgiGuide Computer Guided Implantology

i-CAT

Irish Dental Tomography Ltd operates in Ireland

www.ctscan.co.uk **www.simplantscans.com**



www.simplantscans.com

i-CAT *Cone Beam CT Scanner*

i-CAT™ is a trademark of Imaging Sciences International LLC of Hatfield, USA

Medium Field Of View CBCT

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

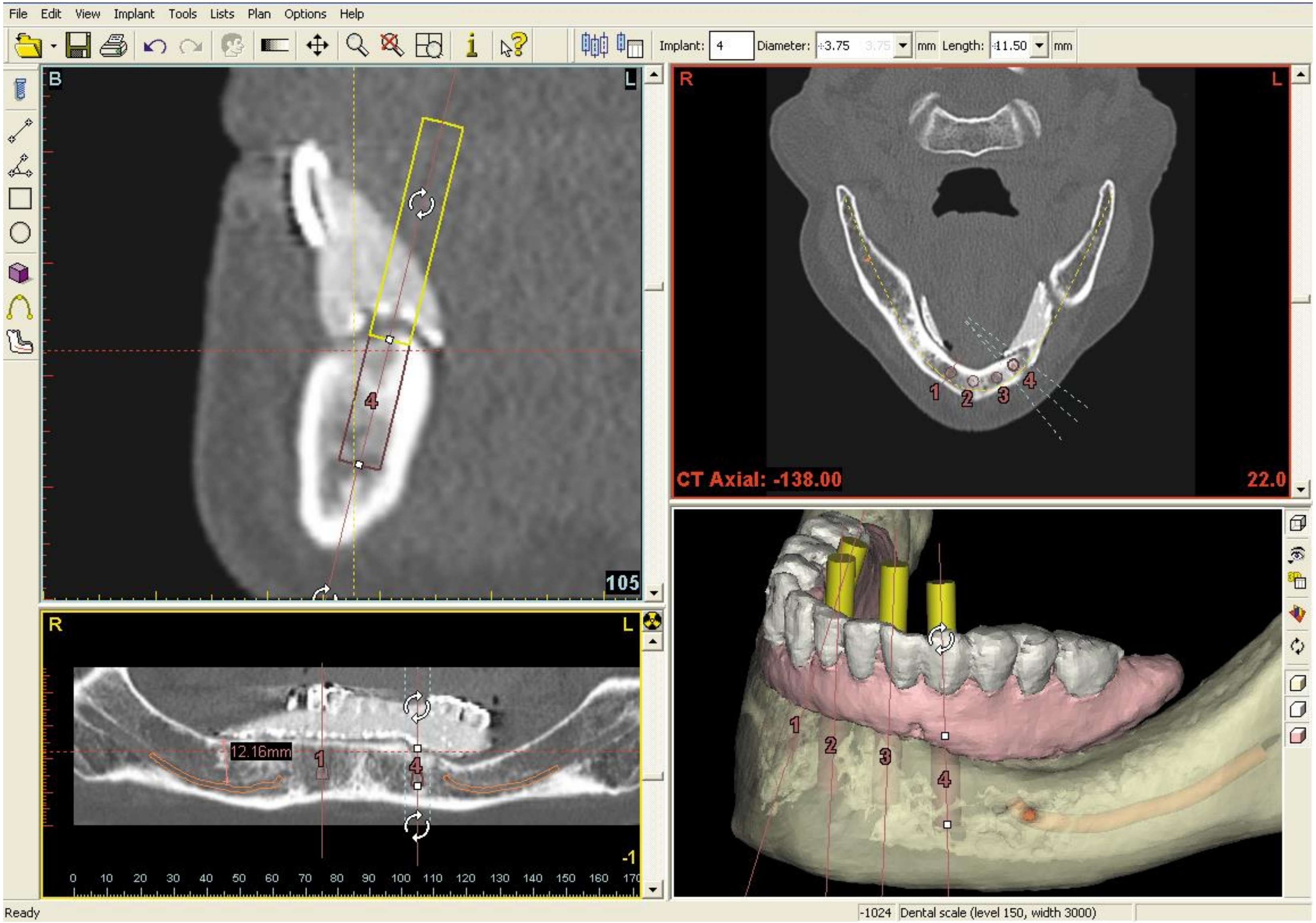
Imaging Excellence Since 1893

Small Field Of View CBCT

GX DP-700™ SERIES

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

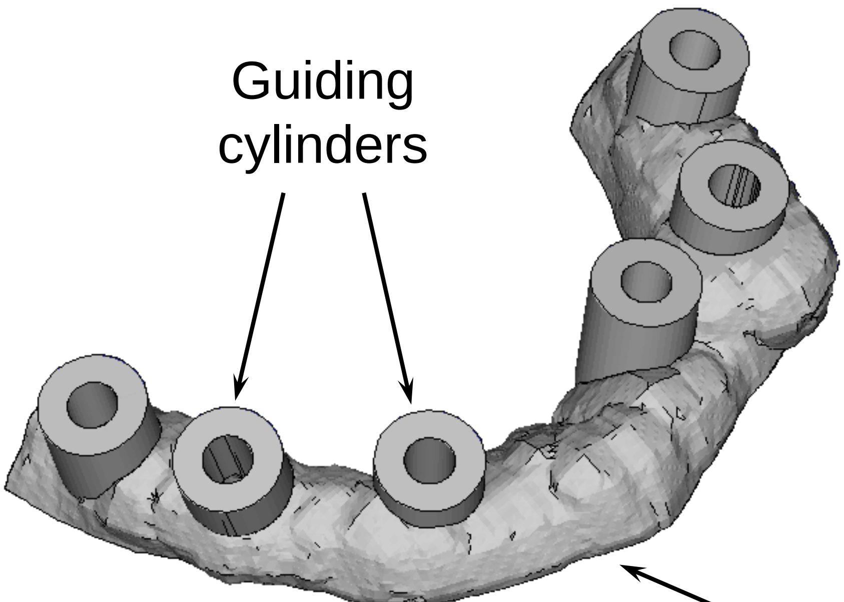
SimPlant® Computer Guided Implantology *interactive implant planning software*



SimPlant™ is a trademark of Materialise Dental NV of Belgium

SurgiGuide Computer Guided Implantology *Surgical drill guide*

Guiding cylinders

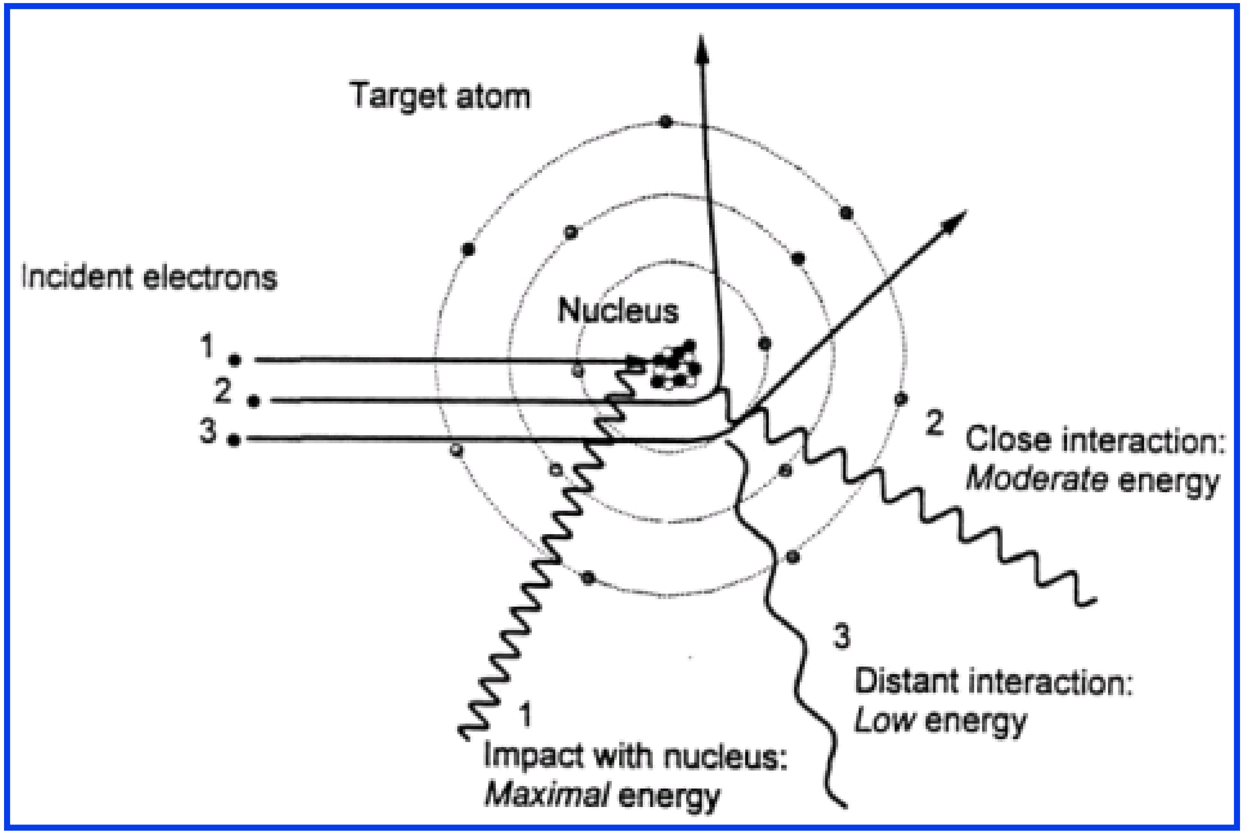


The SurgiGuide controls:
- Position
- Orientation
- (Depth)

Guide resting on:
- Bone
- Mucosa
- Teeth

Outline of Presentation

✔ **Introduction / Disclosures**
- **Risk from Low Radiation Doses**
- **What do we mean by Effective Dose?**
- **How to evaluate the Risks?**
- **How does CT work?**
- **How does Dose affect Image Quality?**
- **What other factors affect Image Quality?**



Target atom
Incident electrons
Nucleus
1
2
3
2
Close interaction:
Moderate energy
3
Distant interaction:
Low energy
1
Impact with nucleus:
Maximal energy

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

Transposition into UK Law

Ionisation Radiations Regulations 1999 – “IRR99”

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

Ionising Radiation (Medical Exposure) Regulations 2000 (amended in 2006) – “IR(ME)R 2000”

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

What's in ICRP103?

Fundamental Principles of Radiation Protection

- **Justification** (benefits must outweigh the risks)
- **Optimisation** (keep doses As Low As Reasonably Achievable)
- **Dose Limits** (20 mSv per year for members of the public)
(no dose limits for medical exposures)

What else is in ICRP103?

- **The distribution of risks to different organs/tissues is judged to have changed somewhat since ICRP60 (1991)**
- **Overall estimate of deterministic effects remains the same**
- **Risk of hereditable effects is judged to be lower**
- **Risk of fatal cancer remains unchanged at just over 5% per Sv**

Risk Coefficients for Stochastic Effects

Detriment ($10^{-2}Sv^{-1}$)	
Cancer	5.5
Hereditable effects	0.2
Total	5.7

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

How do we know that exposure to radiation results in harm?

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

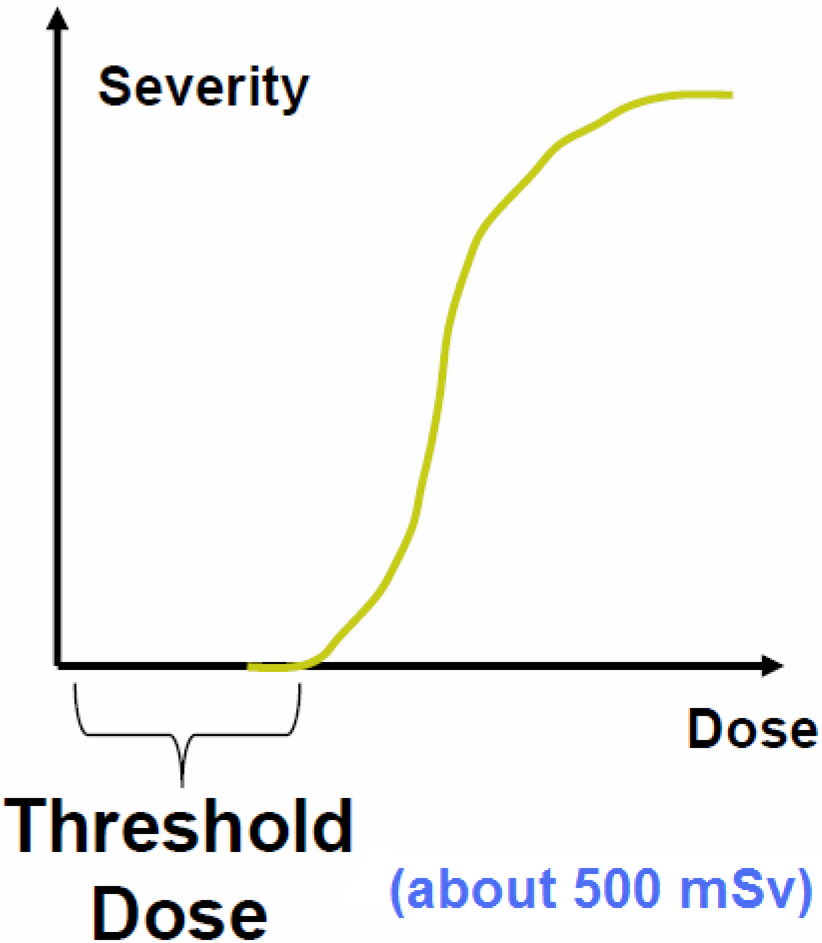
- **known to occur above 20mSv or so**
- **the risk (not the severity) increases with the dose**
- **below about 20mSv we don’t know if they occur or not**

Hereditary Effects are random but the incidence is very low

Dr Mihran Kassabian (1870–1910)

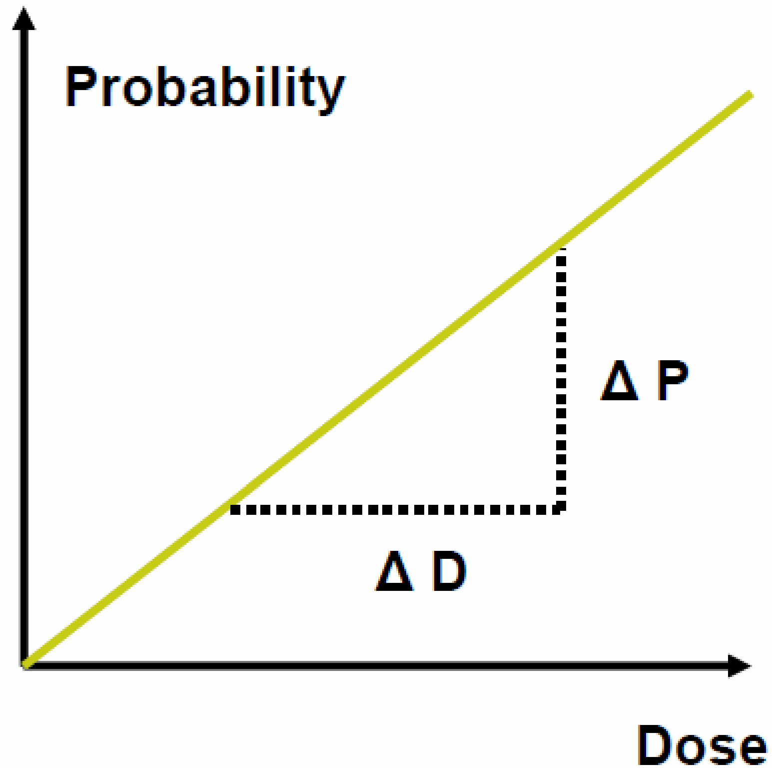



Deterministic Effects



(about 500 mSv)

Stochastic Effects



Risk Factor = Δ P / Δ D

(about 5% per Sievert)

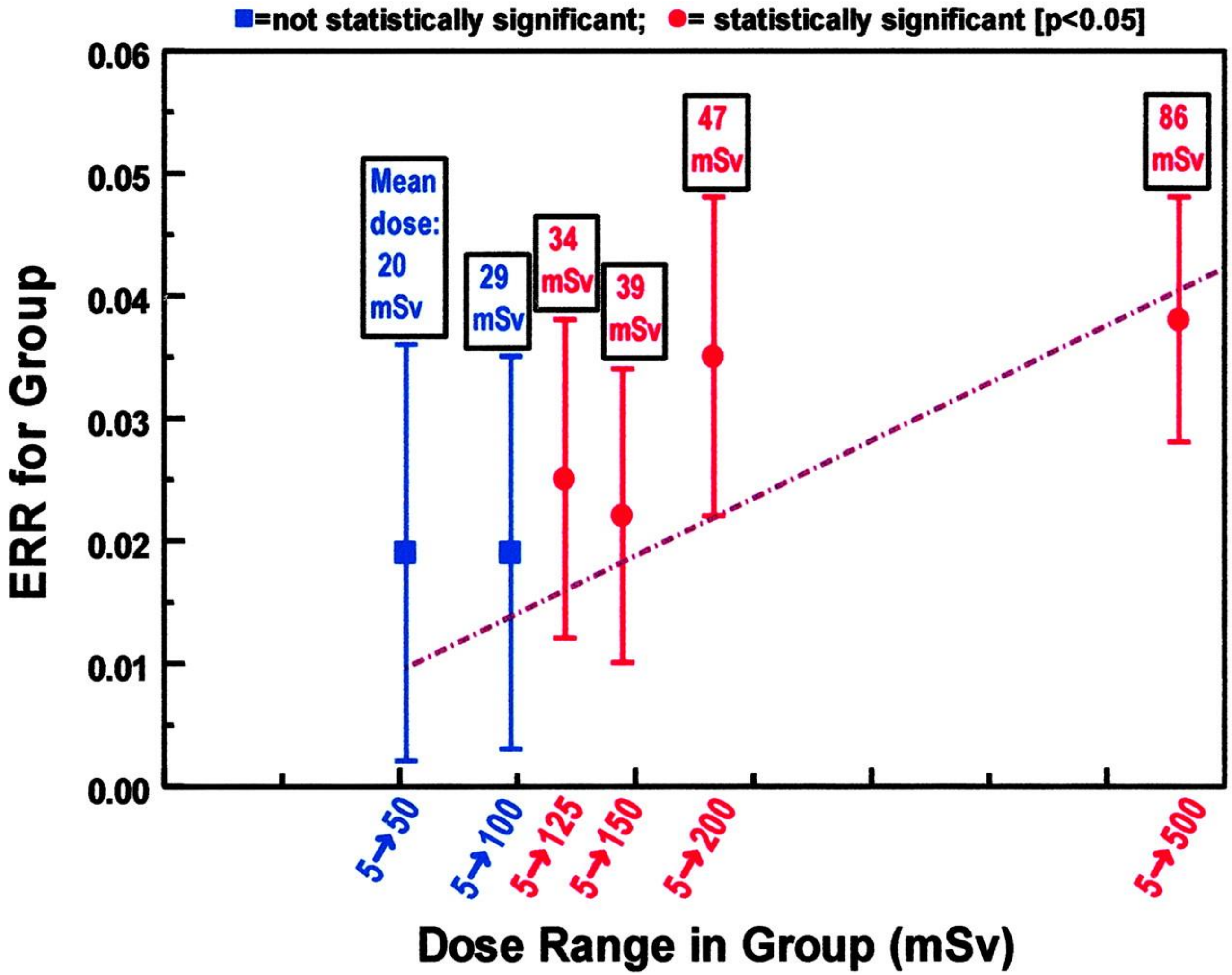
PNAS
Proceedings of the National Academy of Sciences of the United States of America

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

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

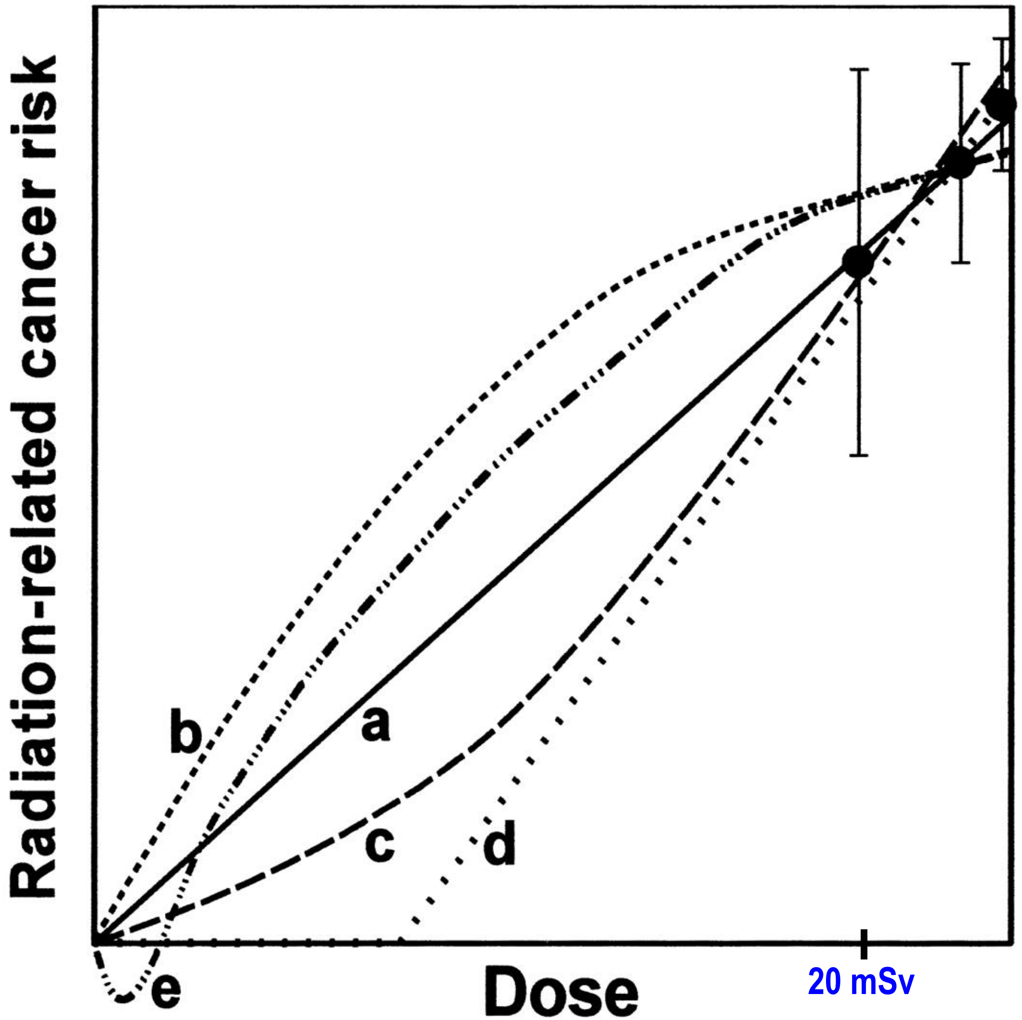
Contributed by Richard Doll, August 29, 2003

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



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

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



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

PNAS

Professional/Education/Science Policies

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

Policy source

Policy text

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

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

Duty Holders under IR(ME)R 2000

The Employer

- provides a framework of policies and procedures

The Referrer

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

The Practitioner

- responsible for justifying the exposure

The Operator

- responsible for carrying it out

Guidance on the Safe Use of Dental Cone Beam CT (Computed Tomography) Equipment

Prepared by the HPA Working Party on Dental Cone Beam CT Equipment

APPENDIX B

Core Curriculum in Cone Beam Computed Tomography (CBCT) for Dentists and Dental Care Professionals

Extracted from the Core Curriculum developed by the HPA Working Party in association with the British Society of Dental and Maxillofacial Radiology (BSDMFR), Version 10 December 2009

The Problem

As *Practitioners* we have a duty to ensure the benefits of exposing the patient to radiation outweigh the risks

But we don't know what the risks are

How can we address this issue in practice?

Use *Effective Dose* to assess the risks!

Effective Dose

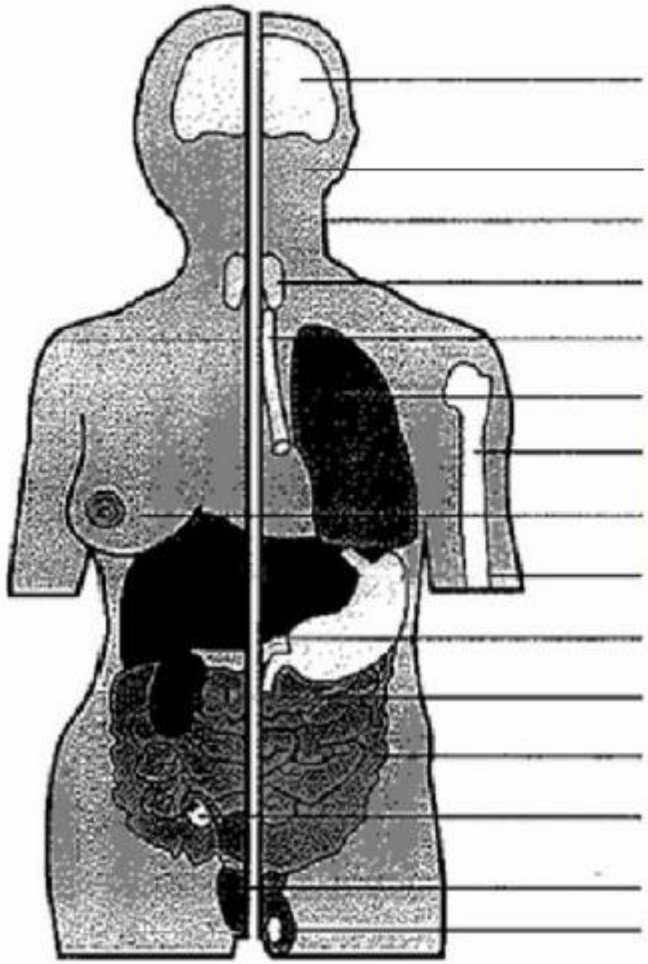
We know the risks from high doses of radiation

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

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

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

Effective Dose is a measure of risk!



	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

Effective Dose (E)

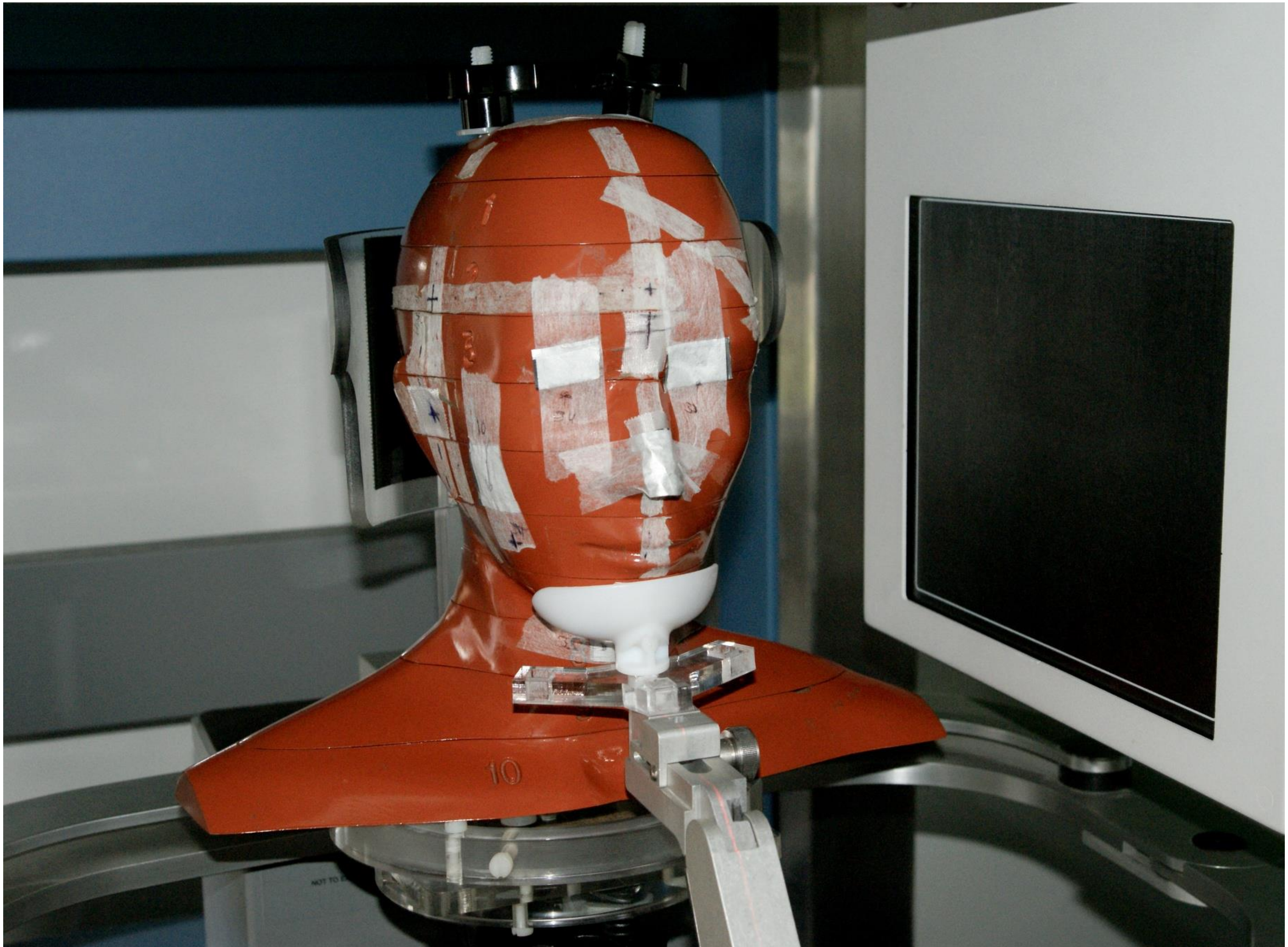
$$E = \sum_T H_T w_T$$

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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Ludlow & Ivanovic, Oral & Maxillofacial Radiology 106,1 (July 2008)

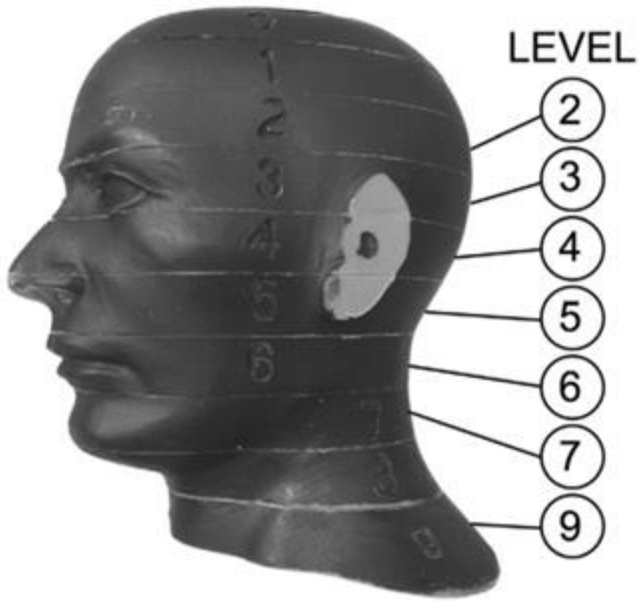
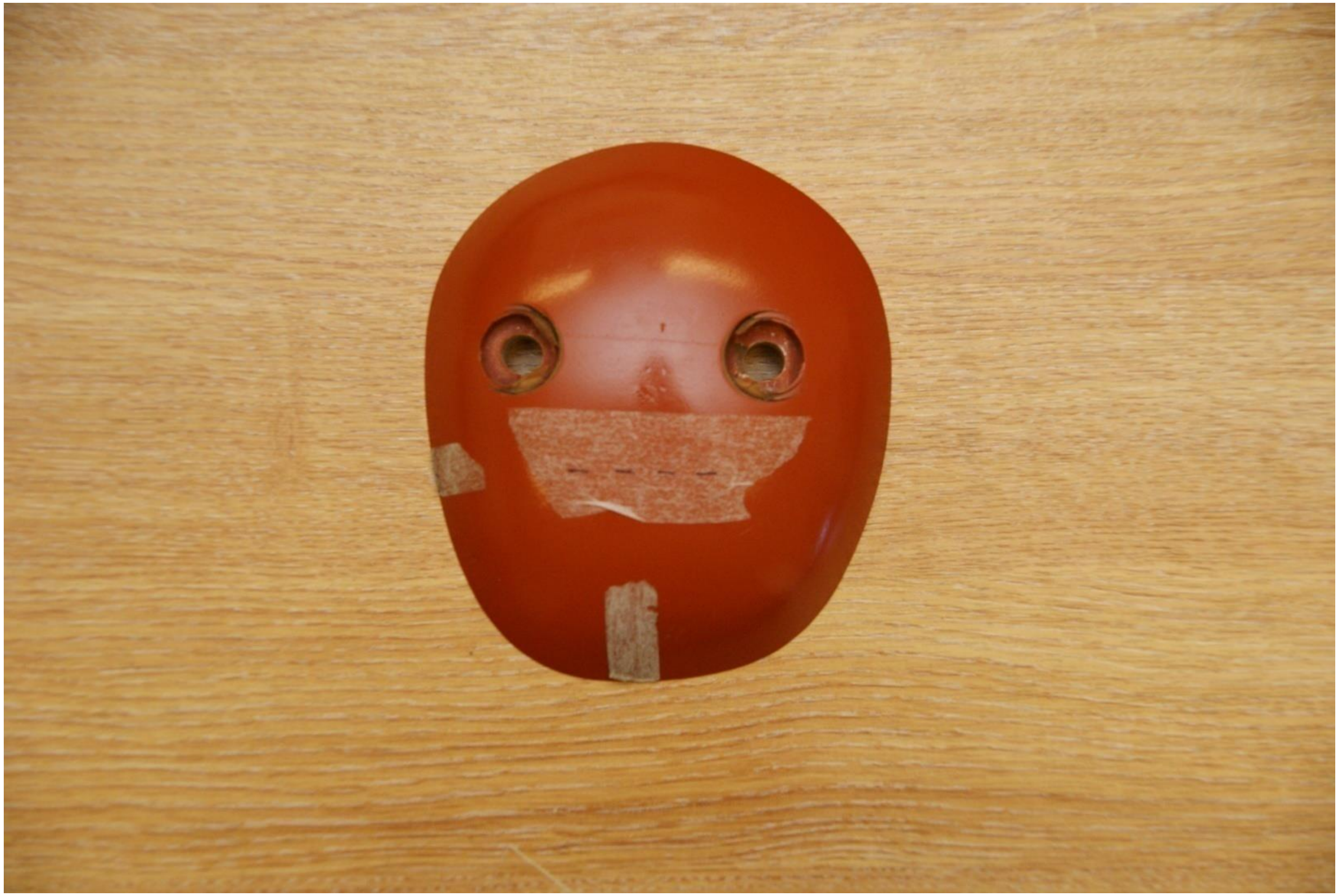


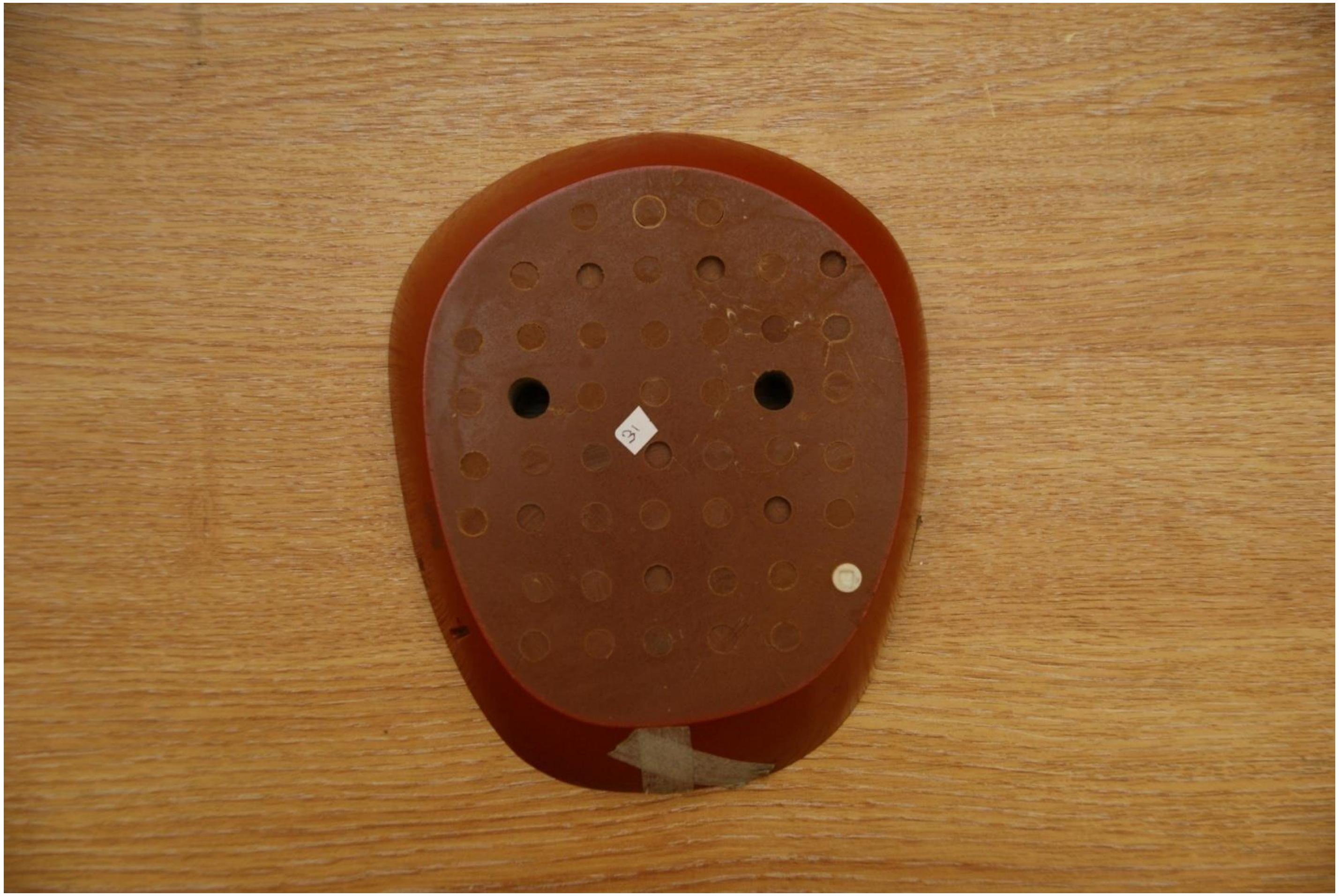
Fig. 1. Adult skull and tissue-equivalent phantom (RANDO). Levels correspond to TLD dosimeter sites identified in Table 2.

Table II. Locations of TLD chips in RANDO phantom

Phantom location	*TLD ID*
Calvarium anterior (2)	1
Calvarium left (2)	2
Calvarium posterior (2)	3
Midbrain (2)	4
Pituitary (3)	5
Right orbit (4)	6
Left orbit (4)	7
Right lens of eye (3)	8
Left lens of eye (3)	9
Right cheek (5)	10
Right parotid (6)	11
Left parotid (6)	12
Right ramus (6)	13
Left ramus (6)	14
Center cervical spine (6)	15
Left back of neck (7)	16
Right mandible body (7)	17
Left mandible body (7)	18
Right submandibular gland (7)	19
Left submandibular gland (7)	20
Center sublingual gland (7)	21
Midline thyroid (9)	22
Thyroid surface—left (9)	23
Esophagus (9)	24

TLD, Thermoluminescent dosimeter; *RANDO*, radiation analog do-

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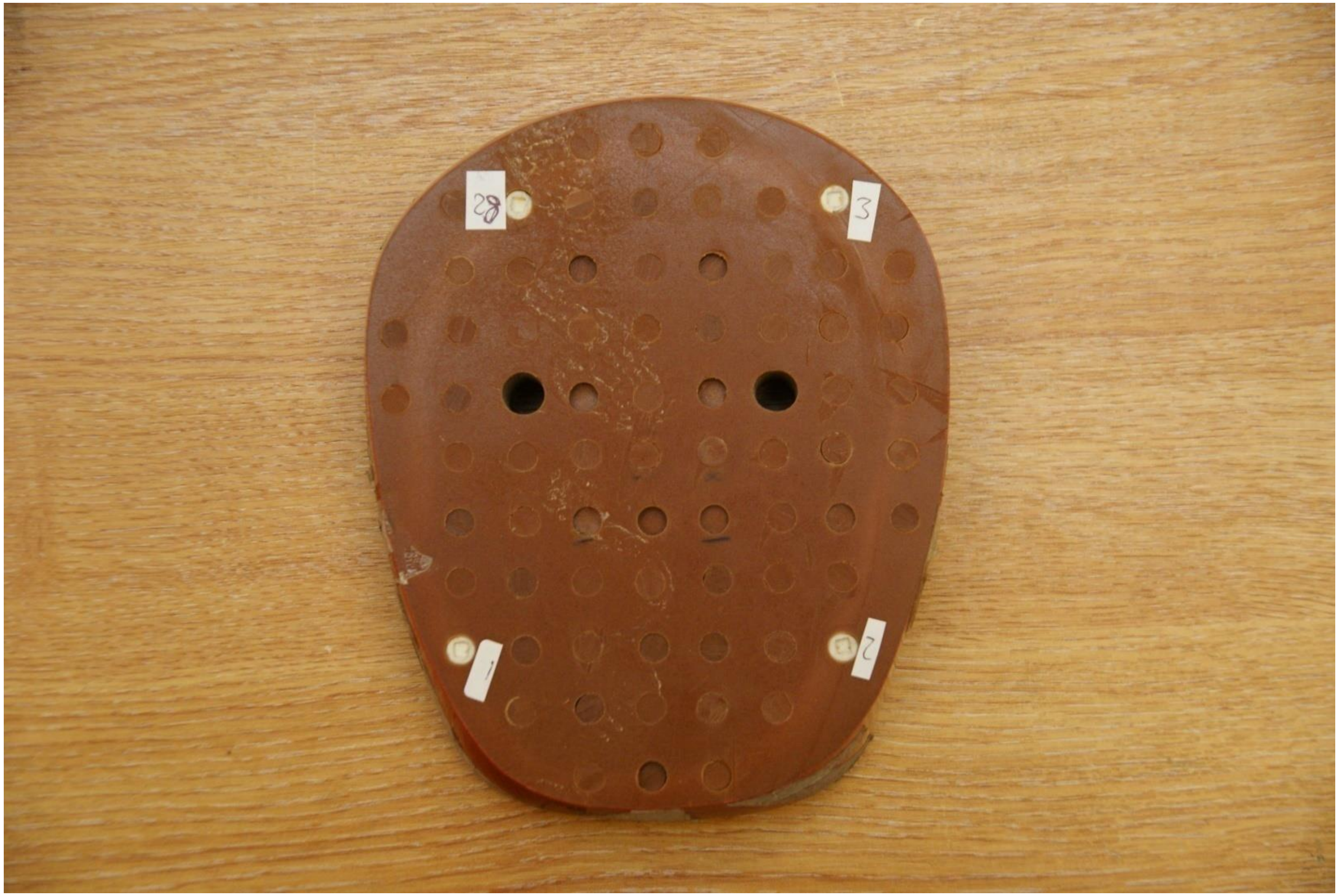
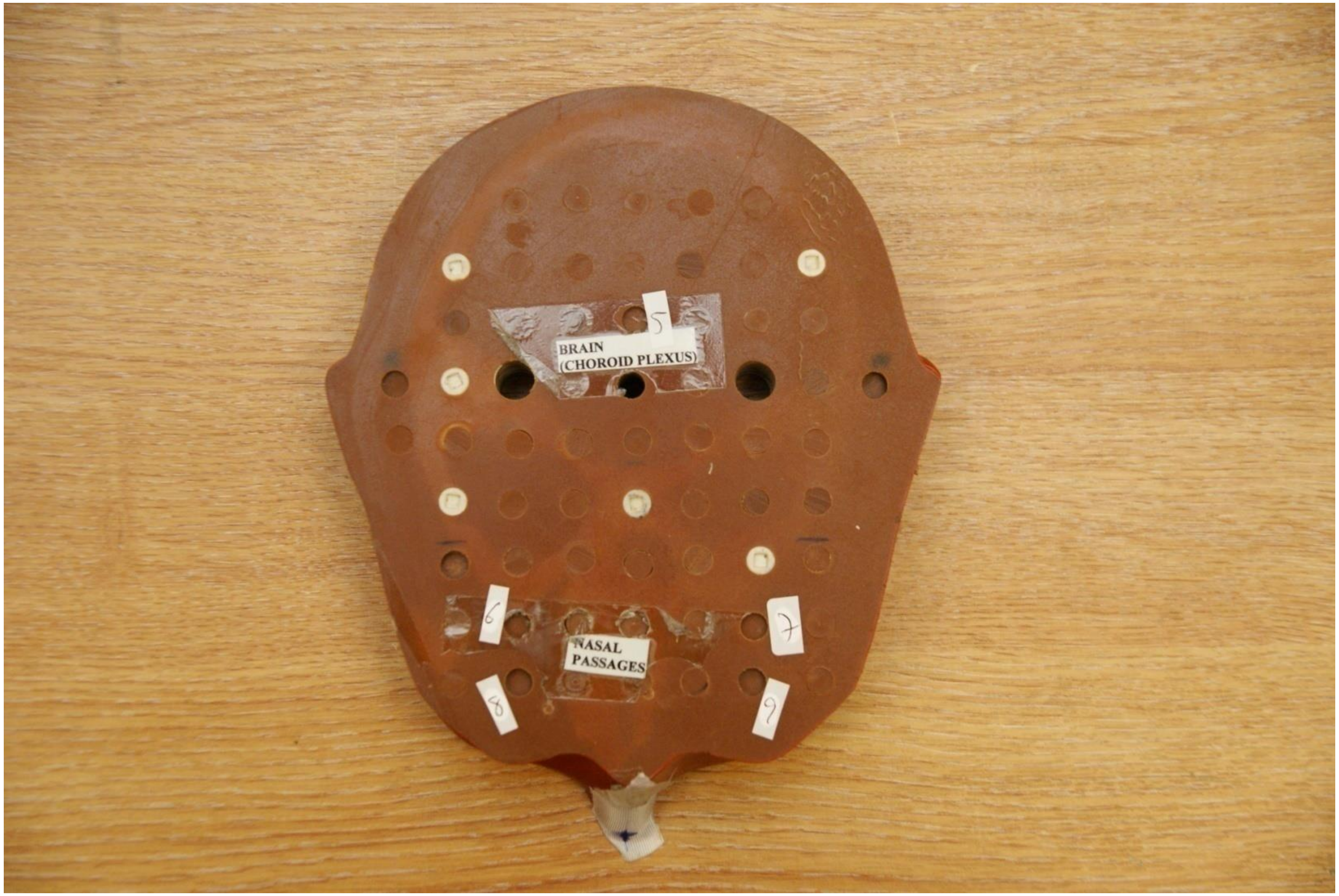
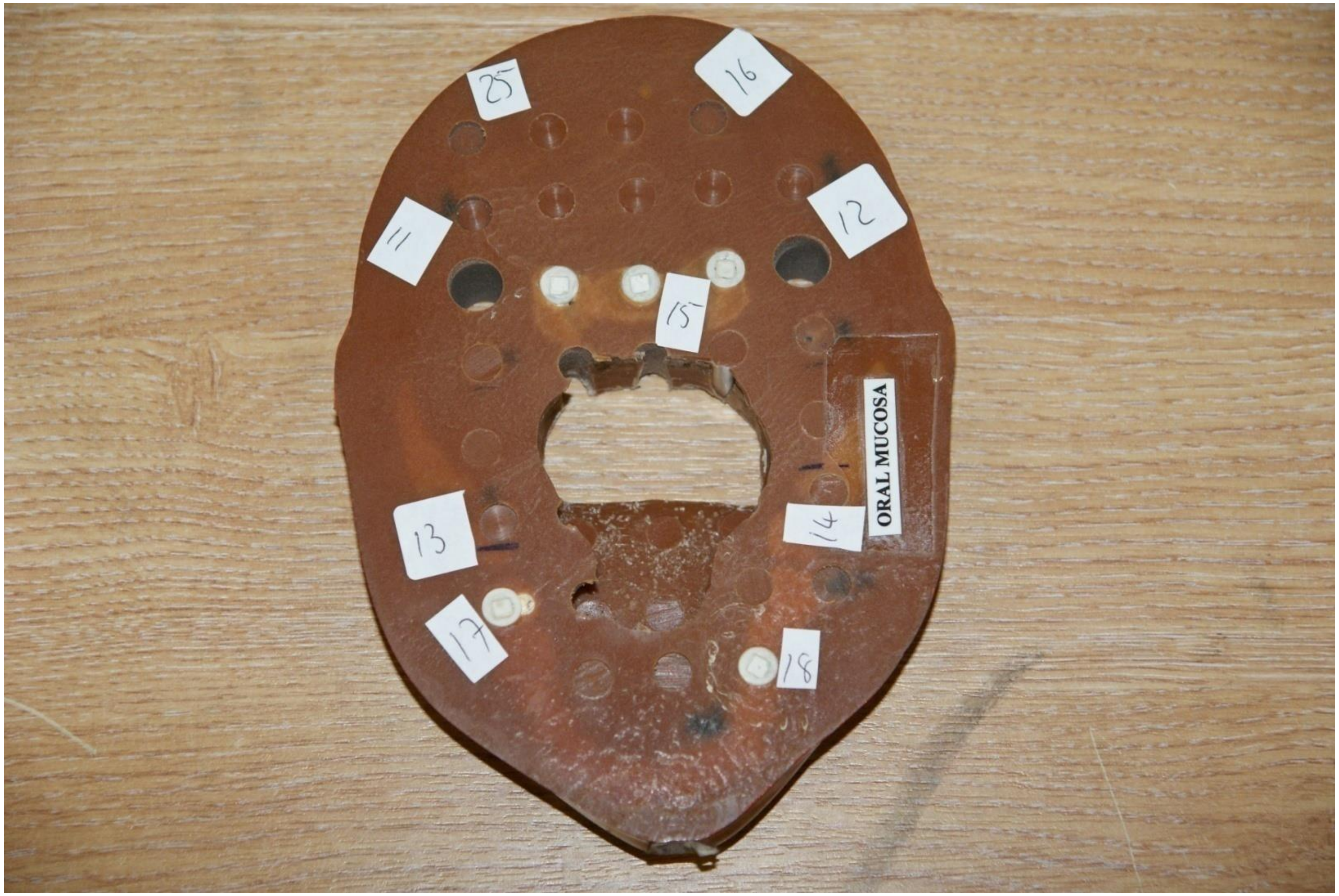
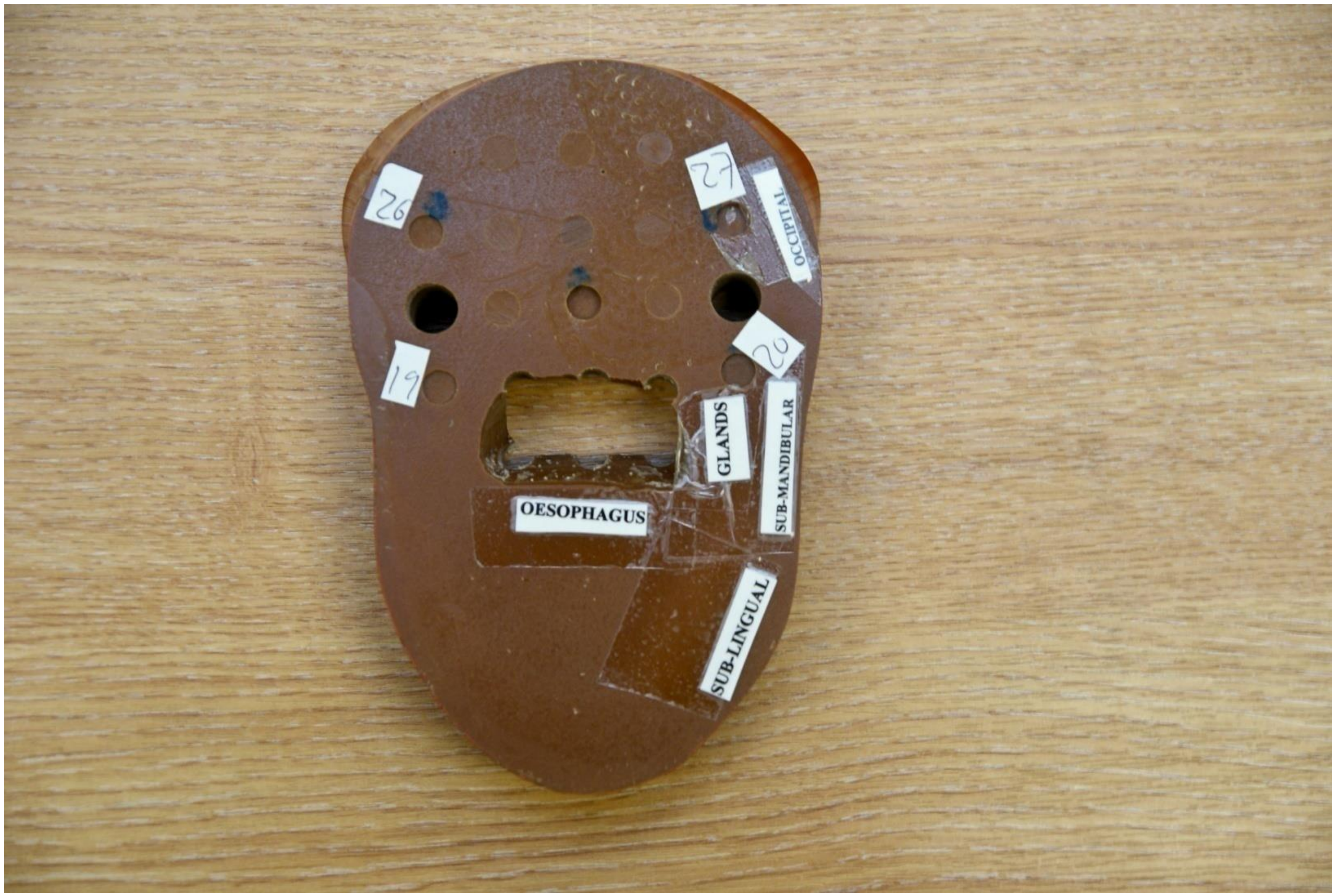

28
3
1
2

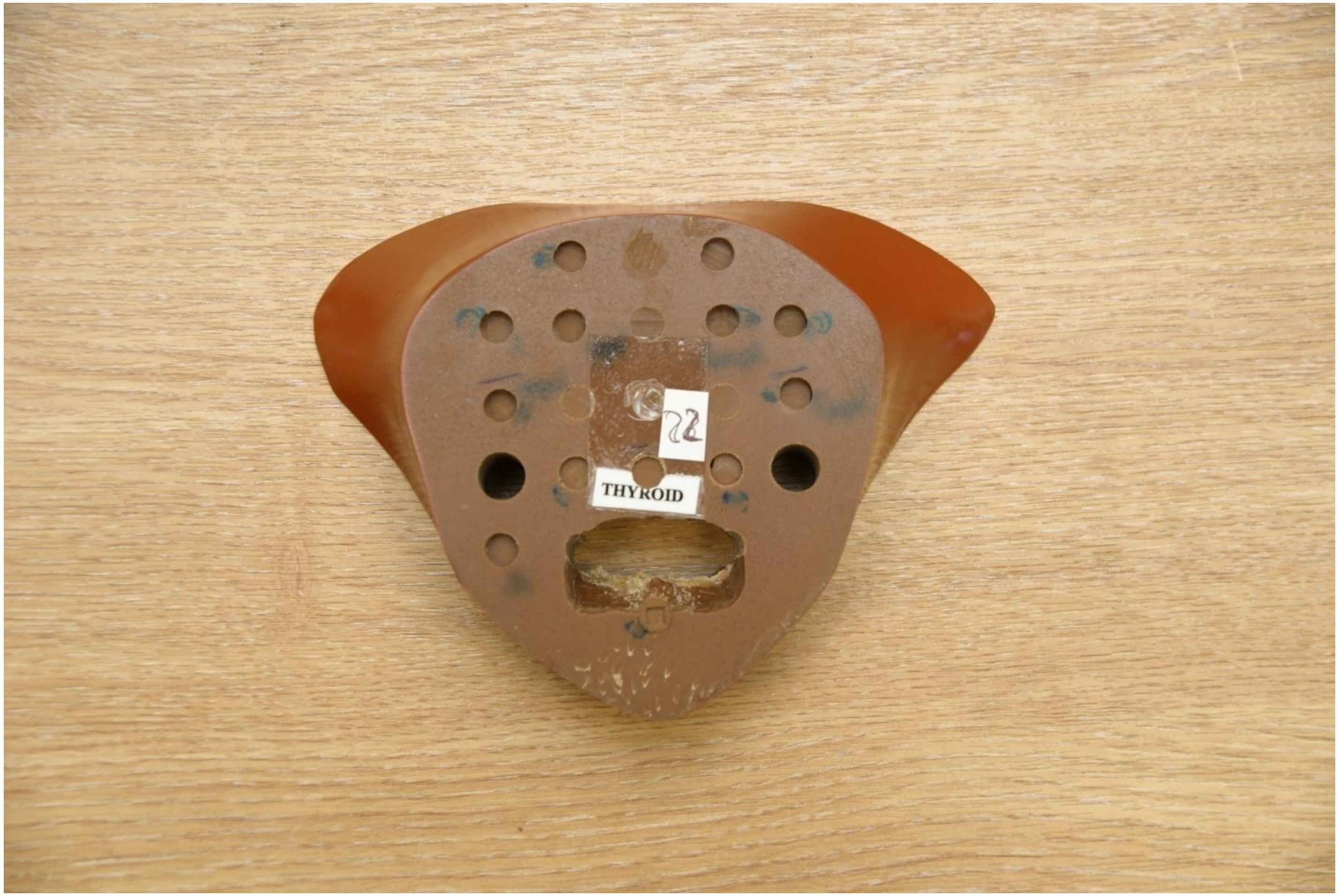

4


5
BRAIN
(CHOROID PLEXUS)
6
7
NASAL
PASSAGES
8
9

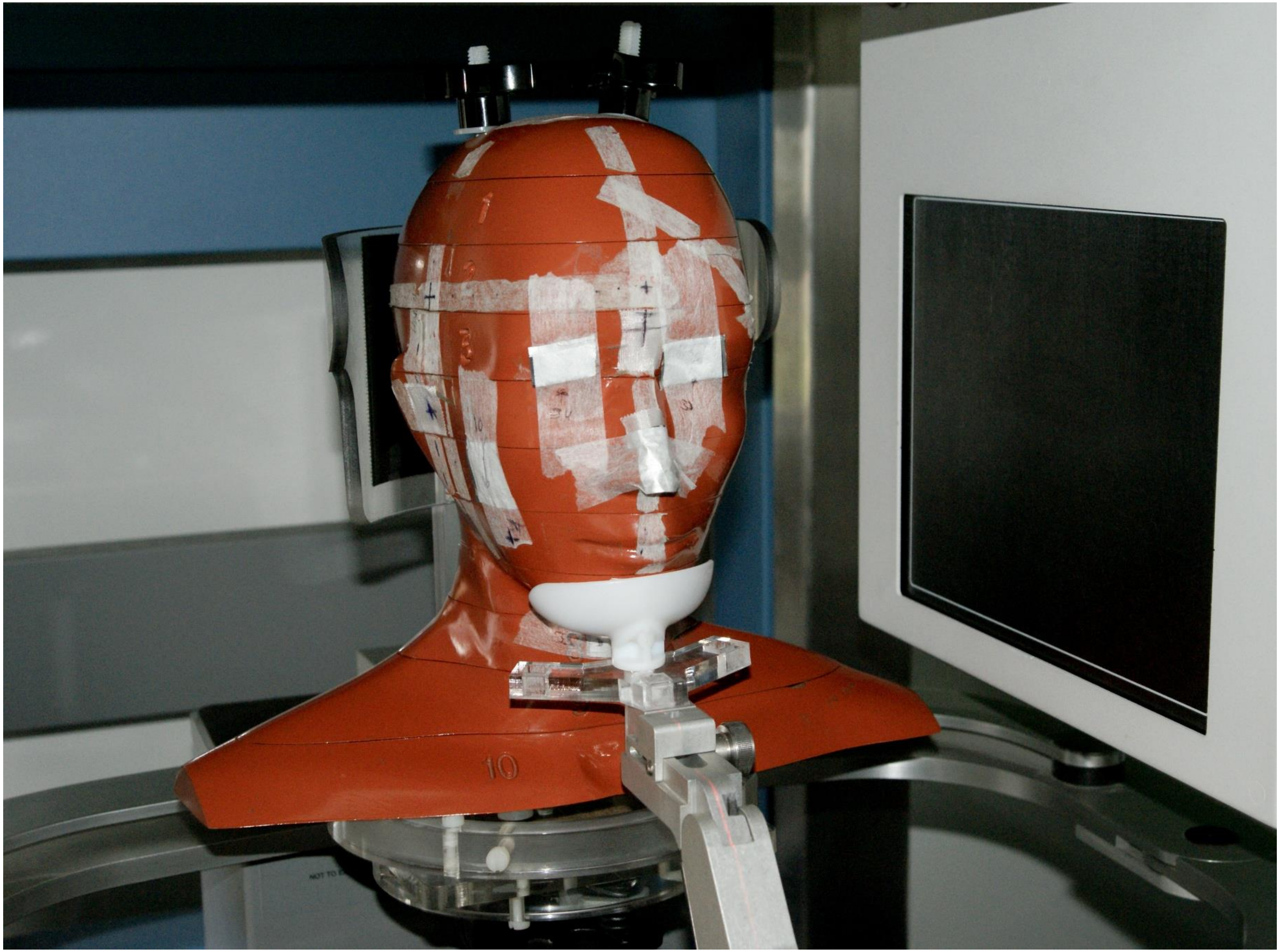

BRAIN
(CEREBELLUM)
30
MIDBRAIN
29


ORAL MUCOSA


26
27
OCCIPITAL
19
20
GLANDS
SUB-MANDIBULAR
OESOPHAGUS
SUB-LINGUAL


22
THYROID


23
24



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

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Colon	0.12
Ovary	0.08
Bladder	0.04
Testes	0.08
Remainder	0.12

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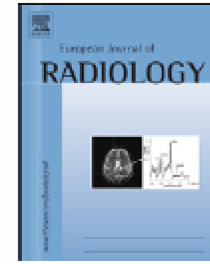
journal homepage: www.elsevier.com/locate/ejrad



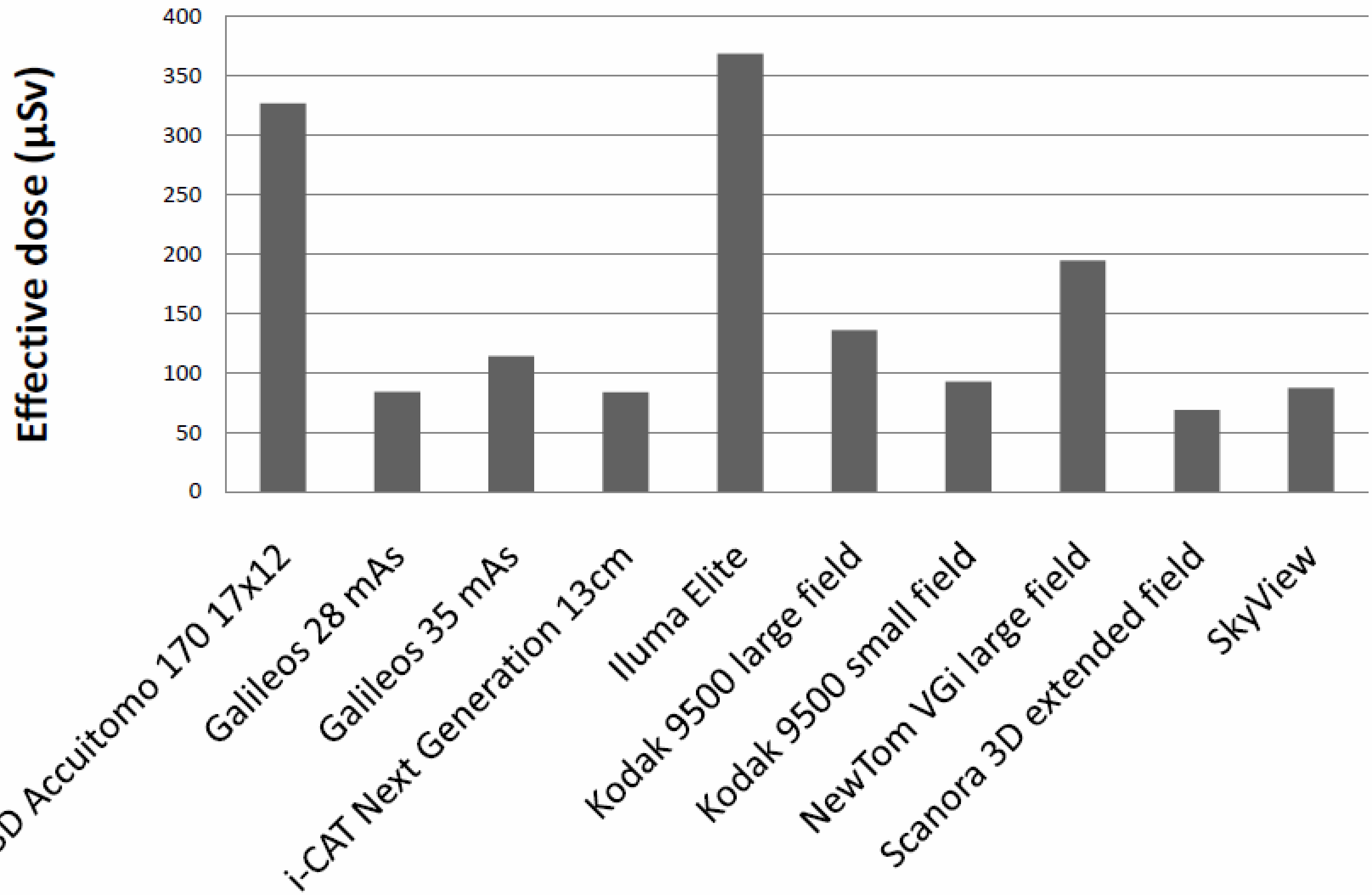
Effective dose range for dental cone beam computed tomography scanners

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*

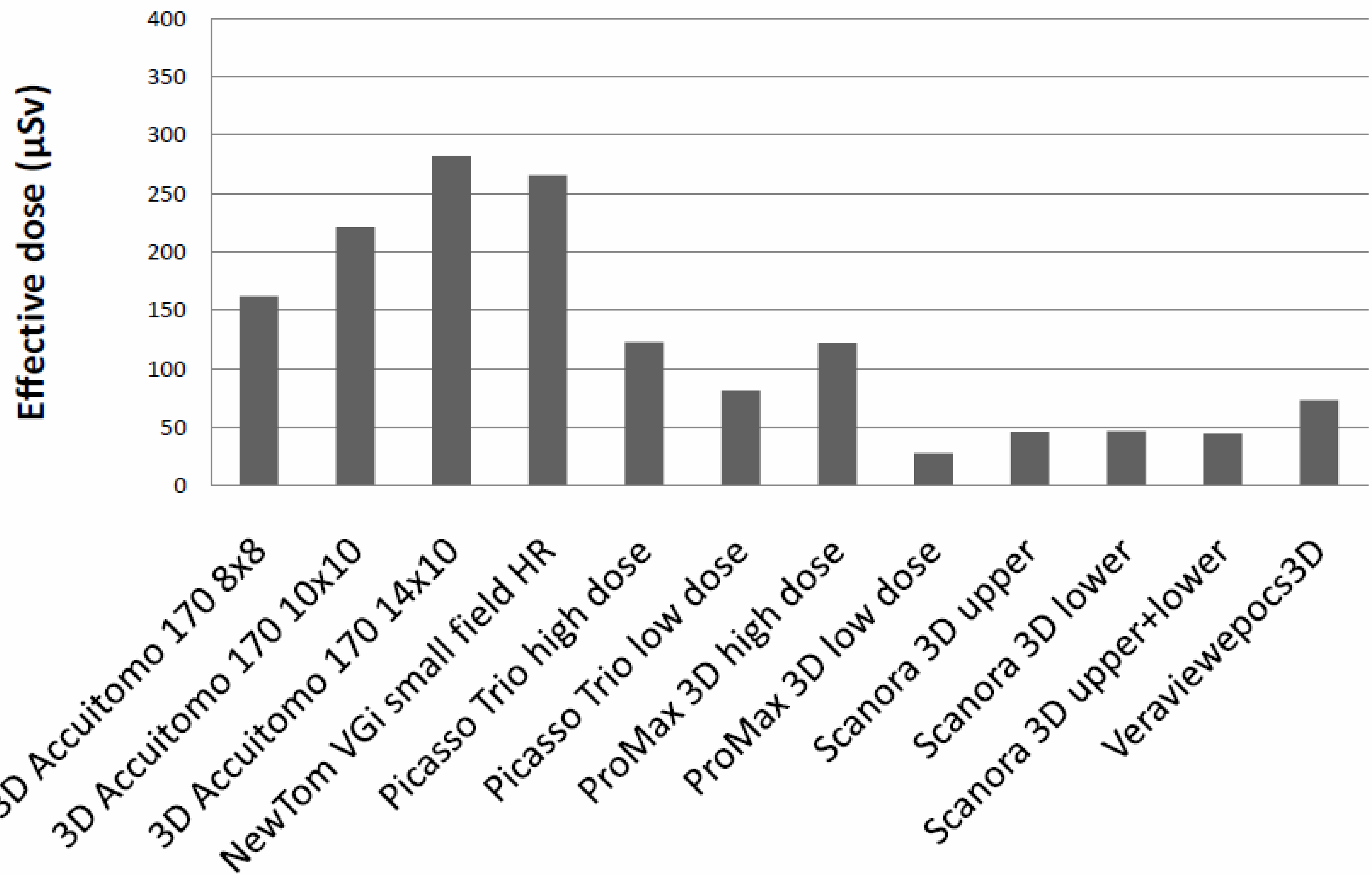
Eur J Radiol 81,2,267-271 (February 2012)

Effective dose for large field CBCTs



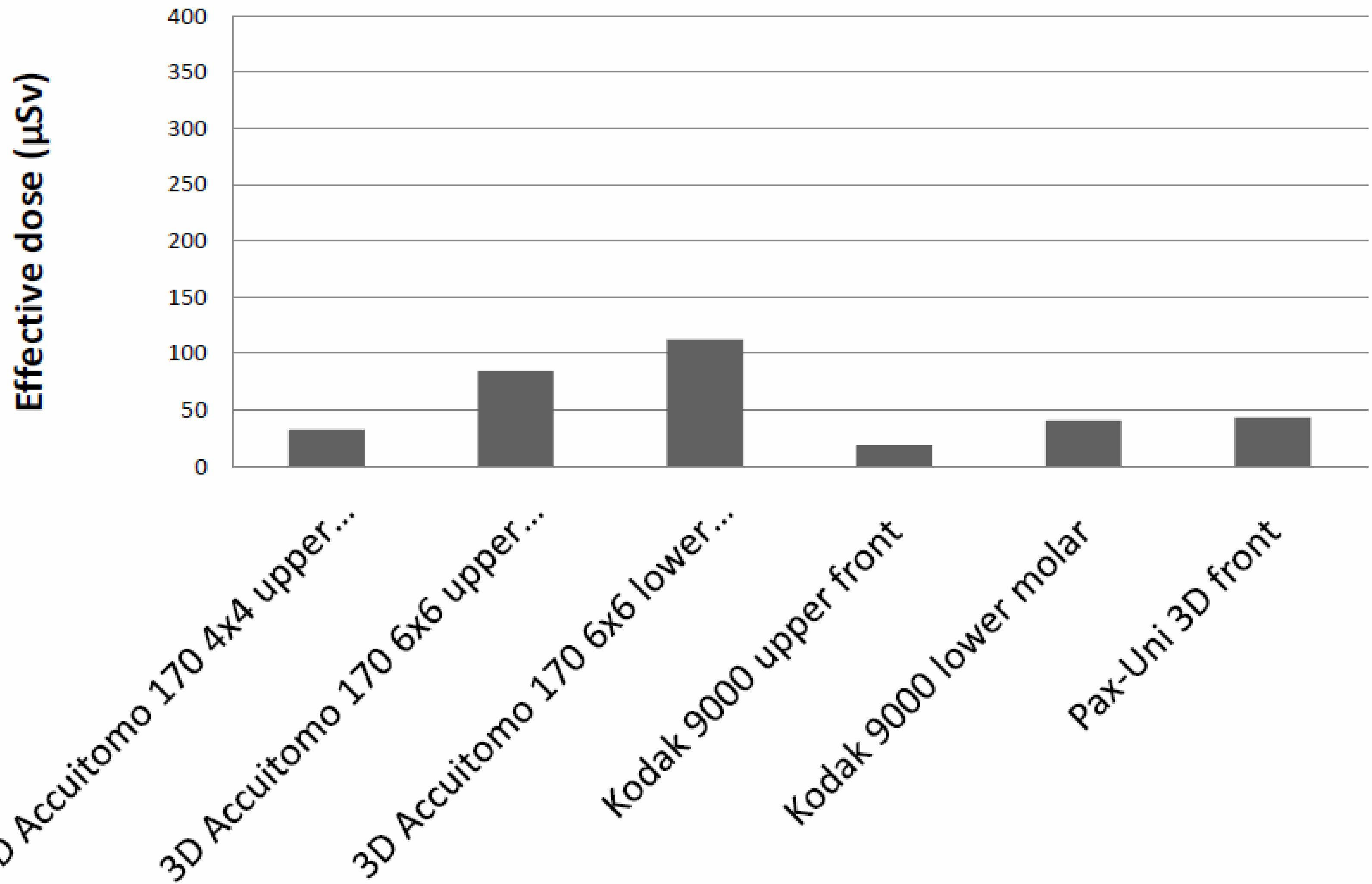
Prof. Ria Bogaerts, Katholieke Universiteit Leuven, March 2011

Effective dose for medium field CBCTs



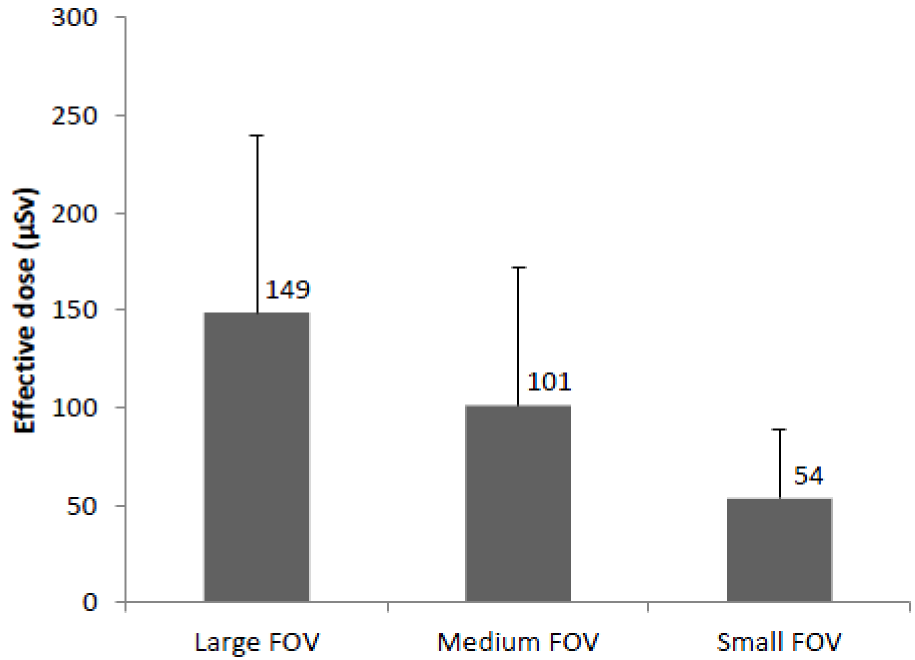
Prof. Ria Bogaerts, Katholieke Universiteit Leuven, March 2011

Effective dose for small field CBCTs



Prof. Ria Bogaerts, Katholieke Universiteit Leuven, March 2011

Figure 5.1: Bar chart showing the effective doses associated with a range of CBCT scanners, classified according to FOV. Adapted from Pauwels et al (2012).



AREA:	**284cm²**	**95cm²**	**20cm²**
FOV:	**16dia x 18h**	**8dia x 12h**	**4dia x 5h**

Estimating Effective Dose in practice

We can’t measure the Effective Dose for every patient

The SEDENTEXCT paper doesn’t cover every situation

SO

We need a practical way to calculate the Effective Dose.

How can we calculate the Effective Dose?

kVp, mA, scan duration (s)

- **can only use these to compare doses on the same machine**

Dose Length Product (DLP)

- **works very well for medical CT**

Dose Area Product (DAP)

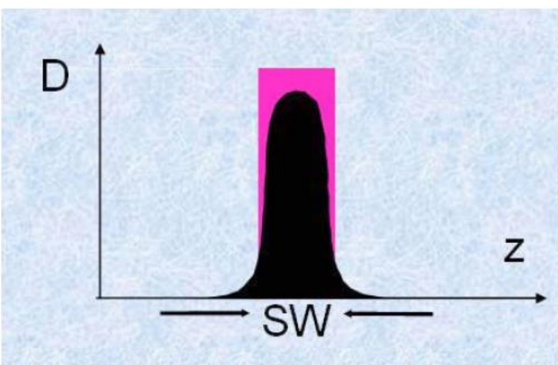
- **works reasonably well for cone beam CT**

Dose Length Product (DLP)

$CTDI_{vol}$ is the dose per cm

DLP = $CTDI_{vol}$ x Irradiated Length

Effective Dose = DLP x F **(where F is a conversion factor)**



$$CTDI = \frac{1}{SW}\int_{-5cm}^{+5cm} D(z)dz \quad (mGy)$$

- **works well for medical CT**
- **most CBCT manufacturers don’t display $CTDI_{vol}$ (exception: J.Morita Accuitomo and Veraviewepocs)**

Conversion Factor F

Tab. 3.1
Average values f_{mean} of conversion factor (in mSv/mGy·cm) to convert from dose free-in-air on the axis of rotation into effective dose for different regions of the body and patient groups (beam quality: 125 kV, 9 mm Al-equivalent); demarcation of the body regions was made according to (Hidajat96/2) (see also fig. 3.1 - 3.3).

Body region	Adults		Children (7 year-old)		Babies (8 week-old)	
	(female)	(male)	(female)	(male)	(female)	(male)
Head	0.0022	0.0020	0.0028	0.0028	0.0075	0.0074
Neck	0.0051	0.0047	0.0056	0.0055	0.018	0.017
Chest	0.0090	0.0068	0.018	0.015	0.032	0.027
Upper abdomen	0.010	0.0091	0.020	0.016	0.036	0.034
Pelvis (*)	0.011	0.0062	0.018	0.011	0.045	0.025
Entire abdomen (*)	0.010	0.0072	0.019	0.014	0.041	0.031

Table from "Radiation Exposure in Computed Tomography" edited by Hans Dieter Nagel
F can also by calculated from ImPACT CTDosimetry calculator www.impactscan.org

Roughly speaking, F = ~~0.002mSv~~ / mGy.cm for Maxilla and ~~0.003mSv~~ / mGy.cm for Mandible

2 µSv **3 µSv**

Accuracy: ±50%

Effective Dose for Medical CT Scanners

Patient ID : 15625528
Sex : F
Patient's Age : 58Y
Image Comment :

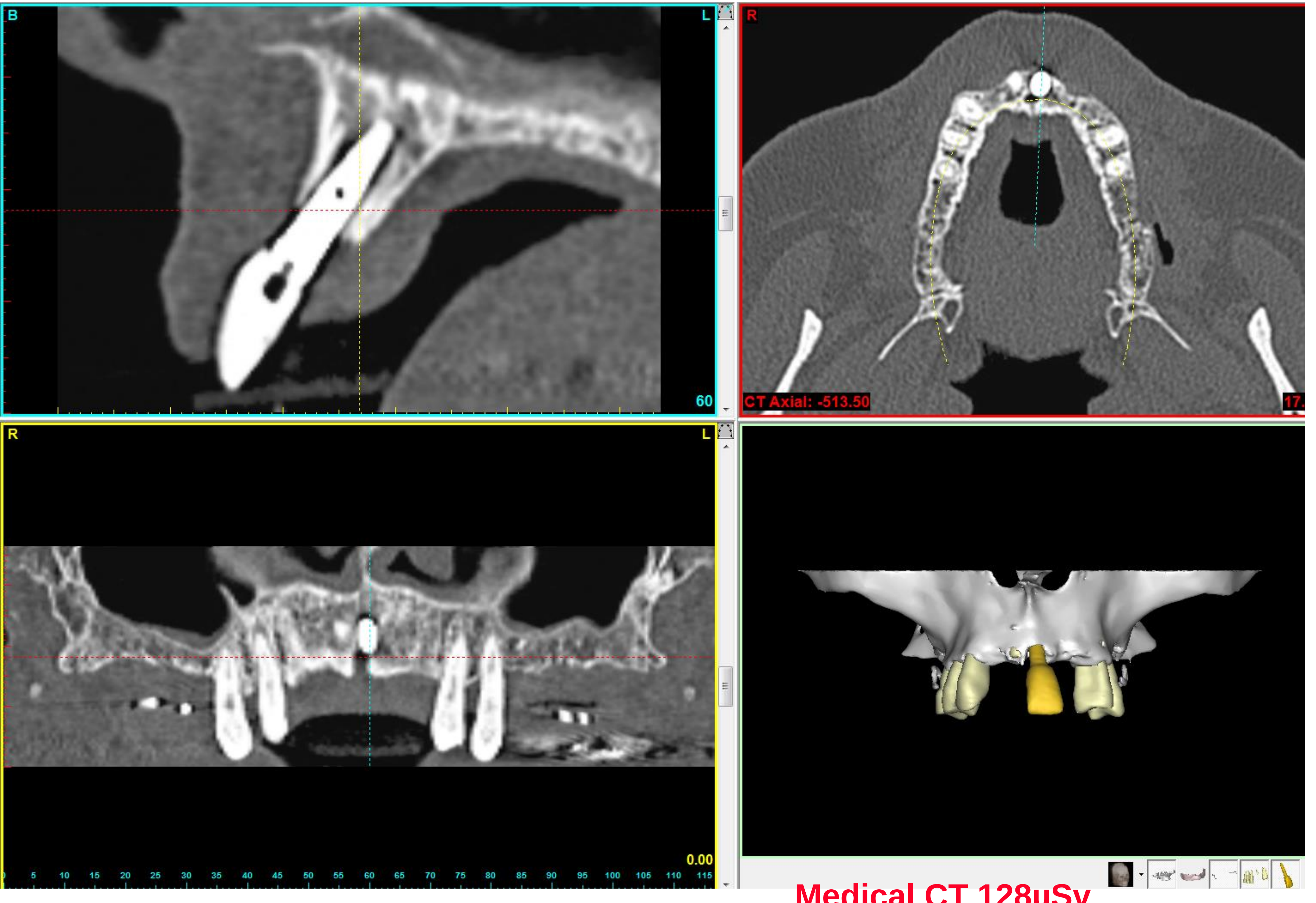
Study ID : 6021
Patient's Birth Date : 1952.07.20

Study Date : 2011.06.30
Body Part :
Contrast Enhance : NONE
Contrast/Bolus Volume :
Contrast density :
Requesting Service :
Referring Physician's Name :
Name of Physician Reading Study :
Operators Name :
Total mAs in Study : 652
Total Scan time in Study : 10.85
Total DLP mGycm : 64.00
Total slice : 5
Scanning Sequence : HELICAL_CT

Multiply DLP by 2 for Maxilla or 3 for Mandible to get the Effective Dose in microSieverts (µSv)

Accuracy: ±50%

Mx 128µSv ROUGHLY



Medical CT 128μSv

IDT Physics Report

Patient ID 23416

Gender Male

Date of Birth 1953-06-12

Scanning Date 2012-08-16

Region Scanned Maxilla

Reason for Scan Proximity of implant to incisive canal

Scanning Site Bath Clinic

Equipment Toshiba Aquilion (64 slice)

Scan Duration 12 seconds

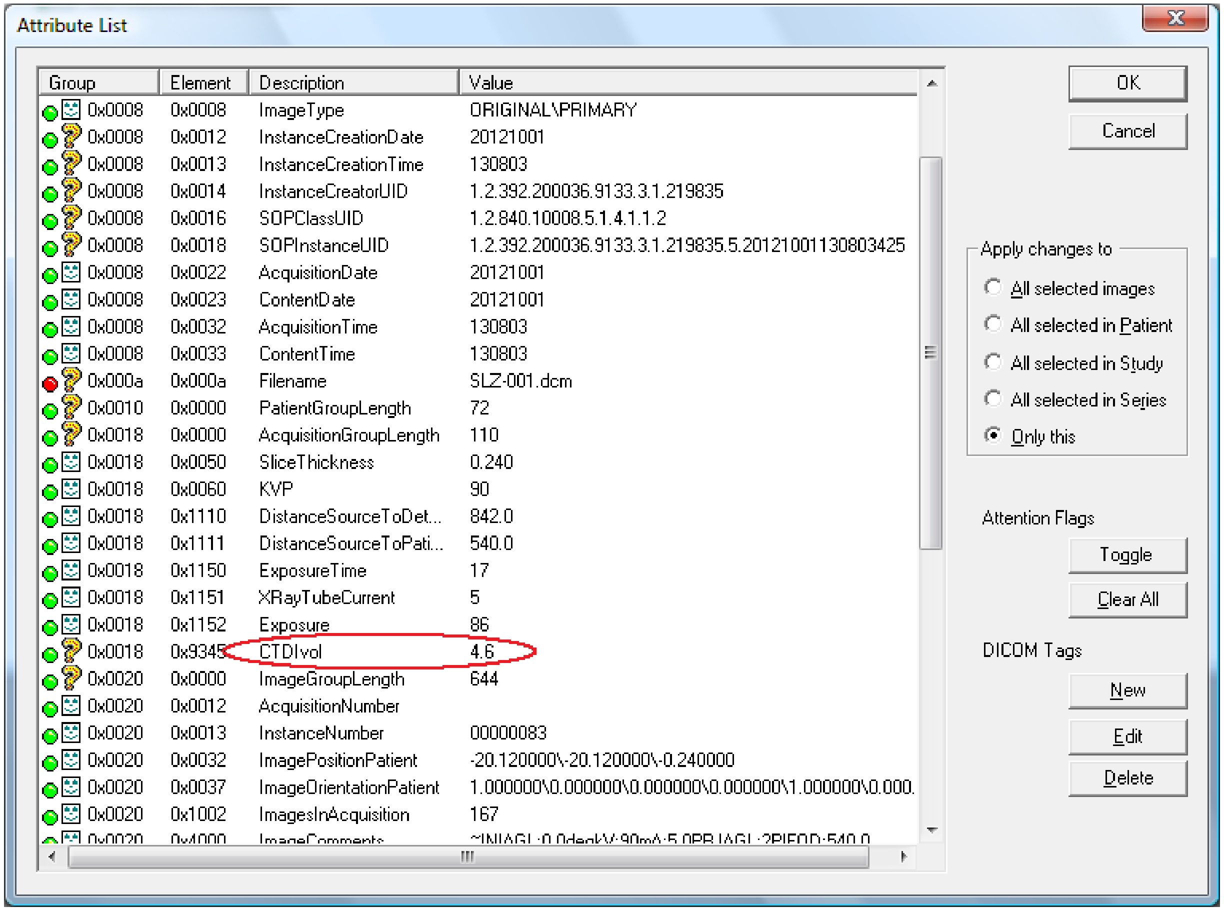
FOV (diameter) 15 cm

FOV (length) 4.2 cm

Dose Length Product (DLP) 64 mGy.cm

Effective Dose 128 microSv approx (calculated from DLP)

J.Morita Accuitomo and Veraviewepochs



DLP = CTDIvol x Irradiated Length = 4.6mGy x 4cm = 18.4mGy.cm

Effective Dose = 18.4 x 3 = 55 microSv

ROUGHLY


B
L
21
R
CT Axial: 0.00
R
L
-2.75
CBCT 55μSv

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]

Table 5
Absorbed organ dose and effective dose for small FOV (localised) protocols.

	3D Accuitomo 170	Kodak 9000 3D	Kodak 9000 3D	Pax-Uni3D
FOV positioning	Lower jaw, molar region	Upper jaw, front region	Lower jaw, molar region	Upper jaw, front region
Red bone marrow	37	21	78	47
Thyroid	195	30	251	209
Skin	32	25	24	55
Bone surface	37	27	35	49
Salivary glands	2120	523	709	1073
Brain	37	18	290	28
Remainder	70	74	86	146
Effective dose	43	19	40	44

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)

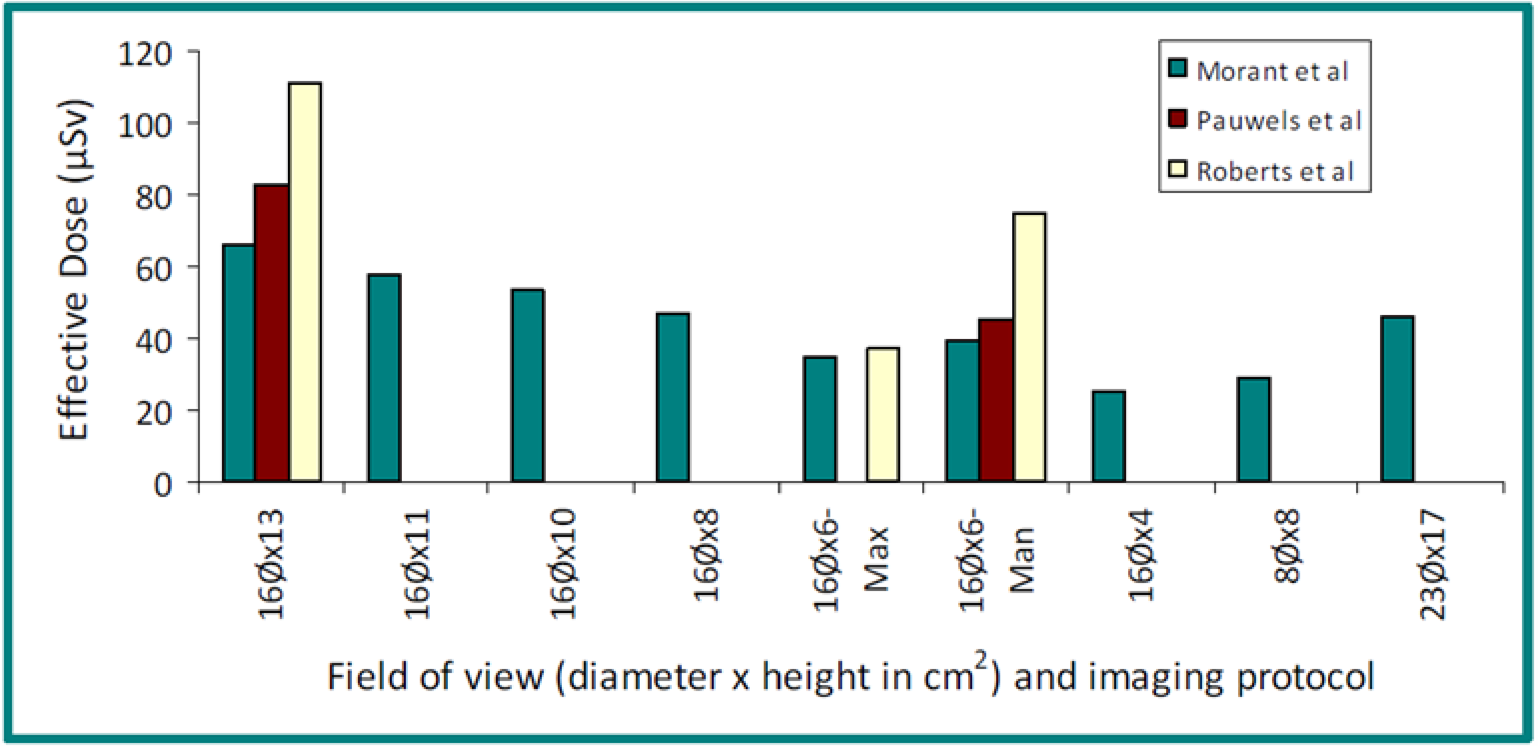
Region	*Volume size (mm x mm)*	*Tube voltage (kV)*	*Tube current (mA)*	*DAP value (mGy cm^2)*	*Effective dose (µSv)*
Upper jaw					
Cuspid	30 x 40	80	5.0–6.0	263–316	21–25
	40 x 40	75	4.0–5.0	260–325	21–26
	60 x 60	75	4.5–5.5	645–788	52–63
Lower jaw					
Second premolar–first molar	30 x 40	75–80	3.0–6.0	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) = 0.08 x DAP (mGy.cm2)

Results of Monte Carlo calculations

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

i-CAT 17-19



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

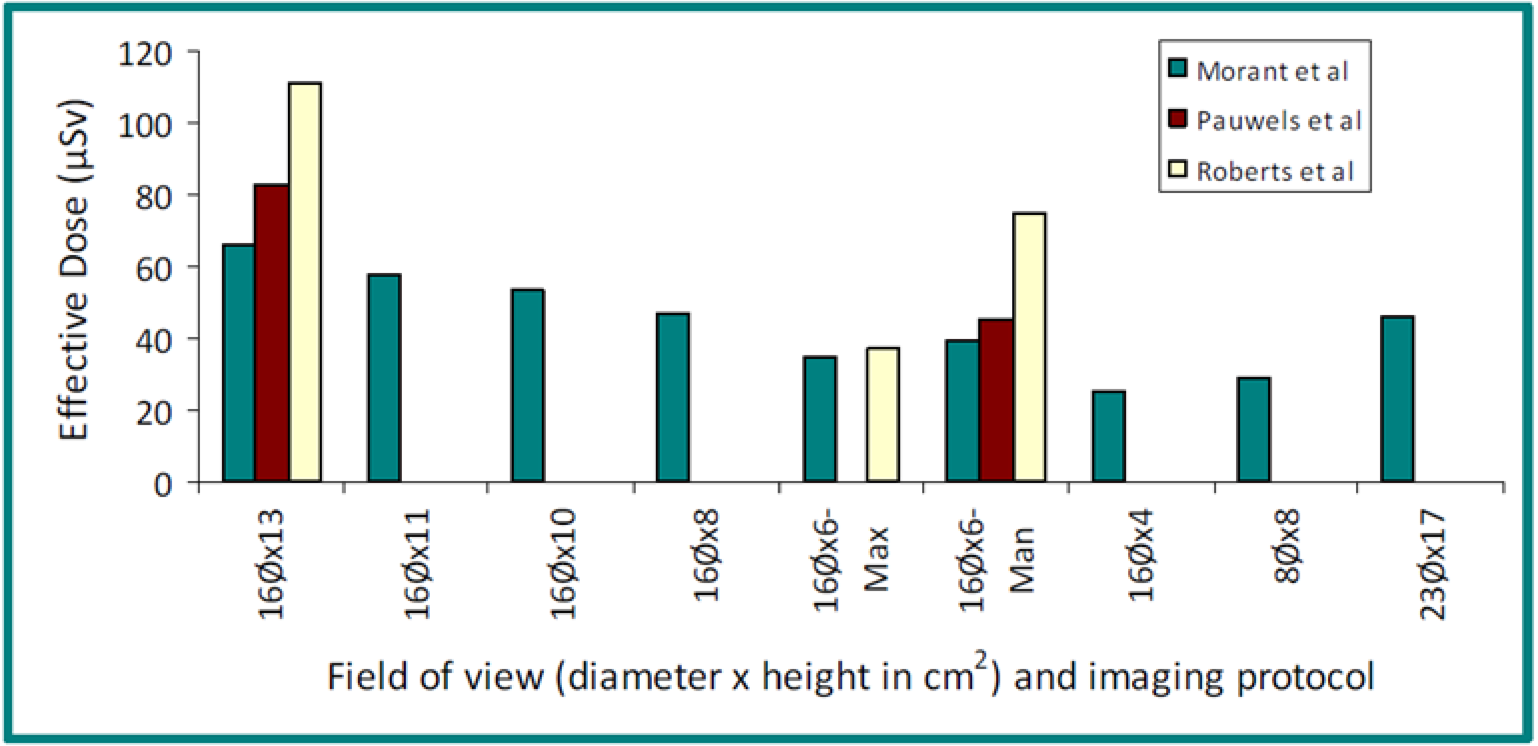
slide from presentation by
Dr Chrysoula Theodorakou, "Dental Cone Beam Computed Tomography", BIR, London, 6 November 2012

The Christie NHS
NHS Foundation Trust

Results of Monte Carlo calculations

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

i-CAT 17-19



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

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

The Christie NHS
NHS Foundation Trust

Results of Monte Carlo calculations

Theodorakou C, Walker A and The SEDENTEXCT Consortium. Paediatric effective and organ dose conversion factors for dental cone beam computed tomography using MCNP5. World Congress on Medical Physics and Biomedical Engineering, 26-31 May, Beijing, China

Accuitomo F170

- Effective dose-DAP relationship:
  - Effective dose (µSv) = 0.183 x DAP ($mGycm^2$), r^2=0.96
  - Effective dose (µSv) = 0.189 x DAP ($mGycm^2$), r^2=0.76

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

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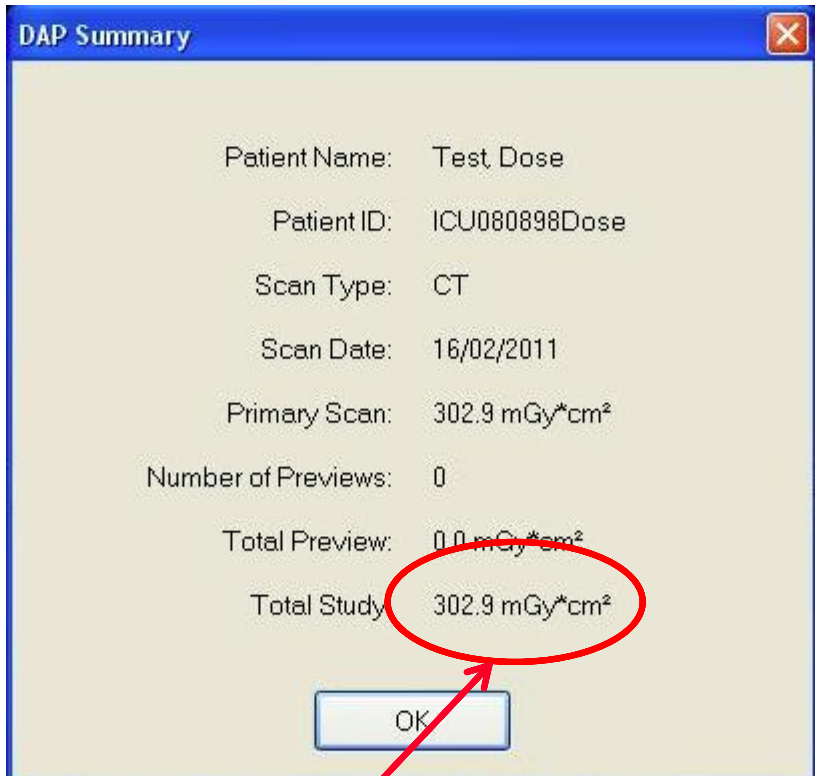
Dose Area Product (DAP) for Cone Beam CT Scanners

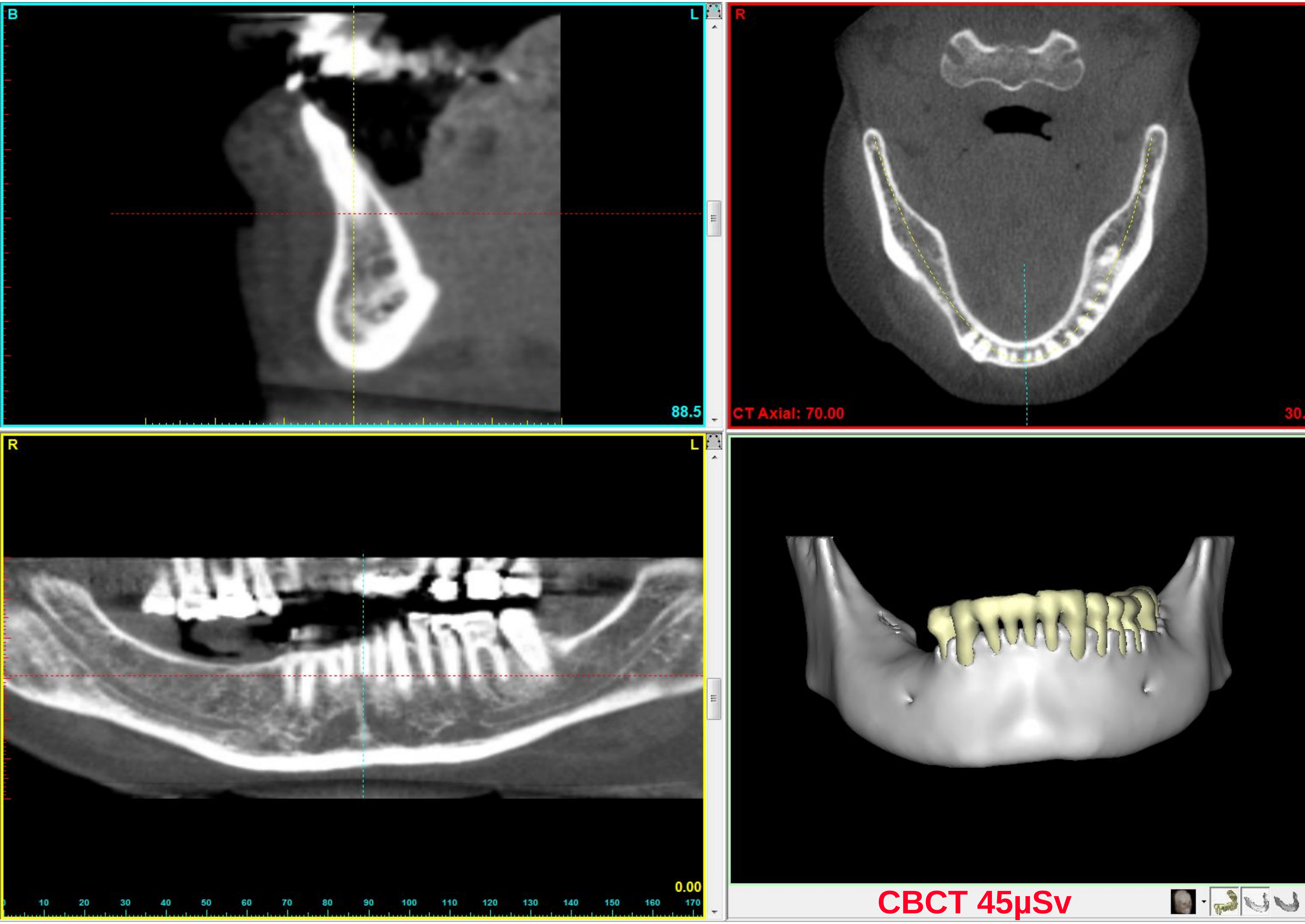


Multiply DAP by 0.1 for Maxilla or 0.15 for Mandible to get the Effective Dose in microSieverts (µSv)

Accuracy: ±50%

Mn 45µSv

ROUGHLY


B
L
88.5
R
CT Axial: 70.00
R
L
0.00
10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170
CBCT 45μSv

Effective dose range for dental cone beam computed tomography scanners

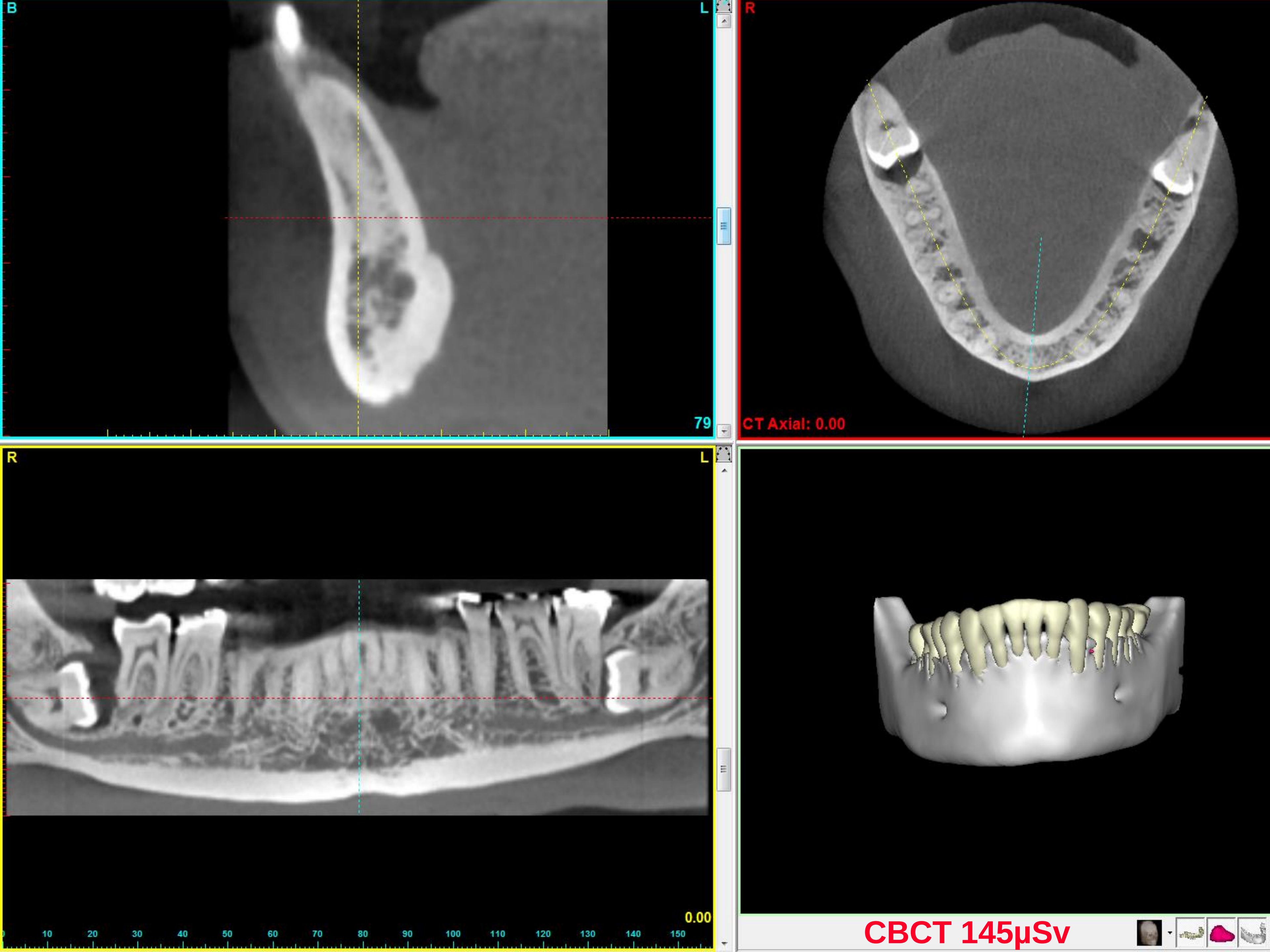
Ruben Pauwels[a,*], Jilke Beinsberger[a,1], Bruno Collaert[b,2], Chrysoula Theodorakou[c,d,3], Jessica Rogers[e,3], Anne Walker[c,3], Lesley Cockmartin[f,4], Hilde Bosmans[f,5], Reinhilde Jacobs[a,6], Ria Bogaerts[g,7], Keith Horner[d,8], The SEDENTEXCT Project Consortium[9]

Table 4

Absorbed organ dose and effective dose for medium FOV (dentoalveolar or single jaw) protocols.

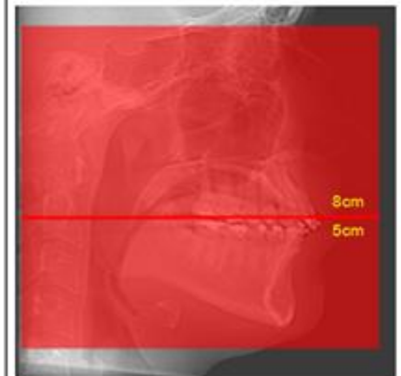
	3D Accuitomo 170	i-CAT N.G.	Kodak 9500	NewTom VGi	Picasso Trio	Picasso Trio	ProMax 3D	ProMax 3D	Scanora 3D	Scanora 3D	Scanora 3D	Veraviewepocs 3D
Protocol[a]	Upper jaw				High dose	Low dose	High dose	Low dose	Upper jaw	Lower jaw	Both jaws	
Red bone marrow	112	33	85	294	126	62	88	27	42	34	37	55
Thyroid	148	251	541	1293	551	583	1021	202	148	352	240	330
Skin	62	25	51	145	113	56	145	15	30	29	31	69
Bone surface	112	33	84	299	156	57	121	26	50	35	39	57
Salivary glands	2138	973	2166	6372	2982	1837	2576	596	1285	1052	1117	1956
Brain	189	46	91	431	134	39	53	28	45	25	31	40
Remainder	85	172	304	881	432	254	346	83	178	147	155	267
Effective dose	54	45	92	265	123	81	122	28	46	47	45	73

[a] If not specified, the positioning of the FOV is dentoalveolar (both jaws).



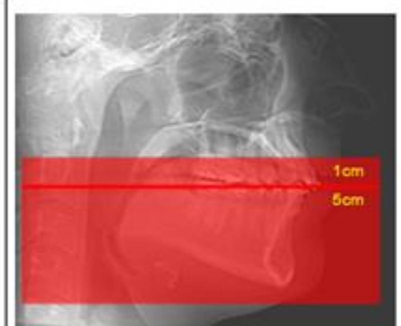
B
L
79
R
CT Axial: 0.00
R
L
0.00
10 20 30 40 50 60 70 80 90 100 110 120 130 140 150
CBCT 145μSv

Effect of Reducing Beam Height



Full face
13cm height x 16cm diameter
83 microSieverts *

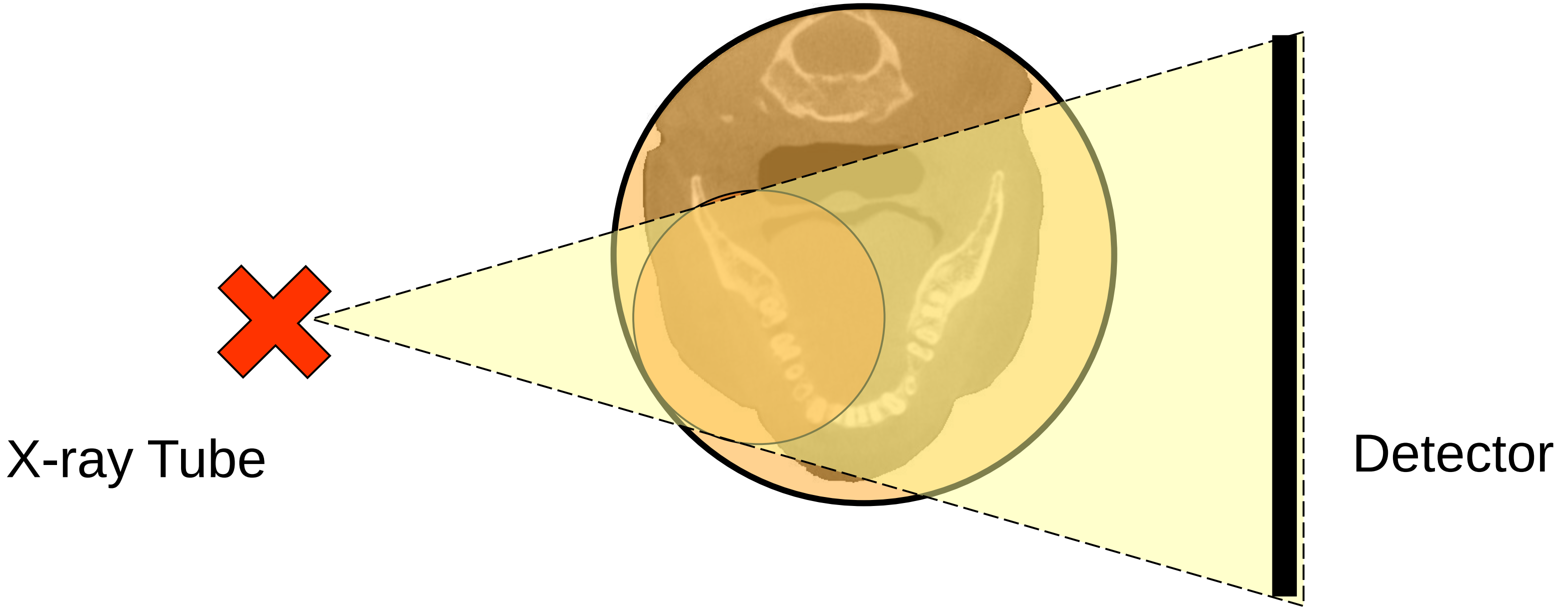
Both arches
8cm height x 16cm diameter
56 microSieverts (interpolated)



Mandible
6cm height x 16cm diameter
45 microSieverts *

*** From: Pauwels et al, Effective dose range for dental CBCT scanners, Euro J Radiol 81, 2, 267-271, Feb 2012.**

Effect of Reducing Beam Width



- **Reducing the beam height by 50% reduces the dose by approximately 50%**
- **Reducing the beam width by 50% reduces the dose by only about 25%**

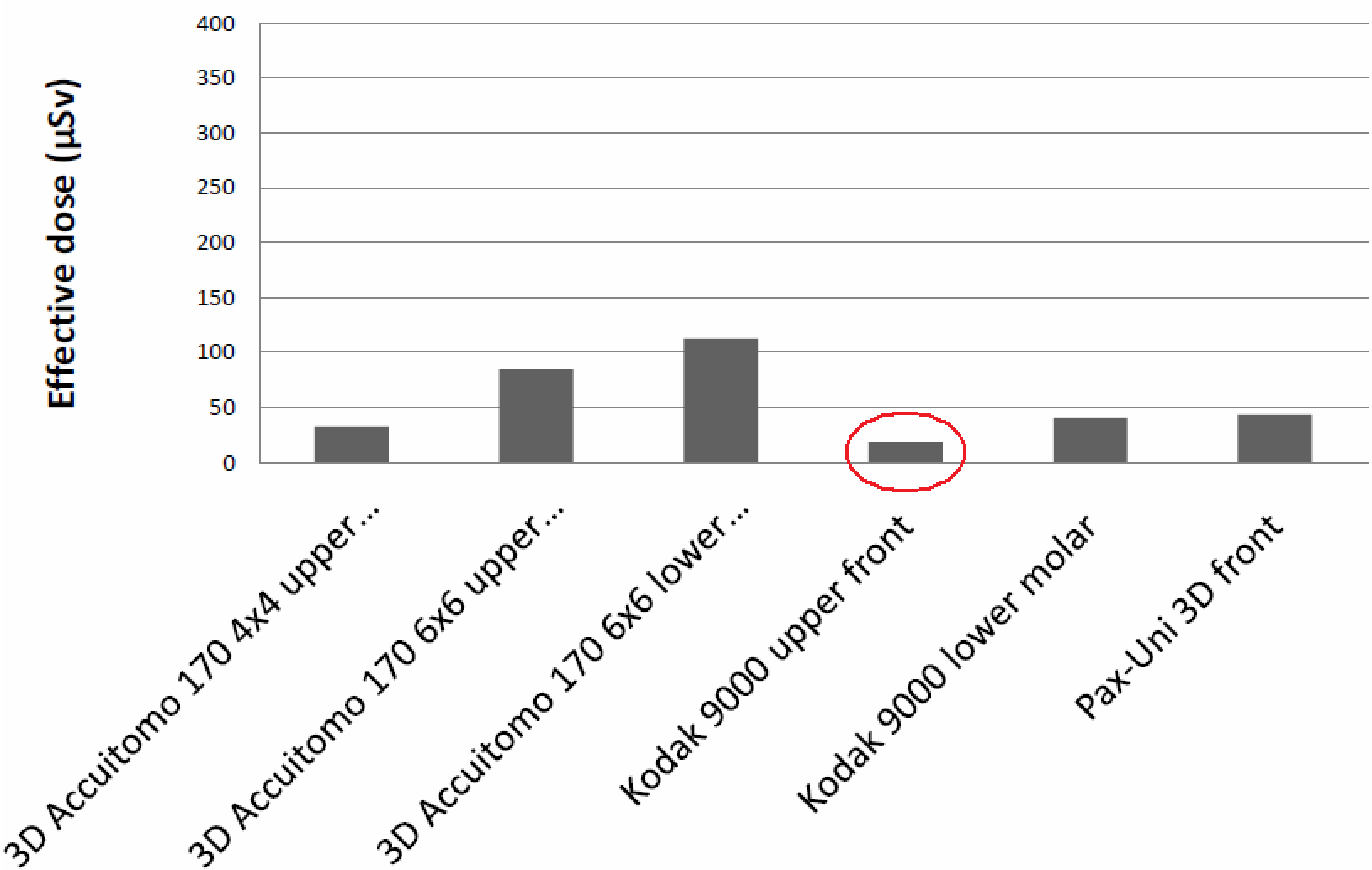
*Typical Doses from Dental X-Rays**

Intraoral (F speed, rectangular collimator)	2 µSv
Intraoral (E speed, round collimator)	6 µSv
Lateral Ceph	4 µSv
Panoramic	24 µSv†
Cone Beam CT Scanner	48 - 1073 µSv†
Medical CT Scanner	534 - 2100 µSv†

***ICRP103 weighting factors**

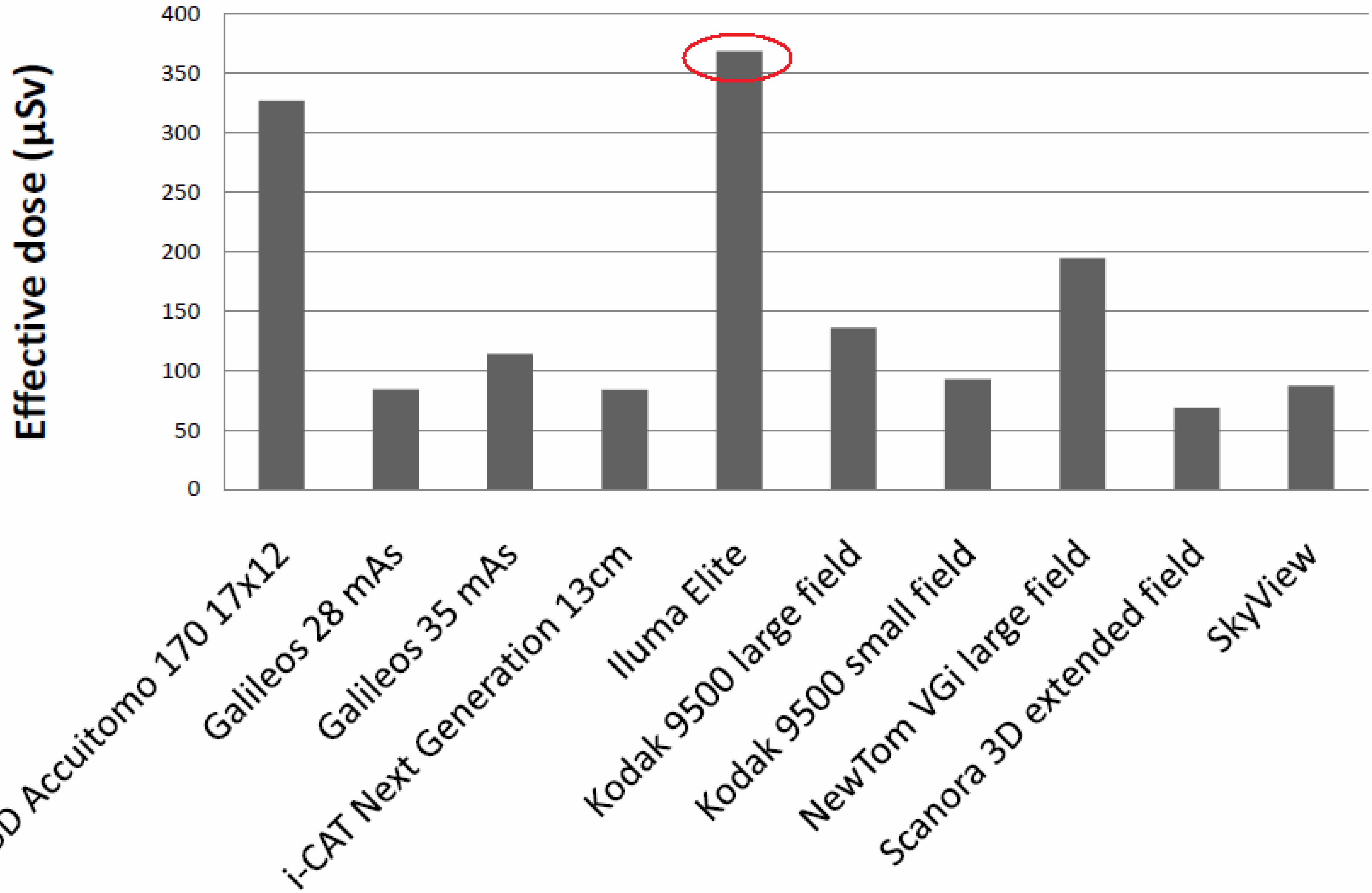
†Holroyd JR, Gulson AD, Guidance on the Safe Use of Dental Cone Beam CT (Computed Tomography) Equipment, HPA-CRCE-010, November 2010

Effective dose for small field CBCTs



Prof. Ria Bogaerts, Katholieke Universiteit Leuven, March 2011

Effective dose for large field CBCTs



Prof. Ria Bogaerts, Katholieke Universiteit Leuven, March 2011

*Typical Doses from Dental X-Rays**

Intraoral **(F speed, rectangular collimator)**	**2 µSv**
Intraoral **(E speed, round collimator)**	**6 µSv**
Lateral Ceph	**10 µSv**
Panoramic	**24 µSv†**
Cone Beam CT Scanner	20 ~~**48**~~ **-** ~~**1073**~~ **µSv†** 400
Medical CT Scanner	**534 - 2100 µSv†**

****ICRP103 weighting factors***

†Holroyd JR, Gulson AD, Guidance on the Safe Use of Dental Cone Beam CT (Computed Tomography) Equipment, HPA-CRCE-010, November 2010

*Typical Doses from Dental X-Rays**

Intraoral **(F speed, rectangular collimator)**	**2 μSv**
Intraoral **(E speed, round collimator)**	**6 μSv**
Lateral Ceph	**10 μSv**
Panoramic	**24 μSv**†
Cone Beam CT Scanner	~~**48 - 1073 μSv**~~† 20 400
Medical CT Scanner **(dental protocol)**	~~**534 - 2100 μSv**~~† 100 1000

**ICRP103 weighting factors*

†Holroyd JR, Gulson AD, Guidance on the Safe Use of Dental Cone Beam CT (Computed Tomography) Equipment, HPA-CRCE-010, November 2010

What is the Risk from an Intraoral x-ray?

- **Assume adult patient,* F speed, rectangular collimation**
- **Effective Dose might be 2 microSieverts approx.**
- **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"

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

What is the Risk from a CBCT scan (worst case)?

- **Assume adult patient***
- **Effective Dose might be 1073 microSieverts = 1.073 mSv**
- **Risk that patient might develop fatal cancer in 20 years time**

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

= 1 in 20 thousand for 1 mSv

= 1.073 in 20 thousand for 1.073 mSv

= 1 in 18,639 for 1.073 mSv

Health & Safety people would call this a "Very Low Risk"

*** If your patient is elderly the risk is 3x less**

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

The Risk from an Intraoral x-ray

Lightning: the risk is negligible

The Risk from a CBCT scan (worst case)

The risk of death from playing soccer is very low (this player survived)

Typical Doses from Dental X-Rays

	Effective Dose (μSv)	Risk	
Intraoral (F speed, rect coll)	2	1 in 10 million	Negligible
Intraoral (E speed, round coll)	6		
Lateral Ceph	10		
Panoramic	24		
Cone Beam CT	48 to 1073	1 in 19 thousand	Very Low
Medical CT	534 to 2100		

Typical Doses from Dental X-Rays

	Effective Dose (µSv)	Risk	
Intraoral (F speed, rect coll)	2	1 in 10 million	Negligible
Intraoral (E speed, round coll)	6	1 in 3.3 million	Negligible
Lateral Ceph	10	1 in 2 million	Negligible
Panoramic	24	1 in 833 thousand	Minimal
Cone Beam CT	48 to 1073	1 in 417 thousand to 1 in 19 thousand	Mimimal to Very Low
Medical CT	534 to 2100	1 in 37 thousand to 1 in 9.5 thousand	Very Low to Low

Implant Surgery Complications: Etiology and Treatment

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

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

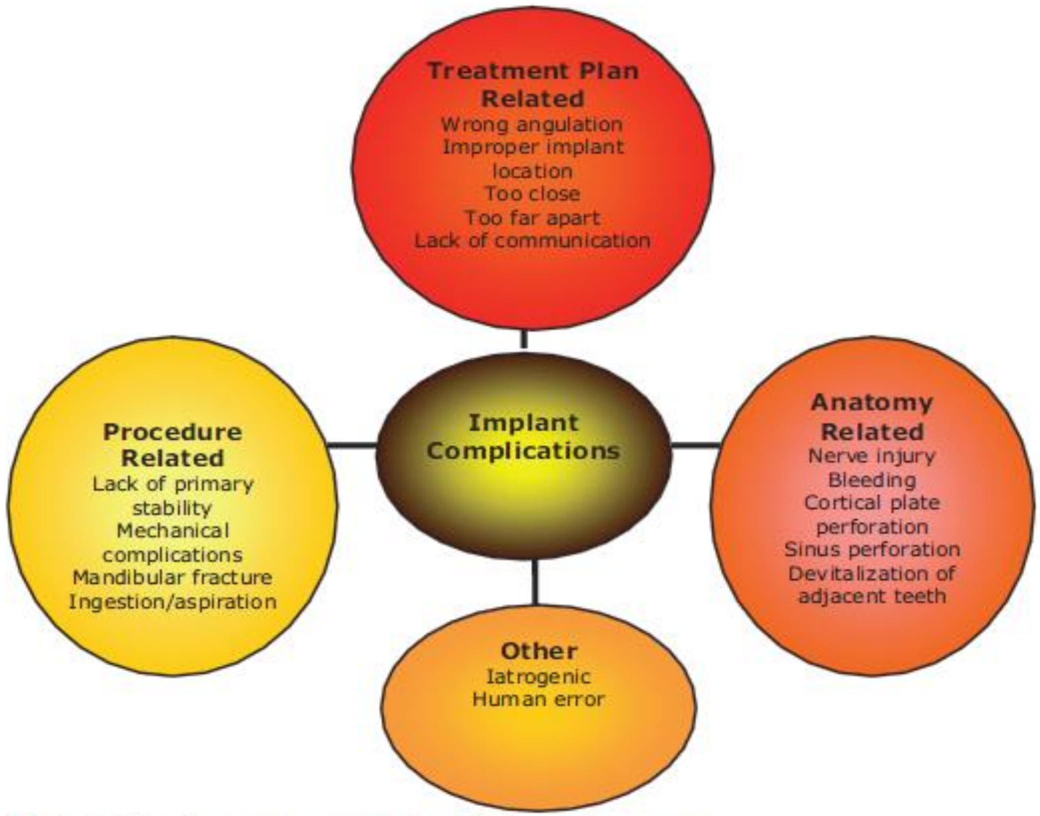


Fig. 1. Outline of common complications during implant surgery.

Clinical complications with implants and implant prostheses

Charles J. Goodacre, DDS, MSD,[a] Guillermo Bernal, DDS, MSD,[b] Kitichai Rungcharassaeng, DDS, MS,[c] and Joseph Y. K. Kan, DDS, MS[d]
School of Dentistry, Loma Linda University, Loma Linda, Calif (J Prosthet Dent 2003;90:121-32.)

	Number of patients affected	Risk	
Hemorrhage-related complications	**92 out of 379**	**1 in 4**	**High**
Neurosensory disturbance	**151 out of 2142**	**1 in 14**	**High**
Mandibular fracture	**4 out of 1523**	**1 in 380**	**Moderate**

Outline of Presentation

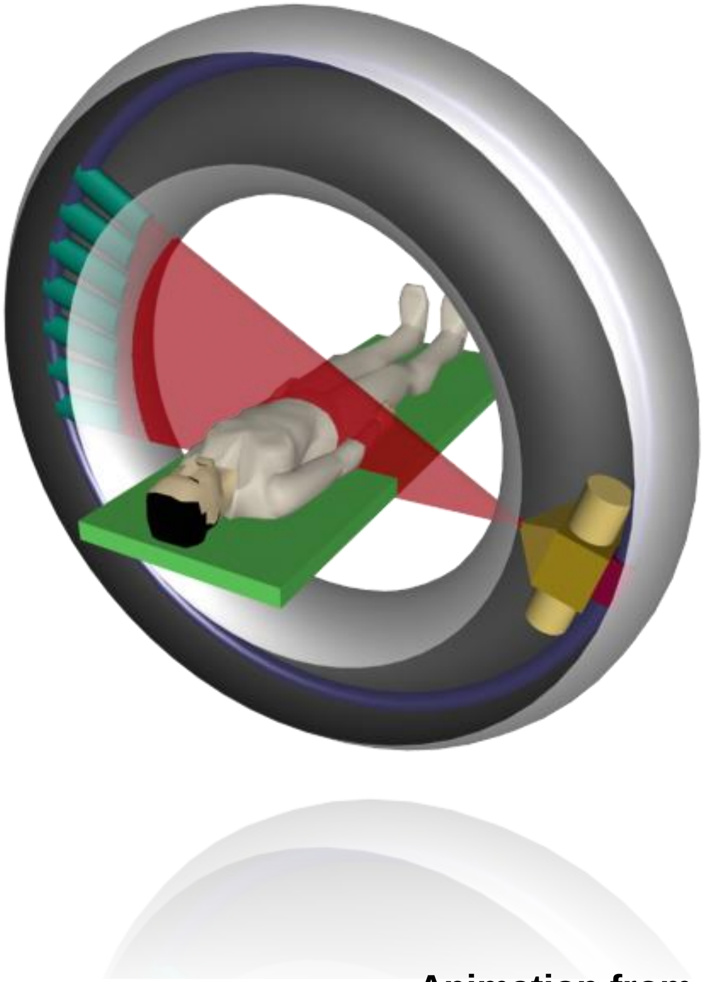
- ✔ Introduction / Disclosures
- ✔ Risk from Low Radiation Doses
- ✔ What do we mean by Effective Dose?
- ✔ How to evaluate Risks?
- How does CT work?
- How does Dose affect Image Quality?
- What other factors affect Image Quality?

how CT works...

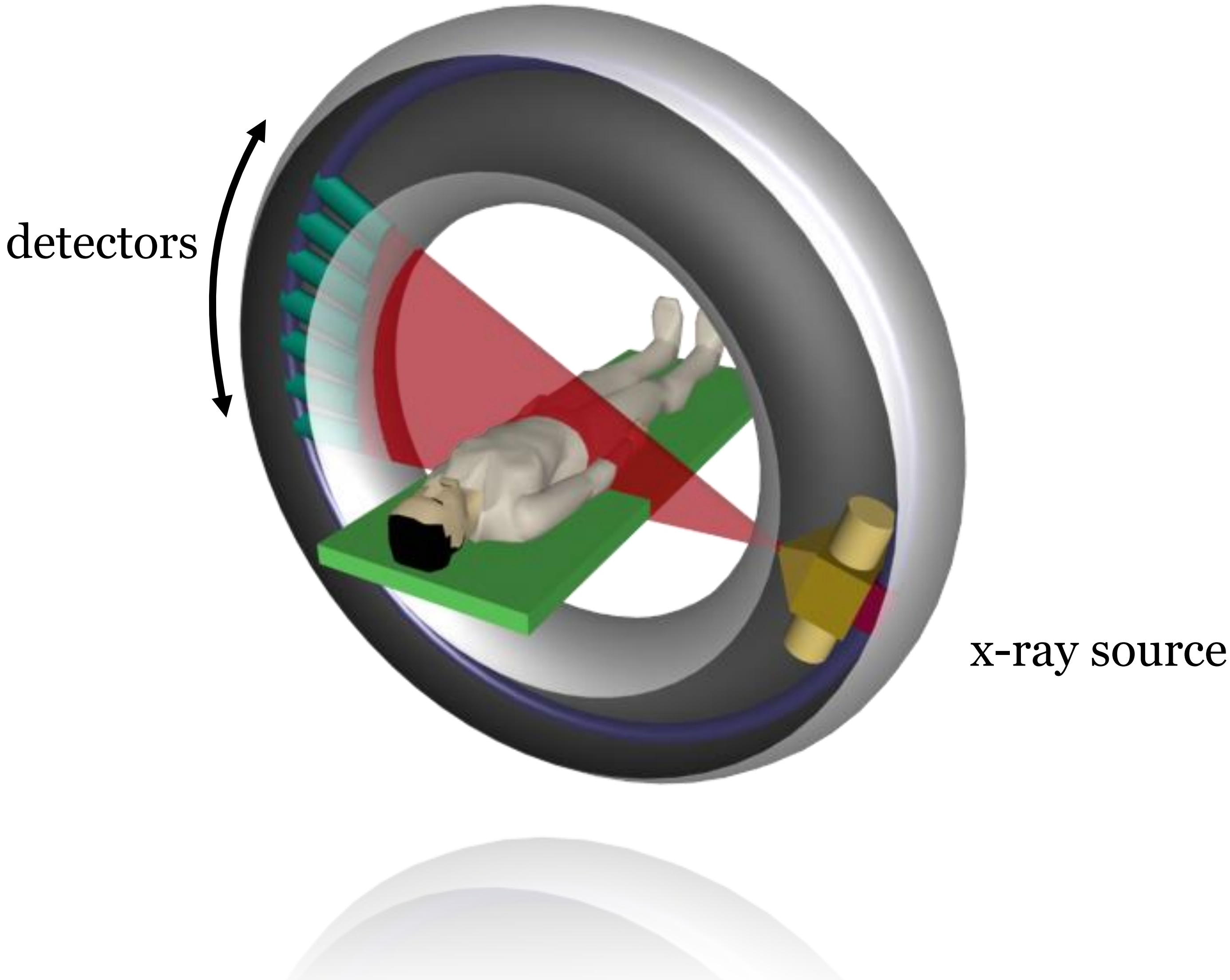
Godfrey Hounsfield

Allan Cormack

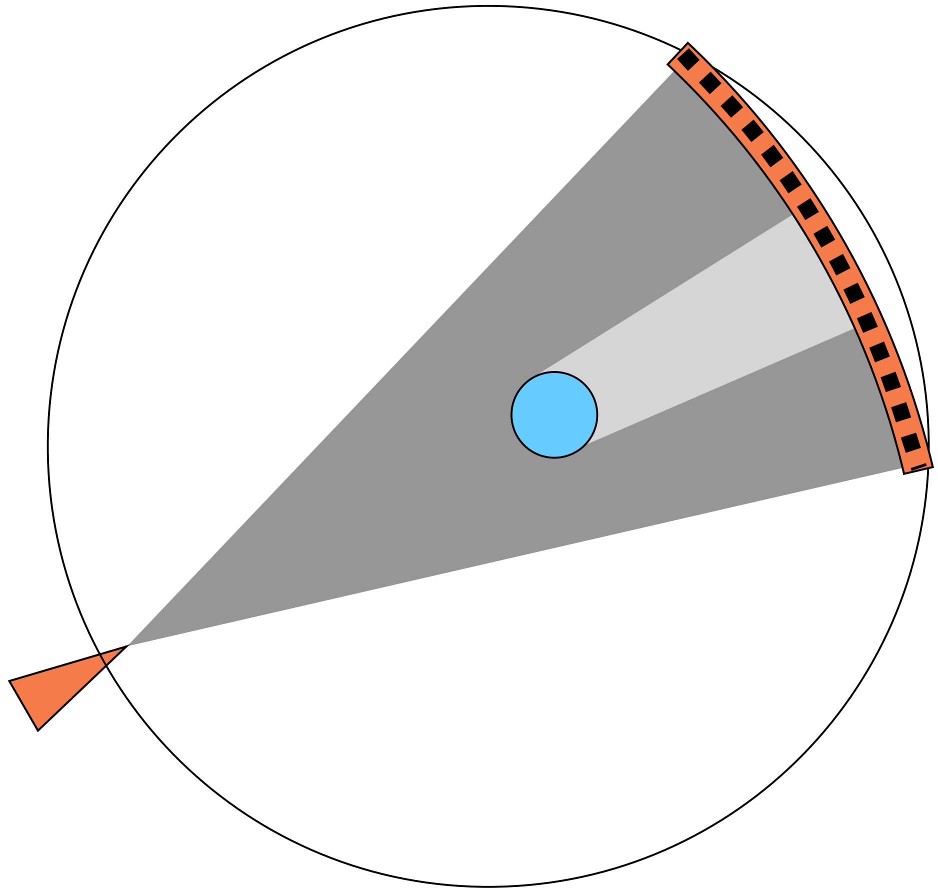
Nobel prize in Medicine, 1979



Animation from
Demetrios J. Halazonetis
www.dhal.com

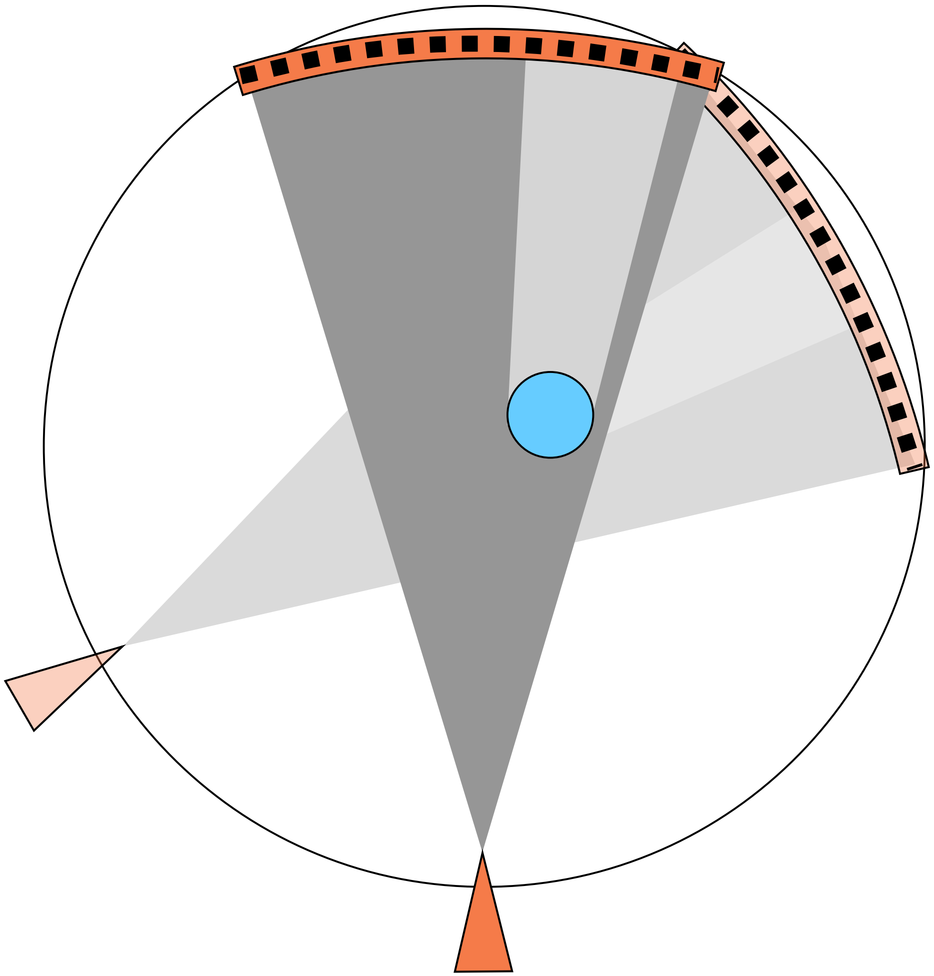

detectors
x-ray source

acquisition



Animation from
Demetrios J. Halazonetis
www.dhal.com

acquisition



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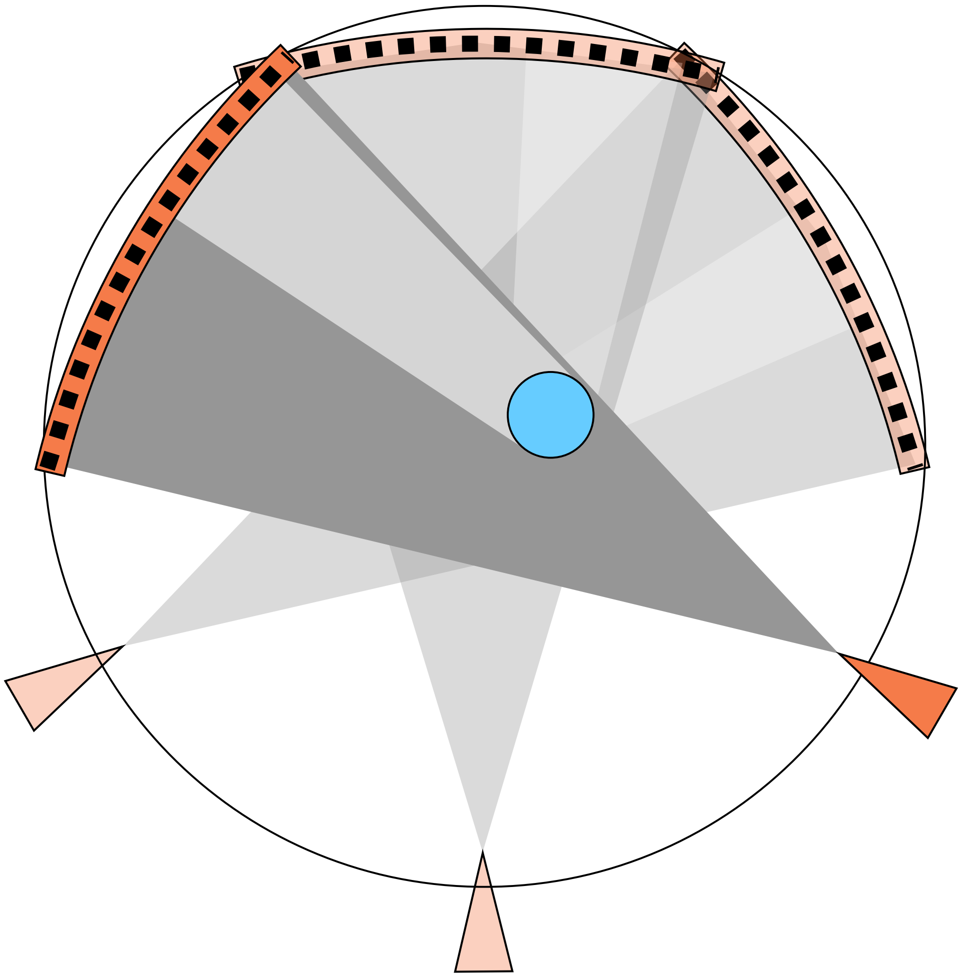

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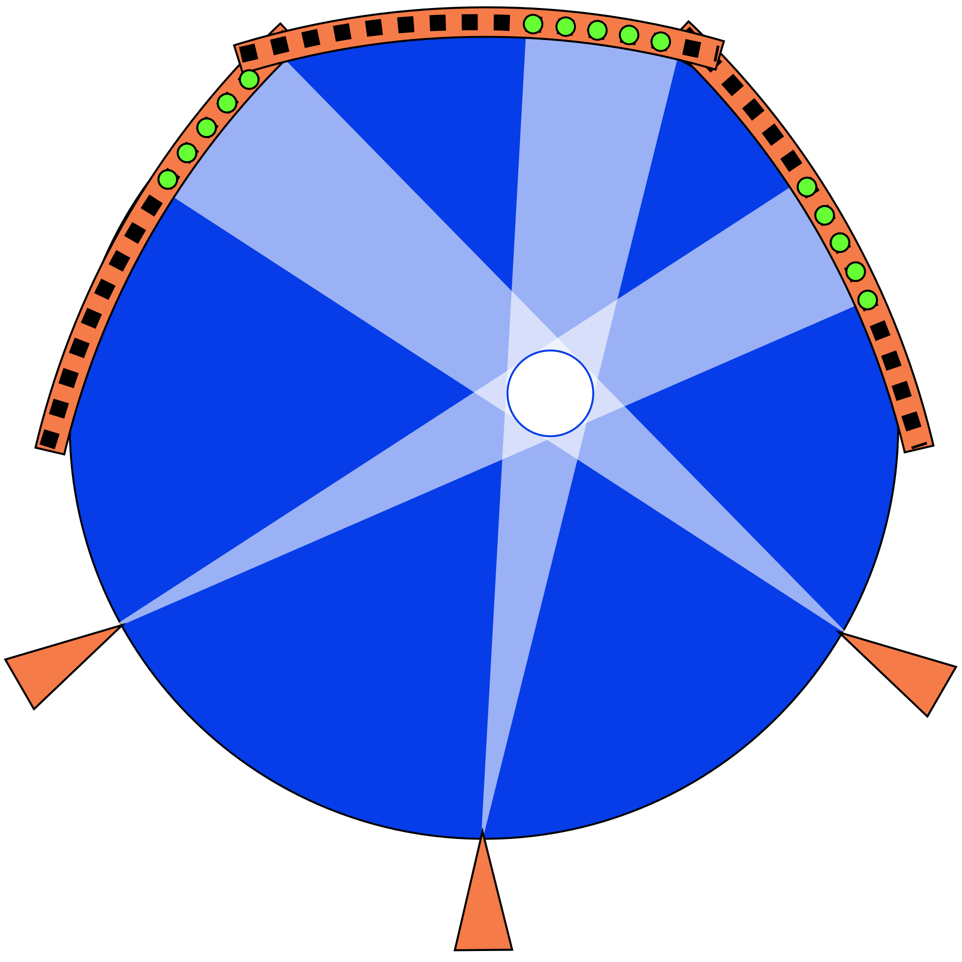
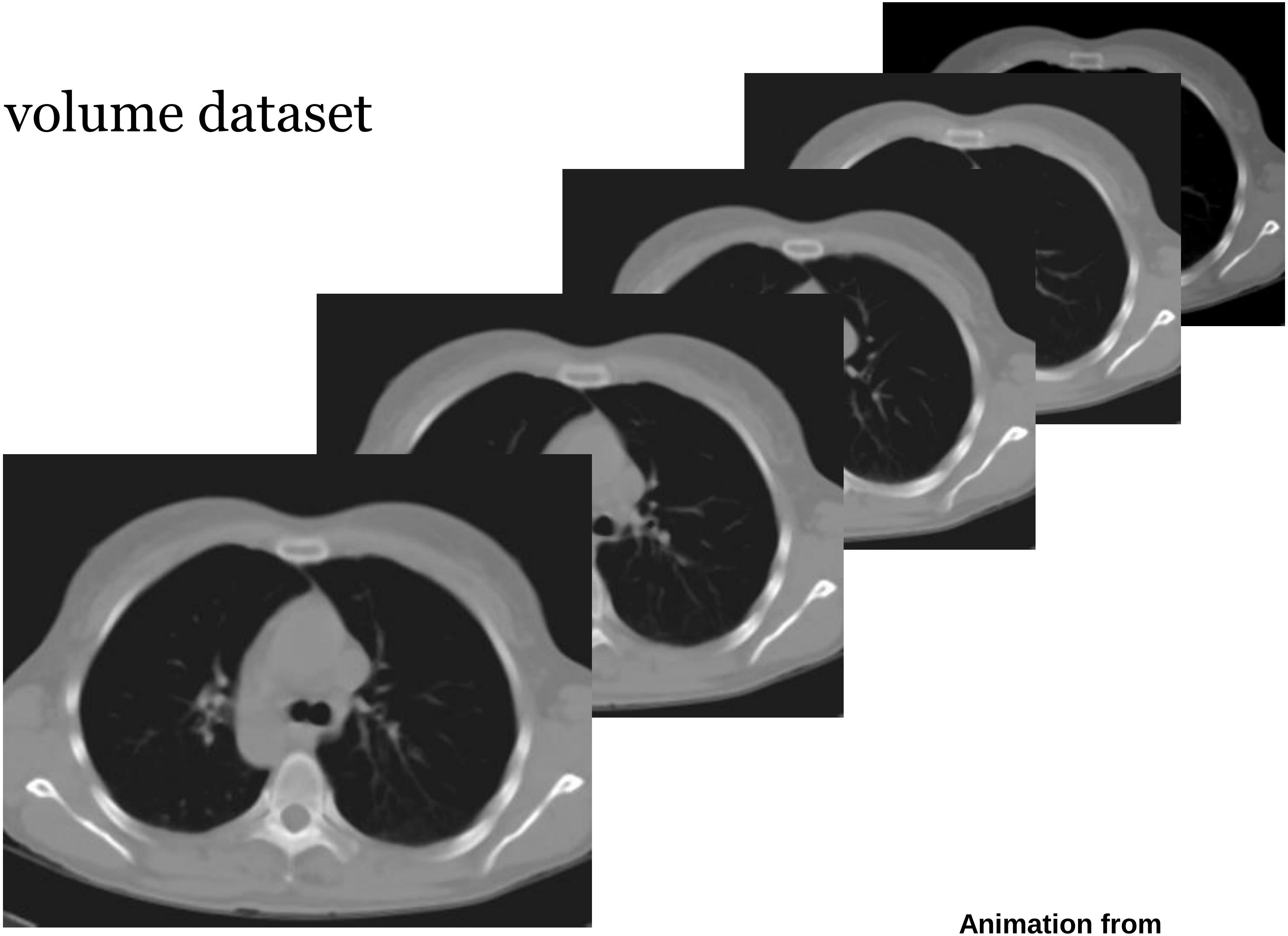
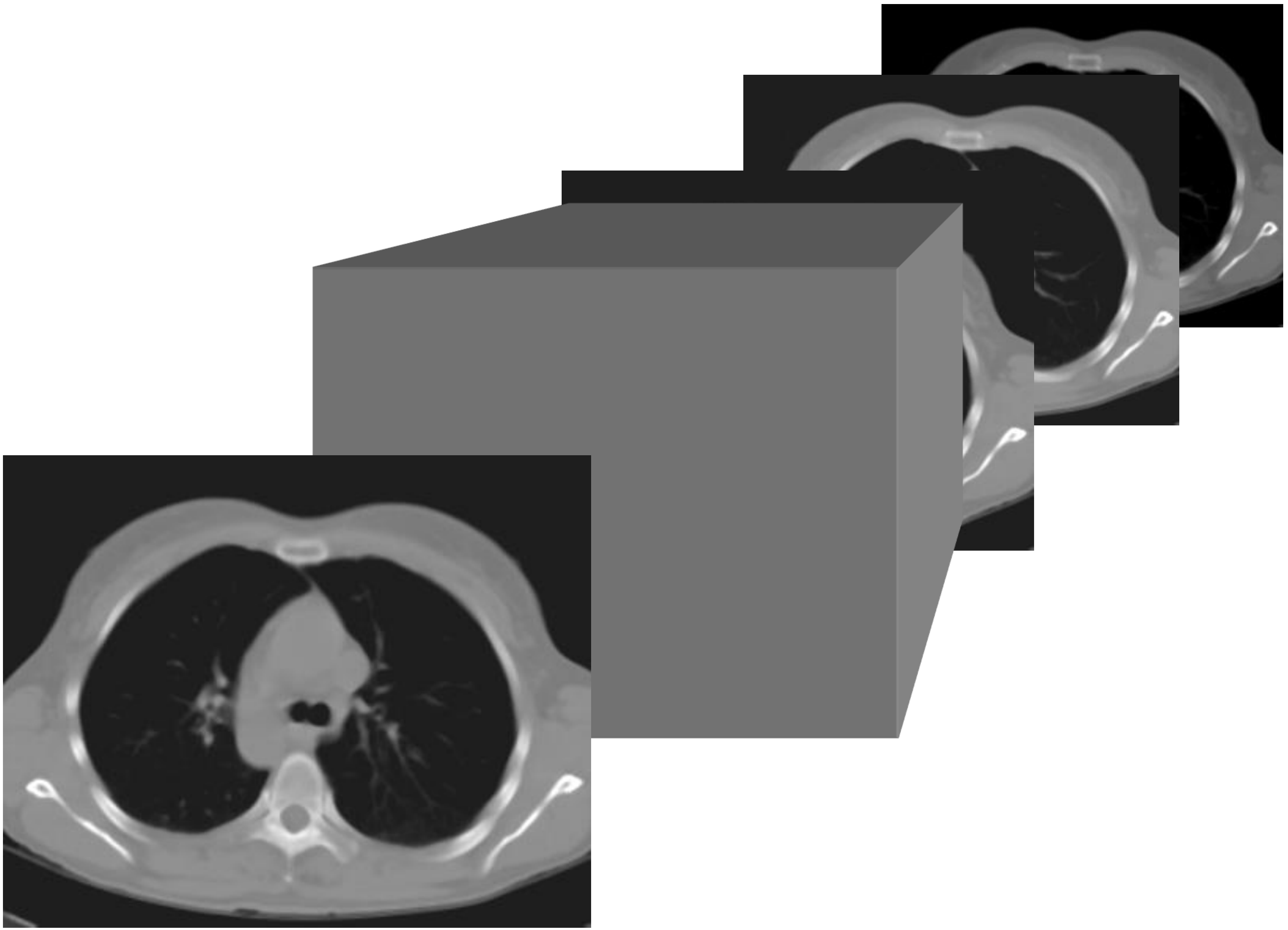
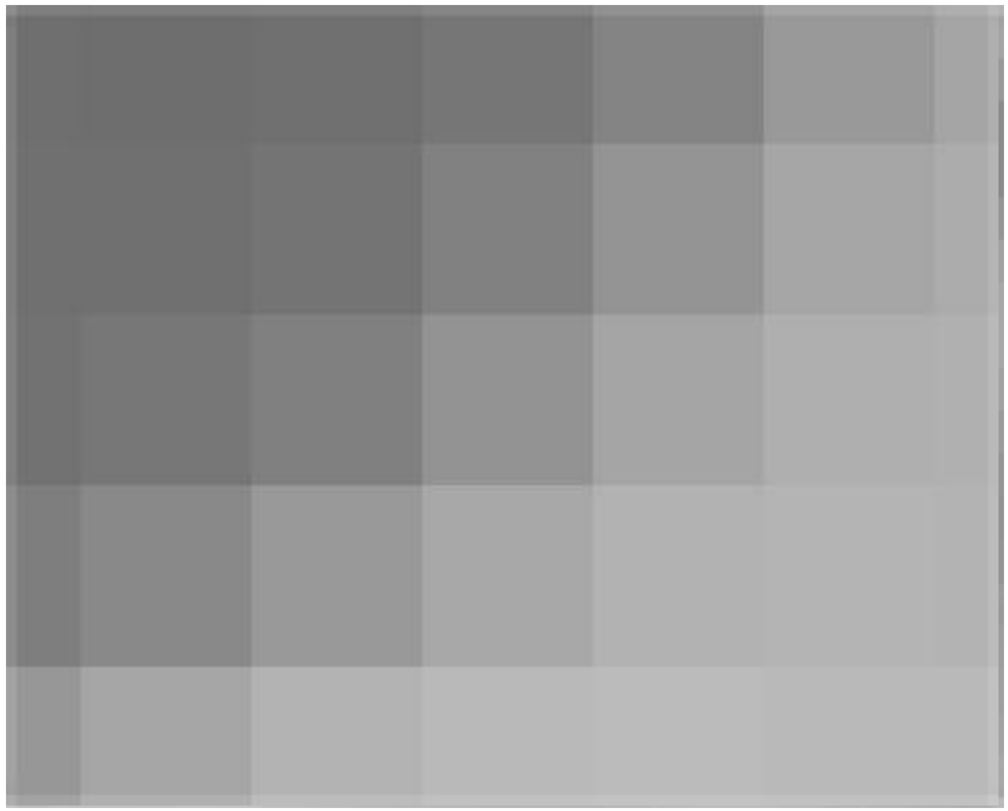


volume dataset



Animation from
Demetrios J. Halazonetis
www.dhal.com





Animation from
Demetrios J. Halazonetis
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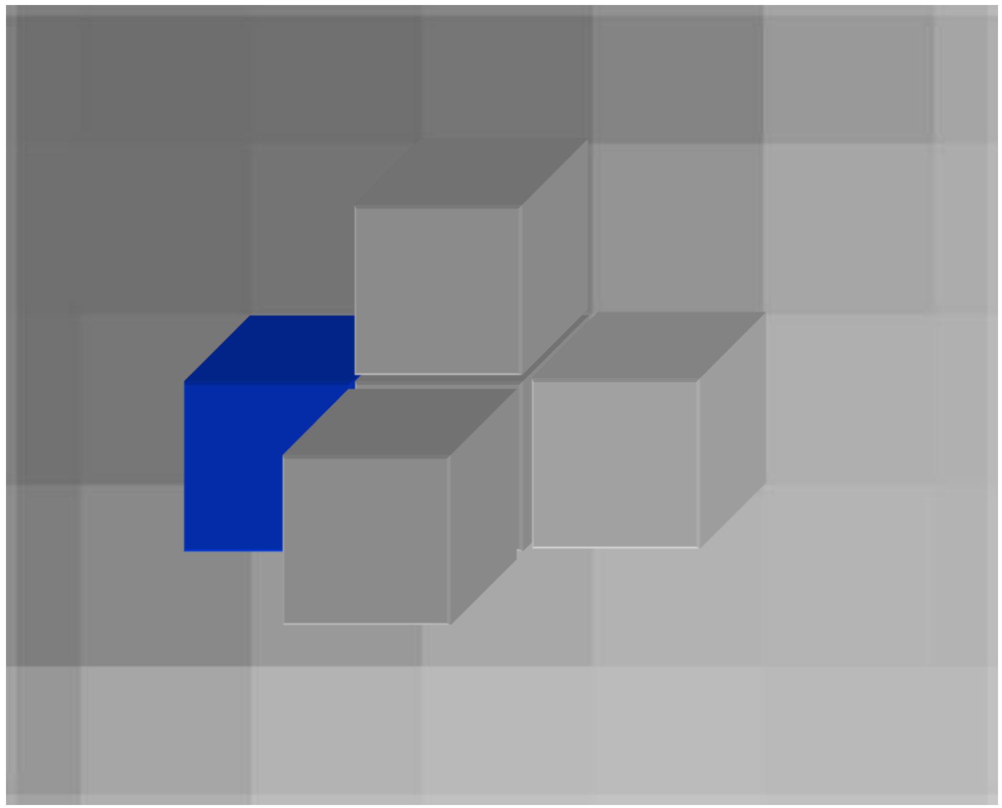
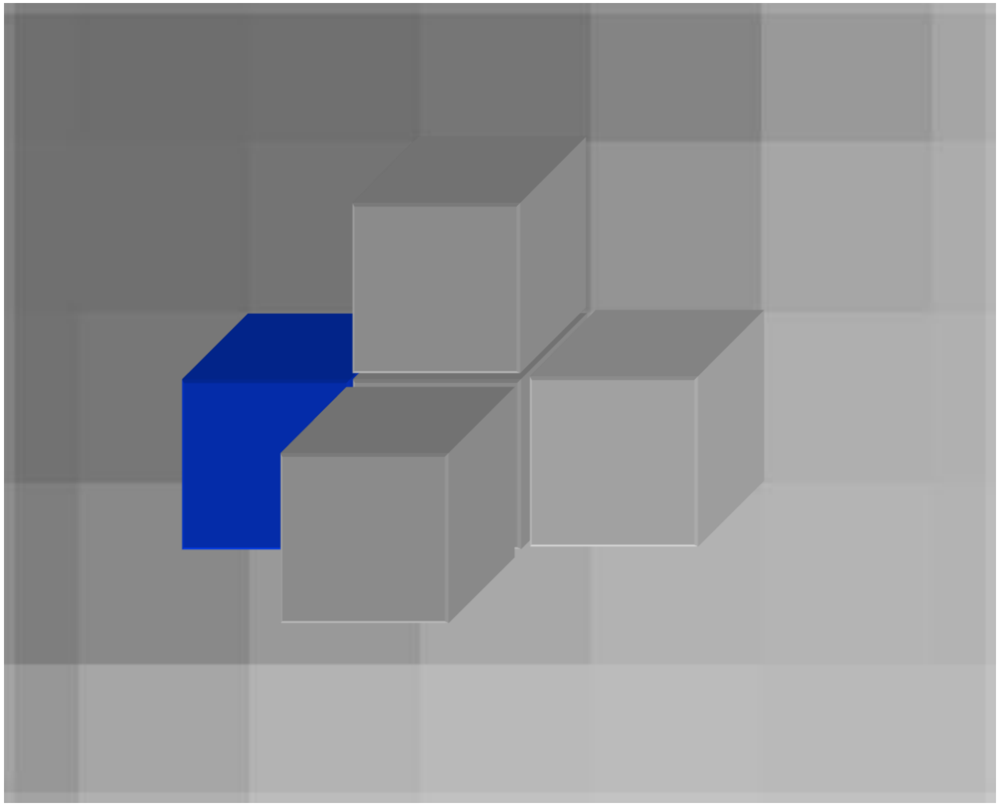
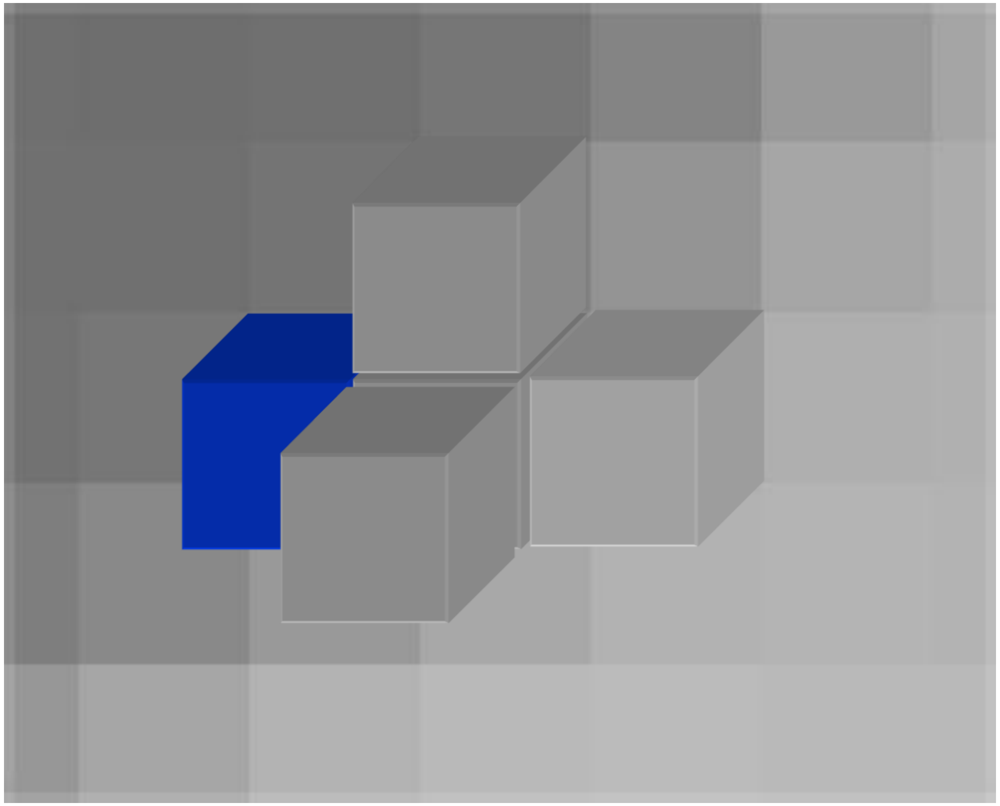


Voxels (**Vo**lume **el**ements)



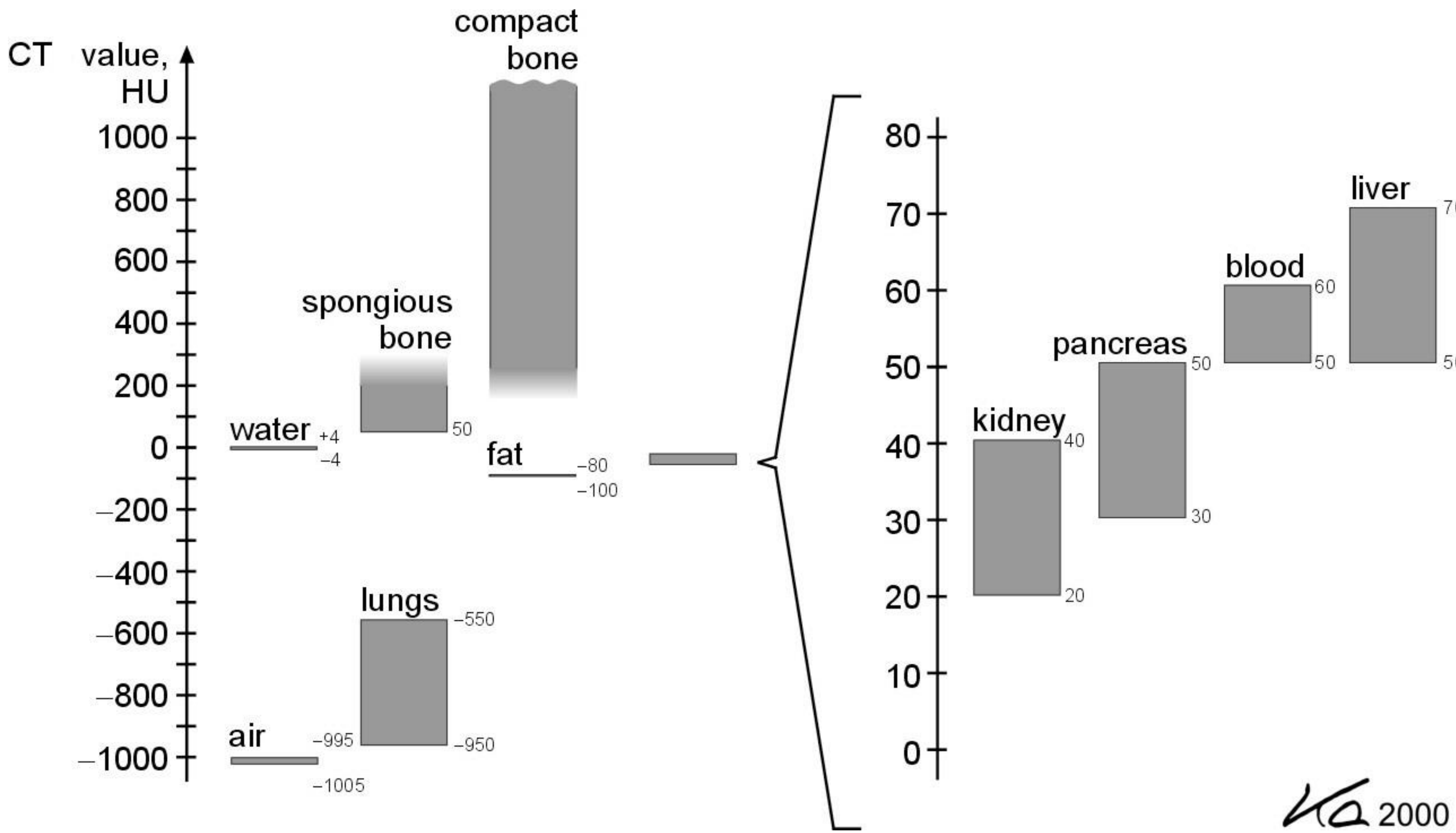
Voxels (**Vo**lume **el**ements)



density:
0 to 4095

(-1000 to 3095
Hounsfield Units)

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



The Hounsfield Scale was devised for medical CT scanners - 120kVp and Large Field Of View

From: Kalender WA. *Computed Tomography.* Munich: Publicis MCD Verlag, ISBN 3-89578-081-2, 2000.

Why is Density Important?

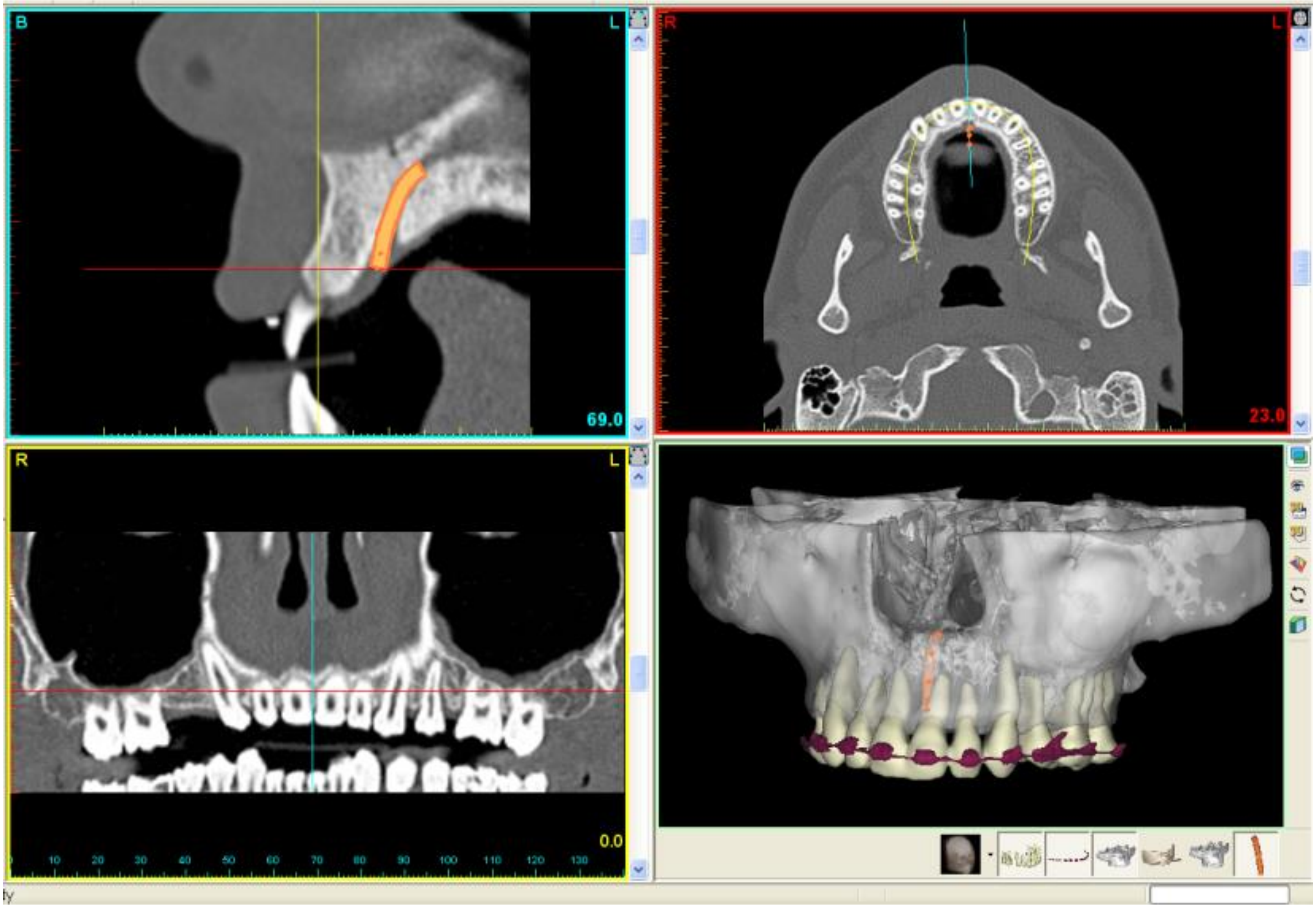
- **Segmentation – making physical models or drill guides**
- **Virtual 3D models e.g. in SimPlant**
- **Clinical application of bone densities e.g. Carl Misch scale**

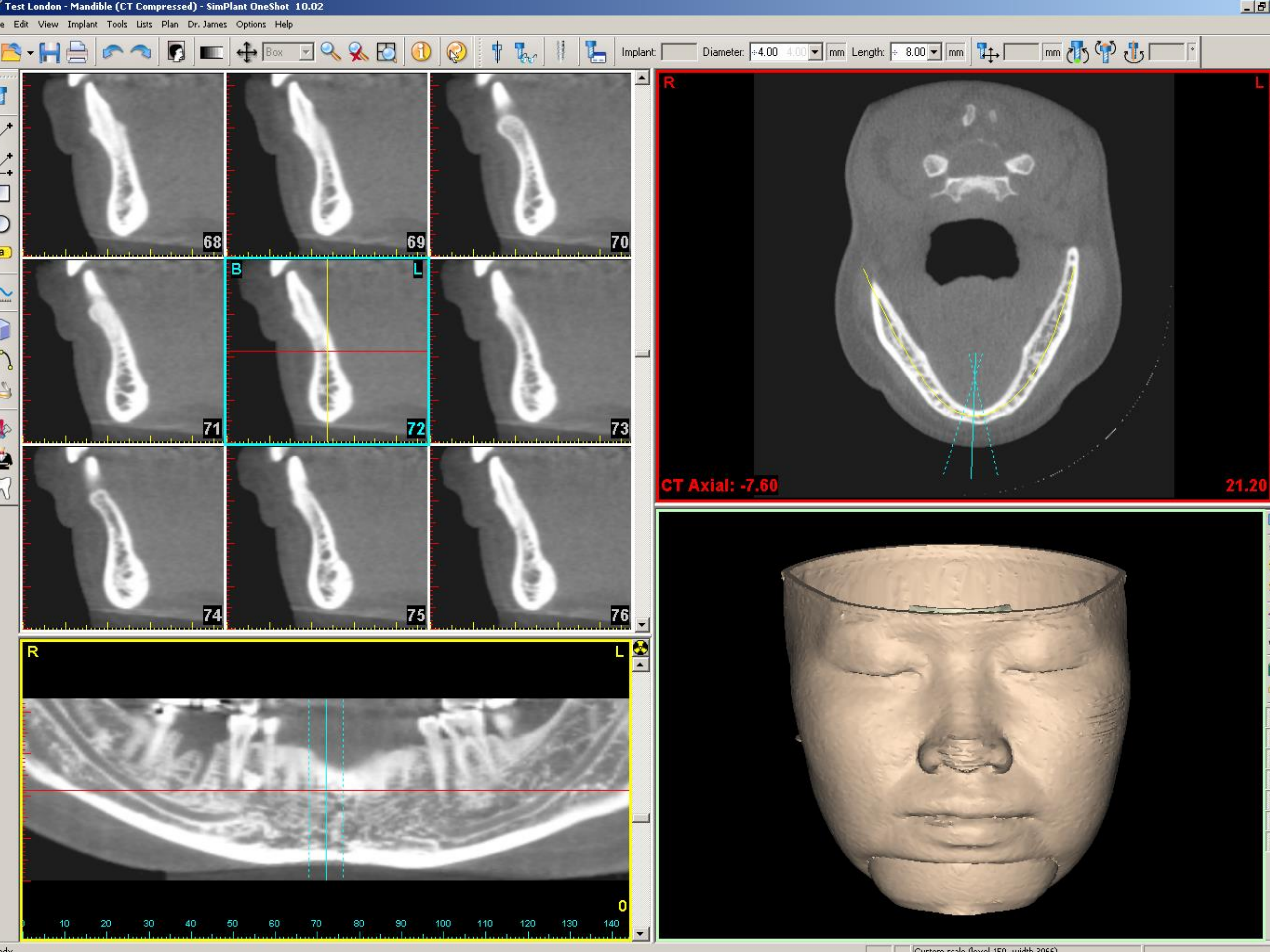
Table 1. Misch classification of bone density

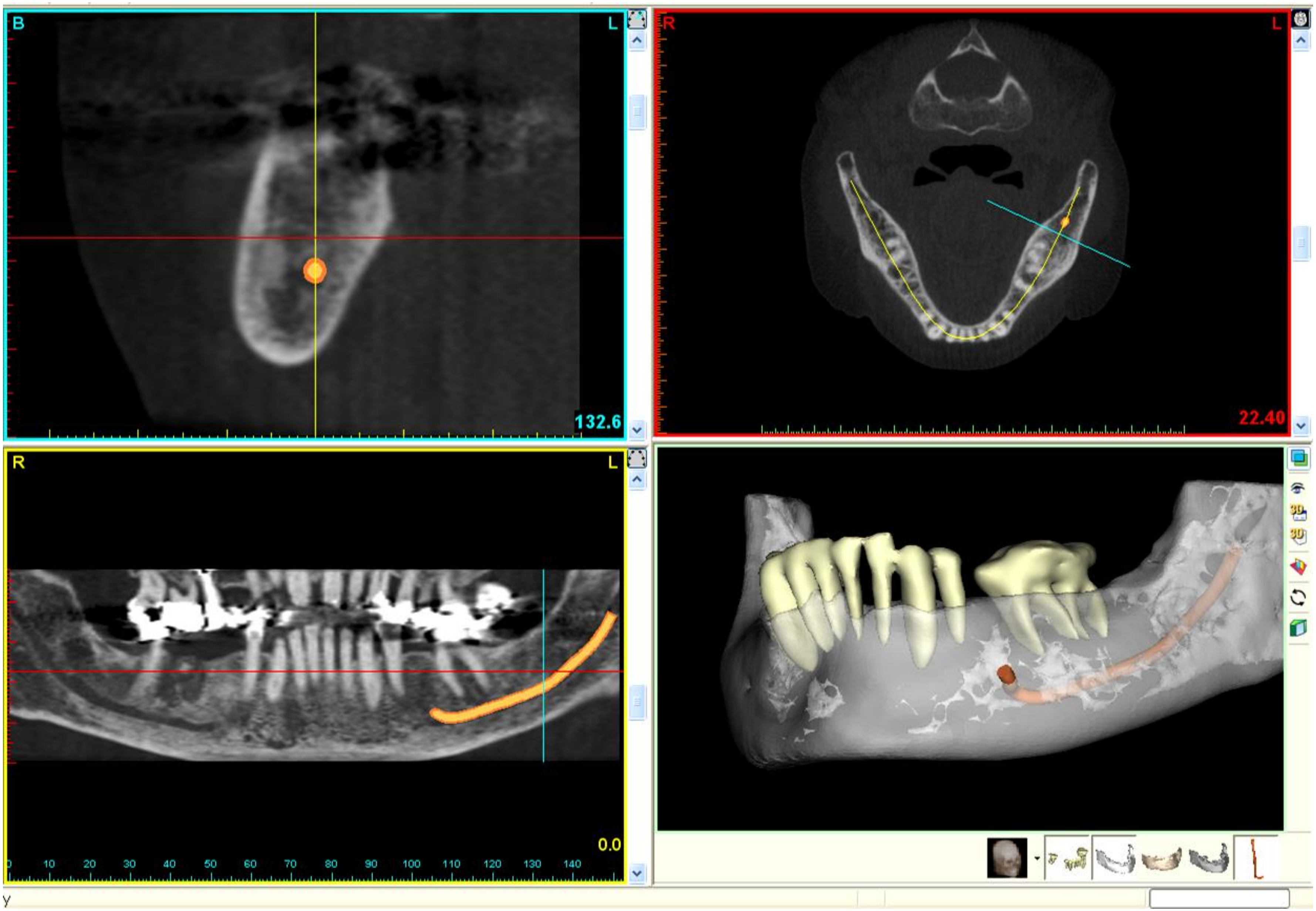
Density	Hounsfield range	Type of bone
D1	> 1250	Dense cortical bone
D2	851–1250	Thick dense to porous cortical bone on crest and coarse trabecular bone within
D3	351–850	Thin porous cortical bone on crest and fine trabecular bone within
D4	150–350	Fine trabecular bone

Adapted from: Misch C. *Contemporary Implant Dentistry.* 2rd edn. Mosby, St Louis, 1999

Segmentation




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
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


B
L
132.6
R
L
22.40
R
L
0.0
10
20
30
40
50
60
70
80
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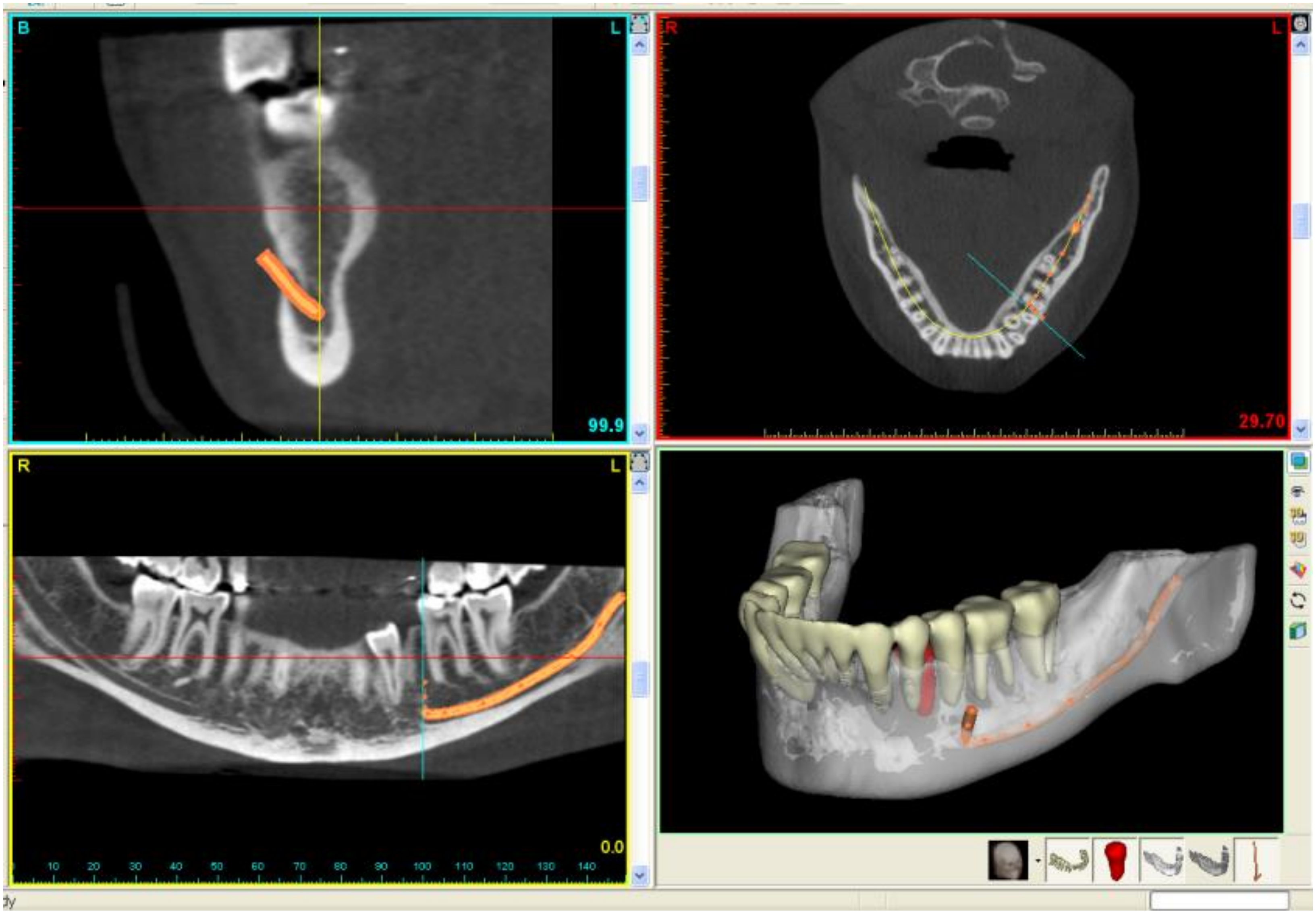
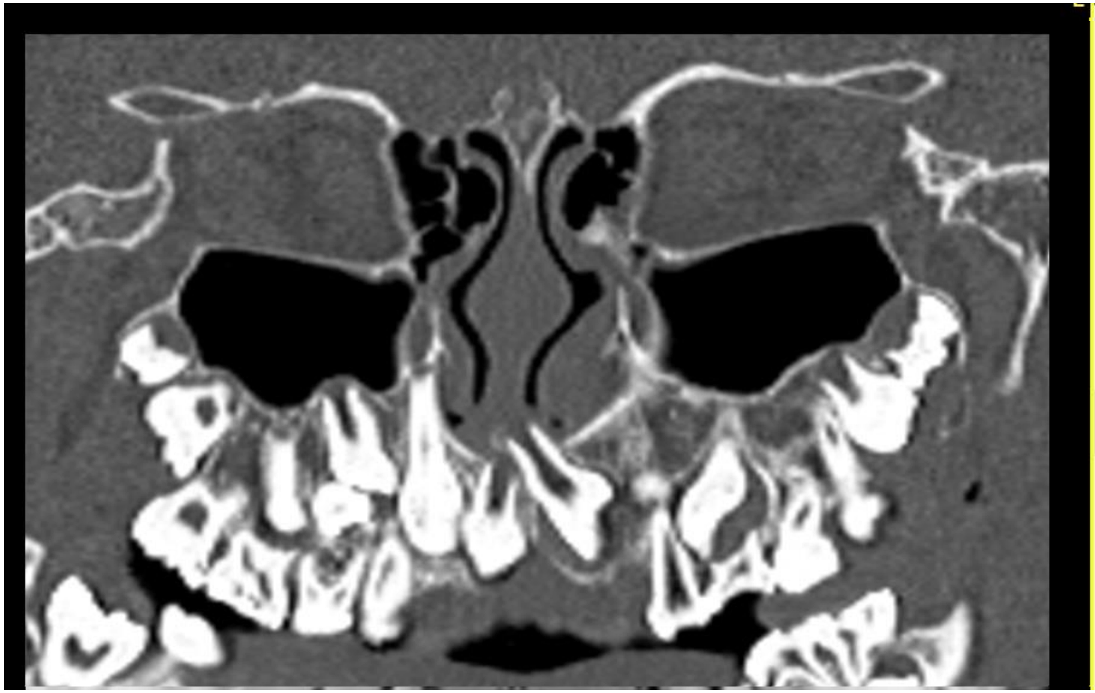
100
110
120
130
140

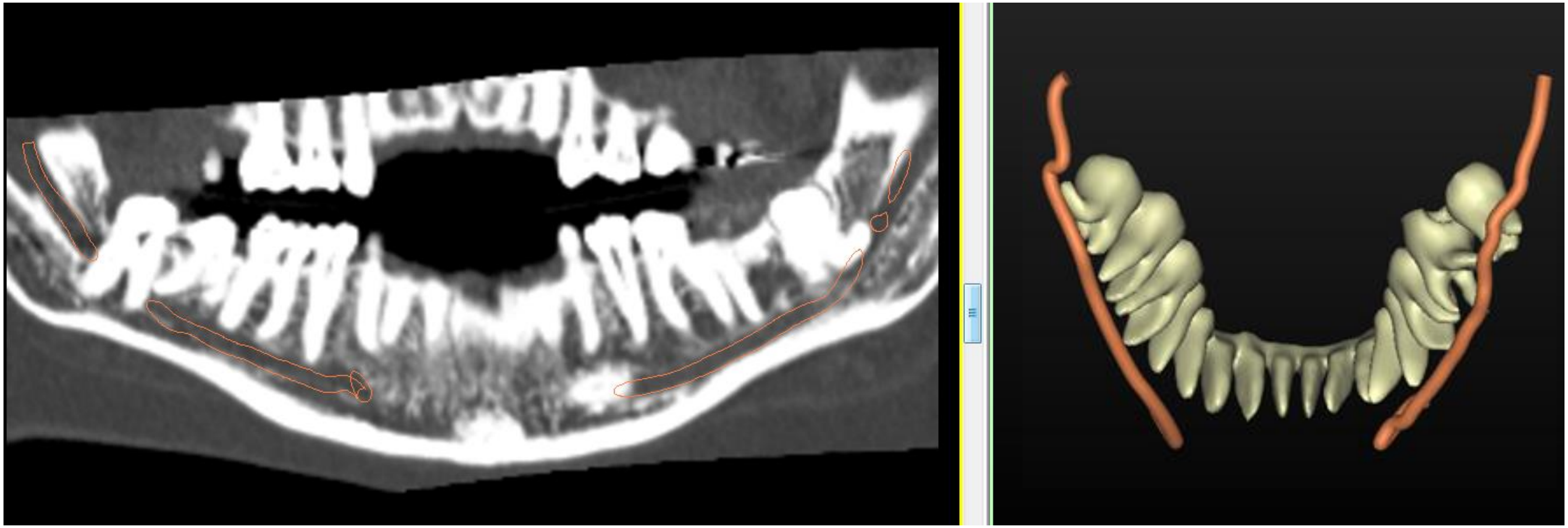

B
L
99.9
R
L
29.70
R
L
0.0
10 20 30 40 50 60 70 80 90 100 110 120 130 140

Hyperdontia

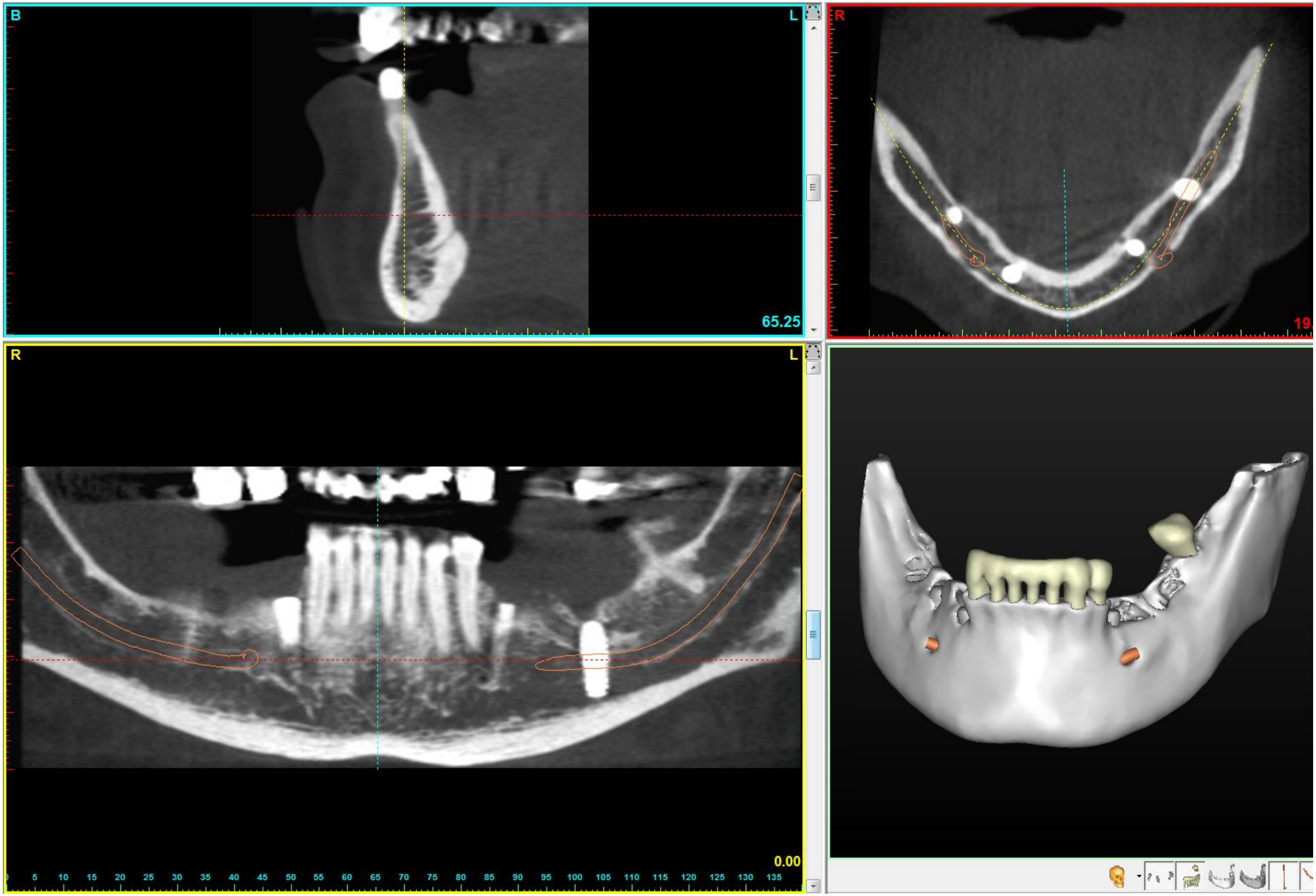


Courtesy of Nicolette Schroeder

Third Molars



Courtesy of Barry Dace



B
L
65.25
R
19
R
L
0.00
0
5
10
15
20
25
30
35
40
45
50
55
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65
70
75
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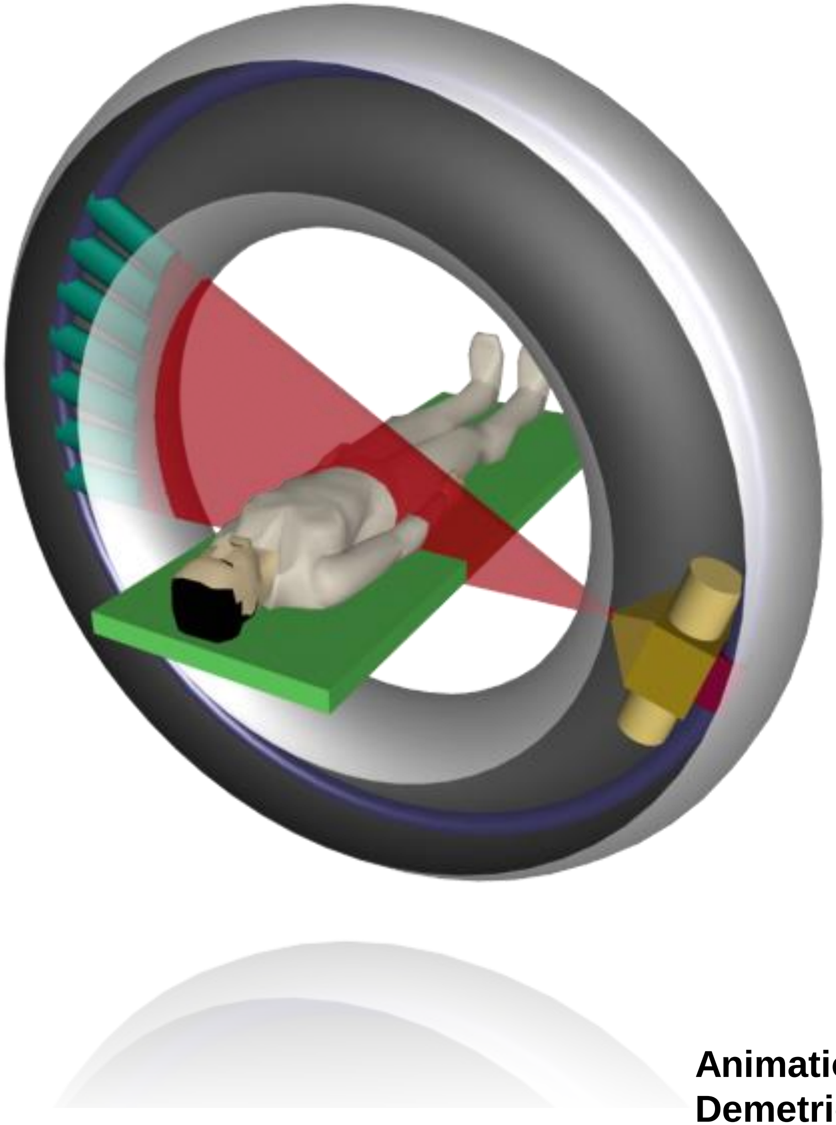
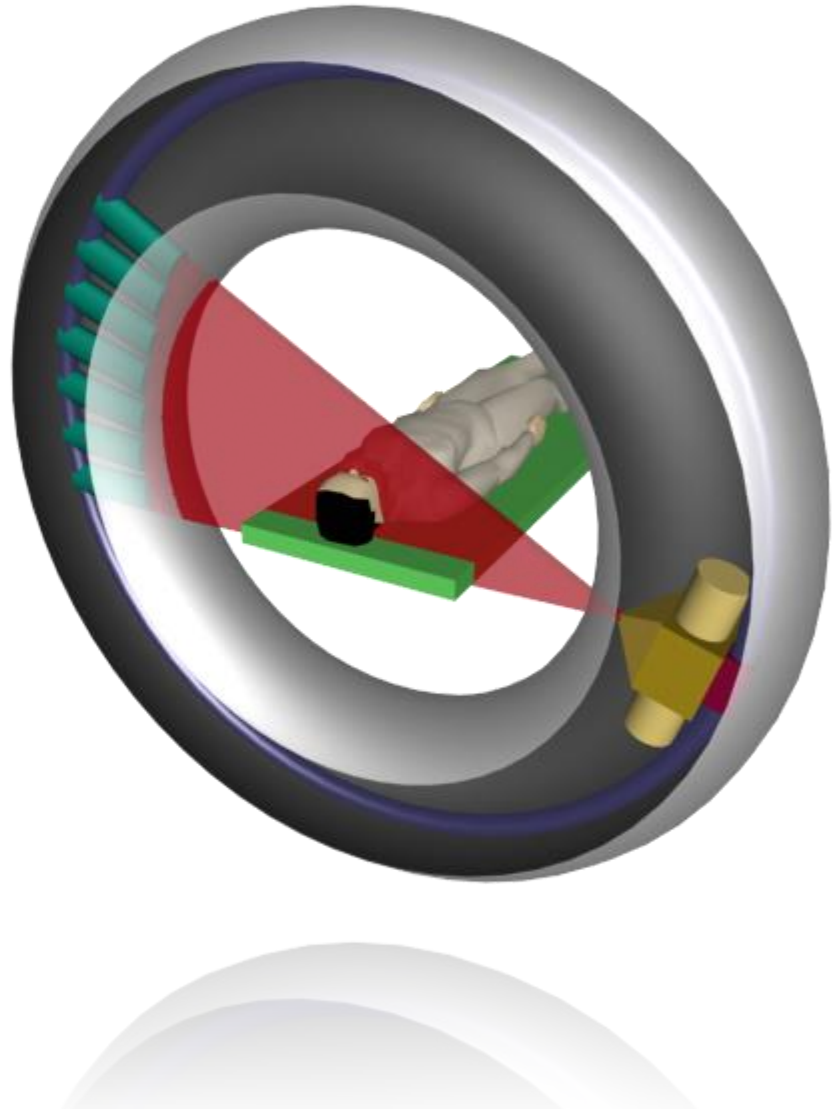
85
90
95
100
105
110
115
120
125
130
135

cone-beam CT (CBCT)

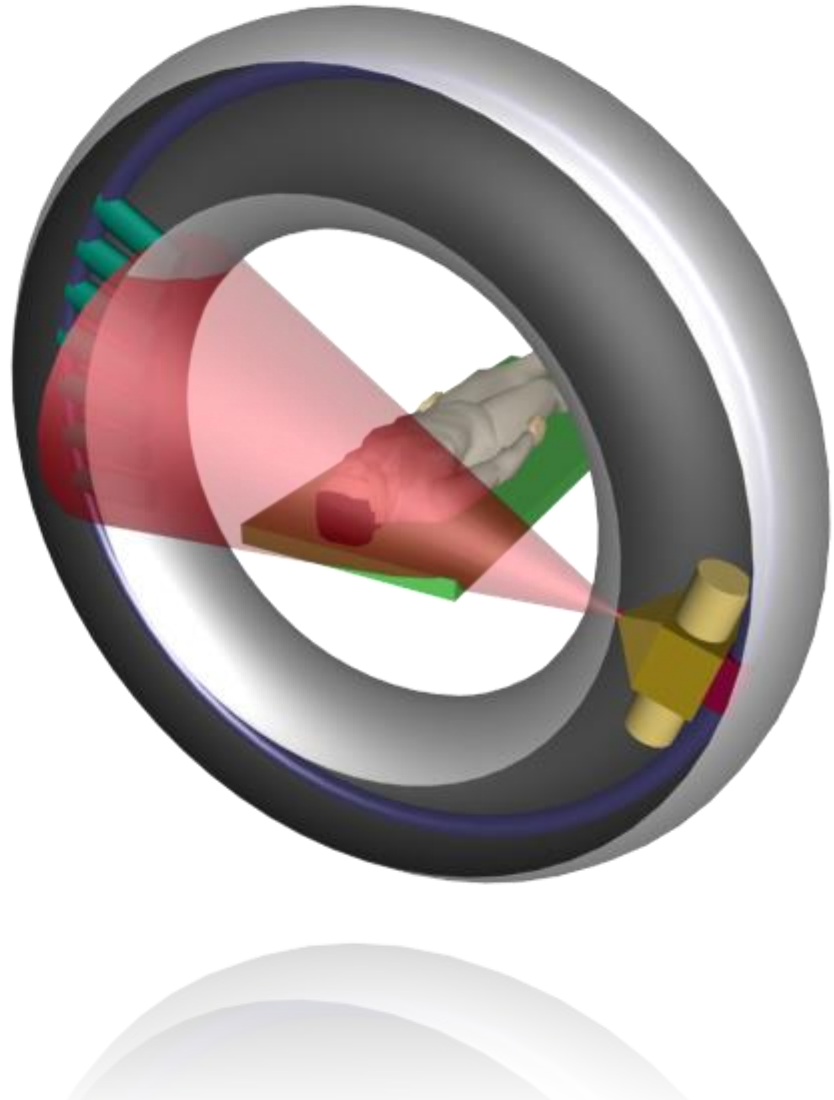


Animation from
Demetrios J. Halazonetis
www.dhal.com

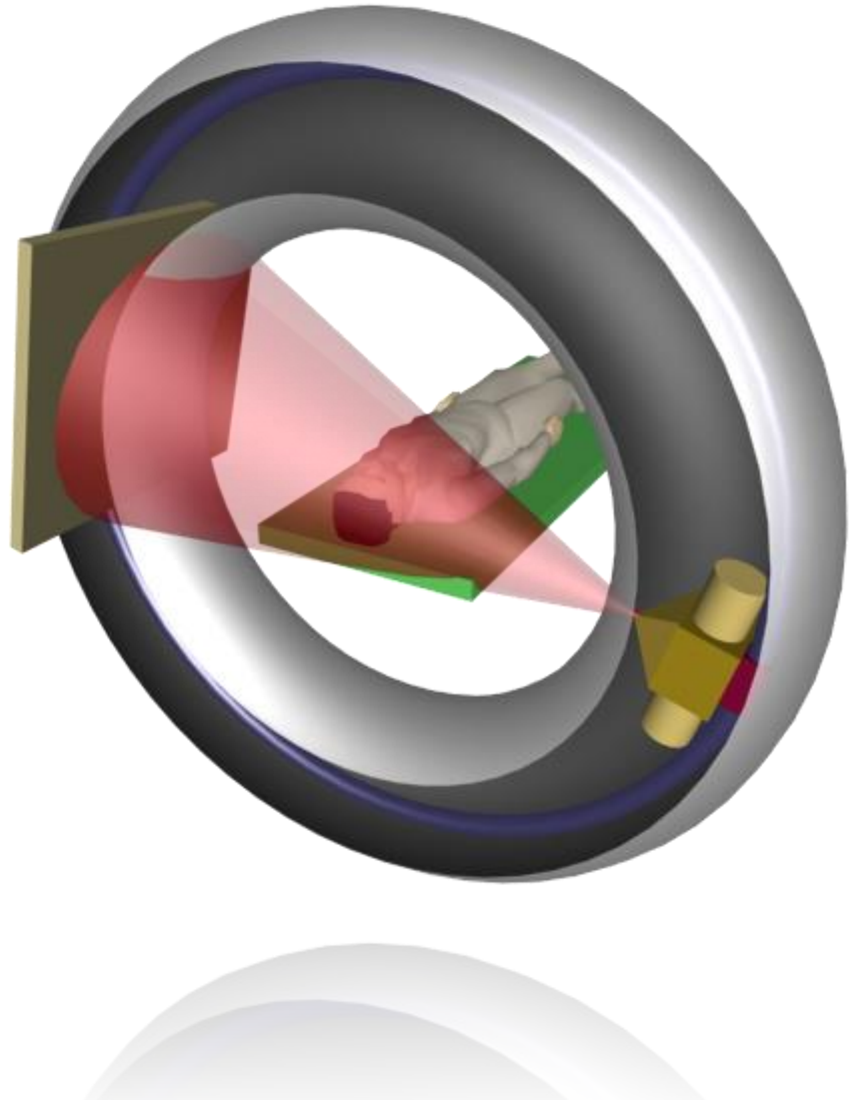
cone-beam CT
(CBCT)



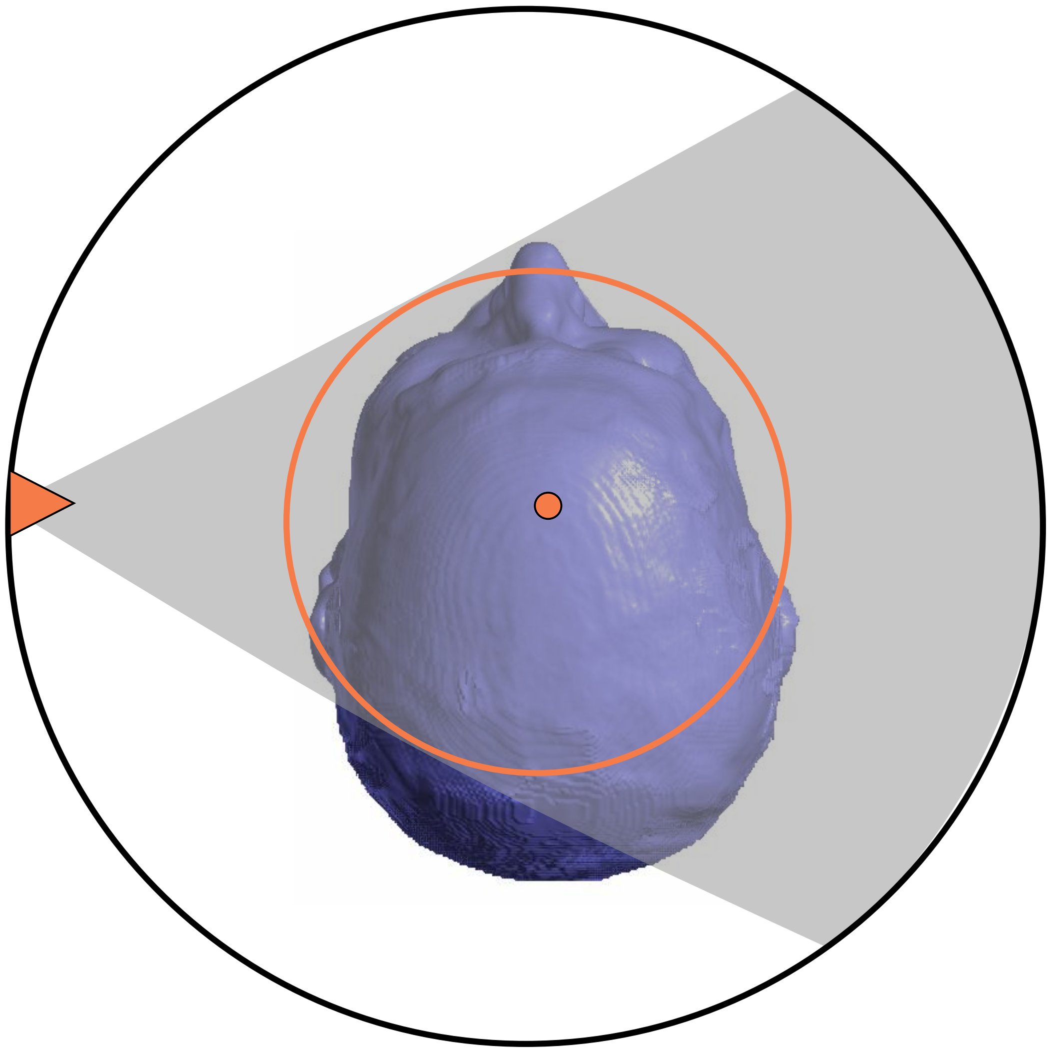
cone-beam CT
(CBCT)

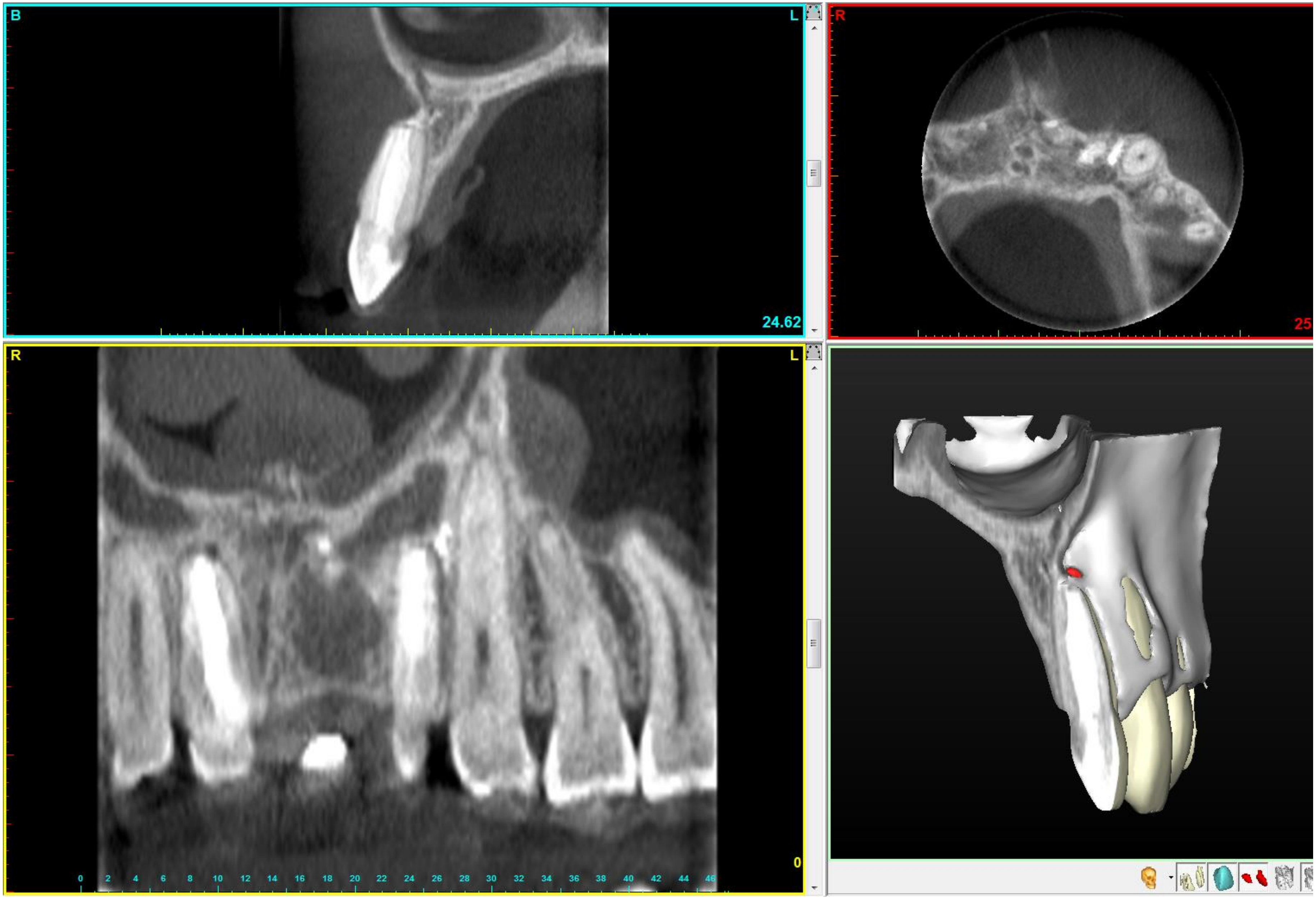


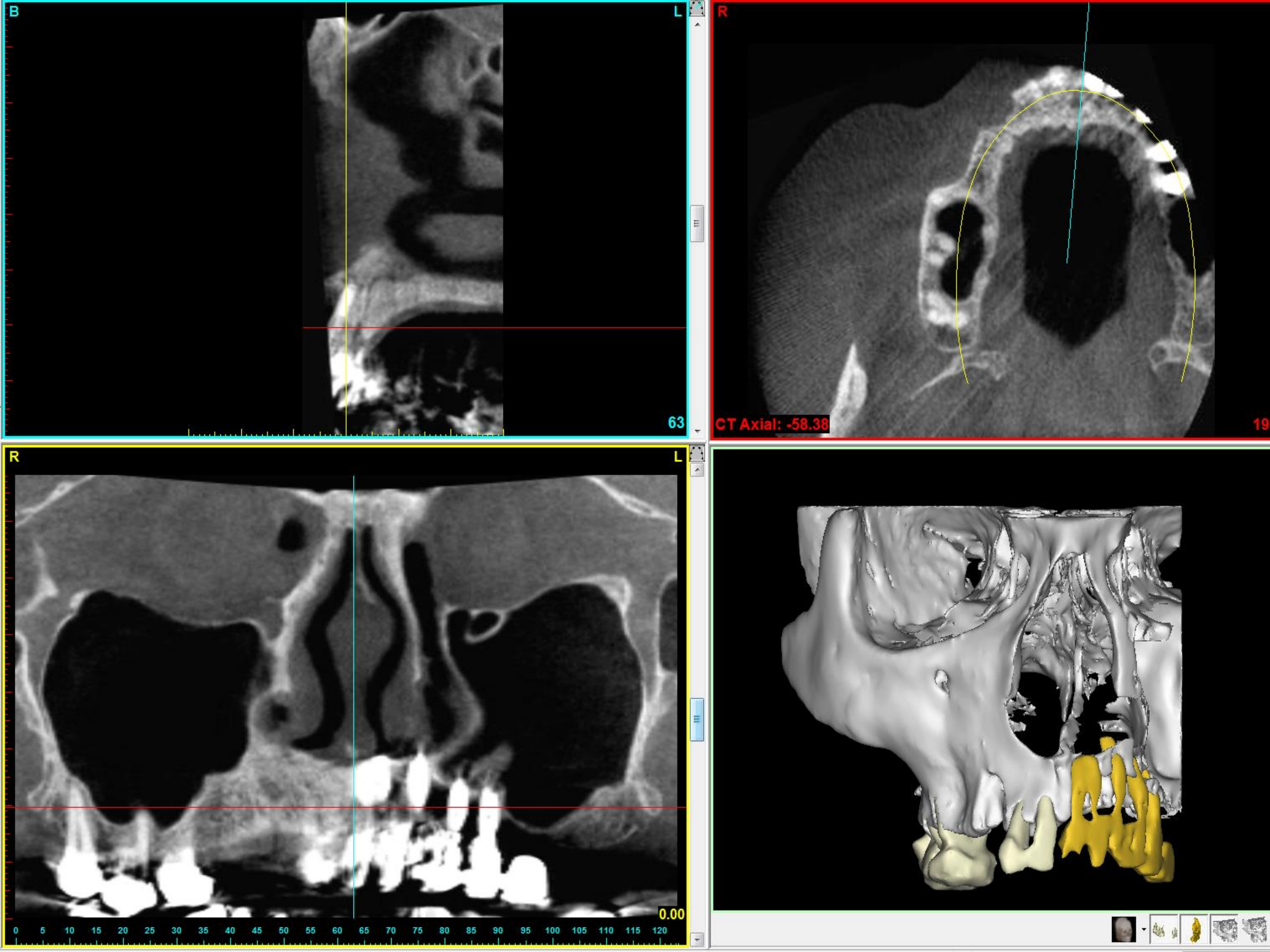
cone-beam CT (CBCT)



cone-beam CT
(CBCT)




B
L
24.62
R
25
R
L
0
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46


B
L
63
R
CT Axial: -58.38
19
R
L
0.00
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

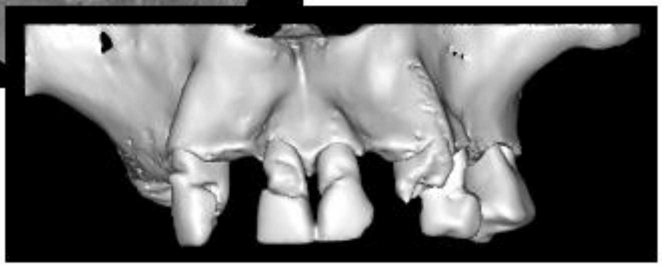
Maxilla – Full Arch

3 small fields stitched together

each 5cm dia x 4cm height

20 µSv

20 µSv



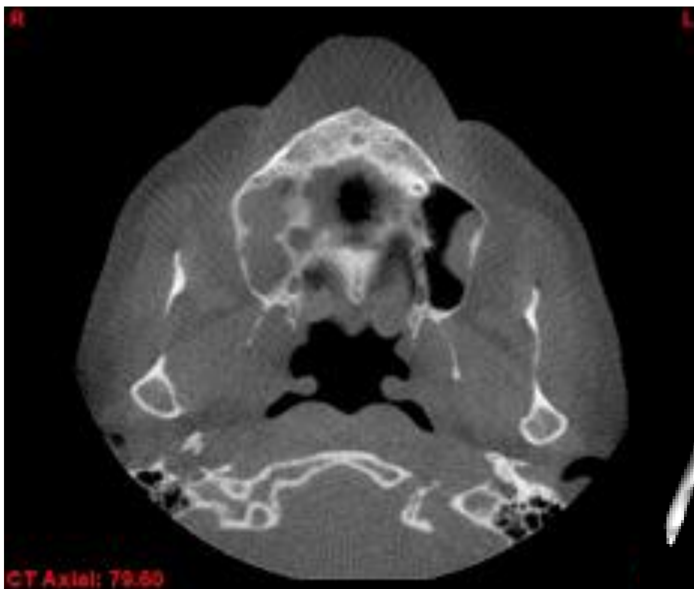
20 µSv

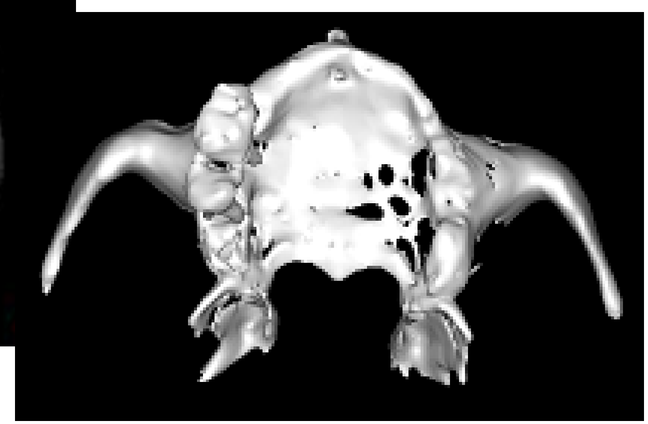
Total: 60 µSv

Maxilla – Full Arch

one large field

16cm dia x 4cm height





Total: 40 µSv

1x1
200 µm
18.60 mm
A
R
Patient information
K9000
70KV 10mA 32.4s
9292494846484648465152928...
653mGy.cm²
2013-01-16 11:50:56
200µmx200µmx200µm
OK
zoom: 1.45
1x1
200 µm
35.00 mm
200 µm
R
L
A

Image Quality

- Noise

- ***depends on radiation dose***

- Artefact

- ***metal objects within the patient***
- ***depends on machine calibration and 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)

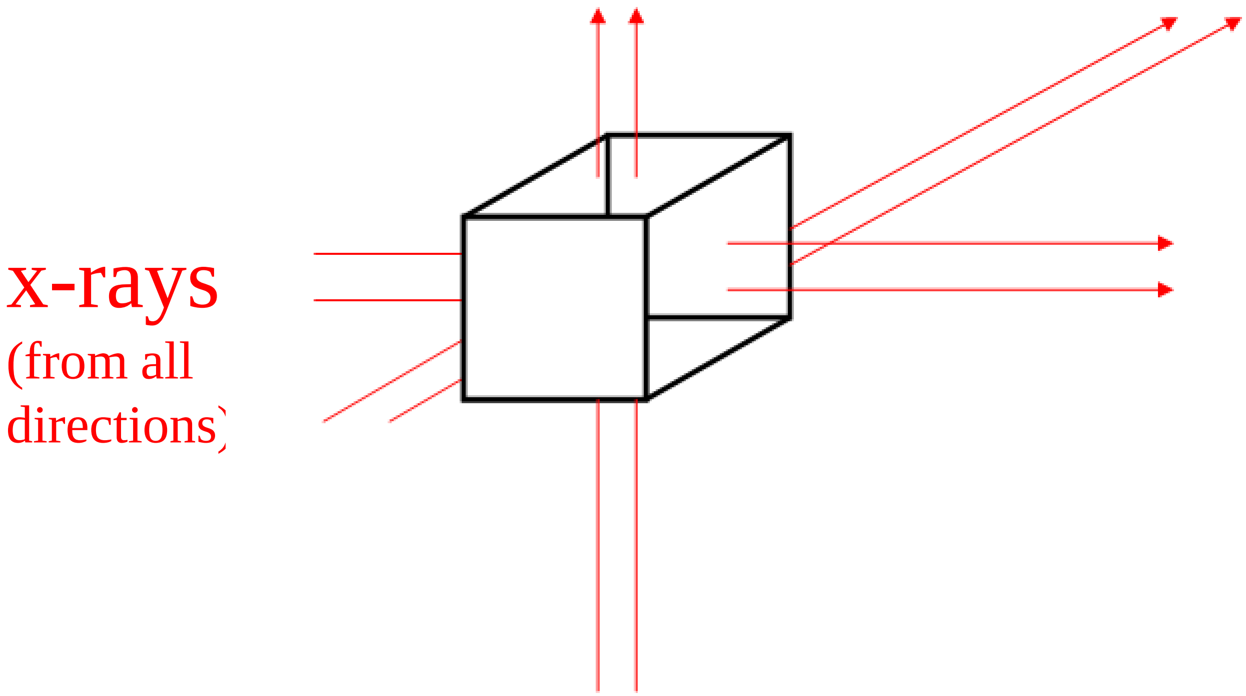
- ***depends on filtration and kVp***
- ***limited by the noise***

Noise in CT / CBCT images

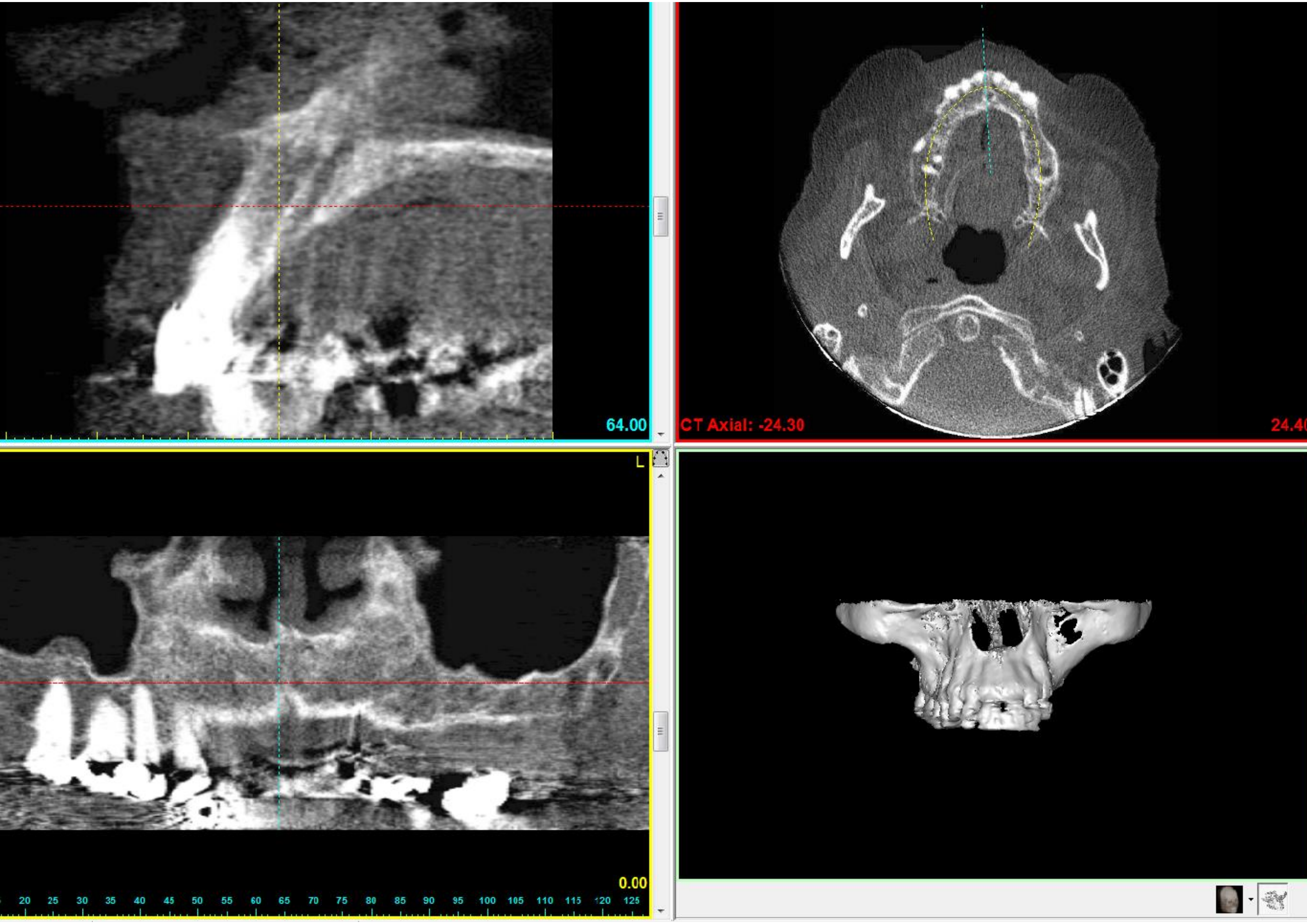
Noise = unstructured contribution to the image which has no counterpart in the object.

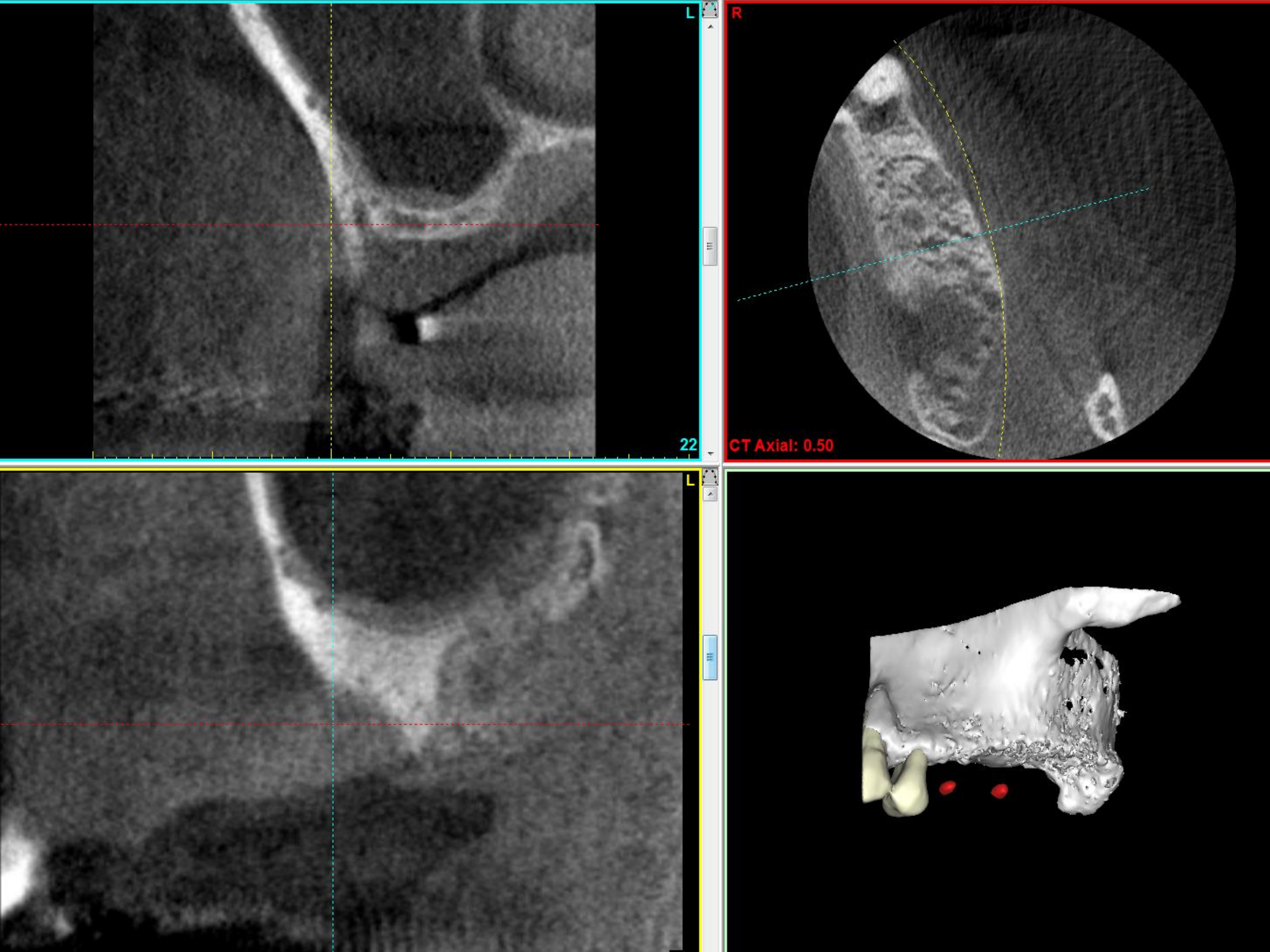
- **Electronic noise (dark current)**
- **Photon noise (not enough x-rays)**
  - **Noise is proportional to $\sqrt{n}$**
  - **Signal-to-Noise Ratio is proportional to $n / \sqrt{n} = \sqrt{n}$**
  - **Where n is the number of x-ray photons**

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 $\sqrt{8}$ = 2.83
mAs (dose) may have to be increased to compensate


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


L
22
R
CT Axial: 0.50
L

Scan Duration versus Voxel Size

- **The noise increases as the voxel size gets smaller**
- **On most machines the operator may choose to increase the dose (mA or scan duration) to compensate for this**
- **On some machines (e.g. i-CAT 17-19 and CB-500) the operator must choose a longer scan duration to obtain a smaller voxel size**
  (e.g. 0.25mm voxels require a 23s scan duration on CB-500)
- **Advantage of the longer scan duration is better spatial resolution since the detector acquires more samples**
- **Disadvantages are: (a) more dose (b) patient movement.**

Other things that affect Image Quality

✔**Noise**

- ***depends on radiation dose***

- Artefact

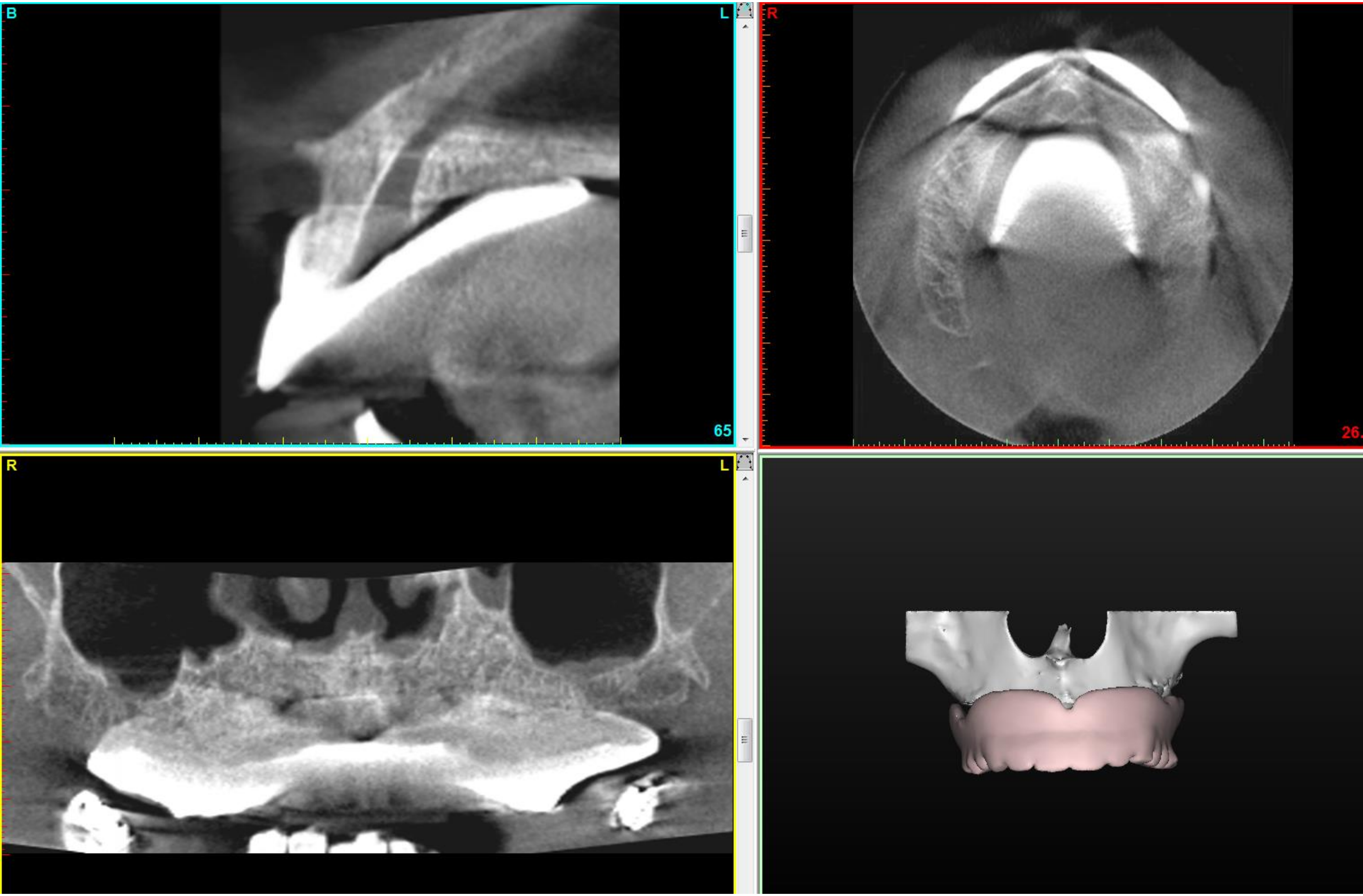
- ***metal objects within the patient***
- ***depends on machine calibration and operator technique***

- 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 filtration and kVp***
- ***limited by the noise***


B
L
65
R
26.
R
L

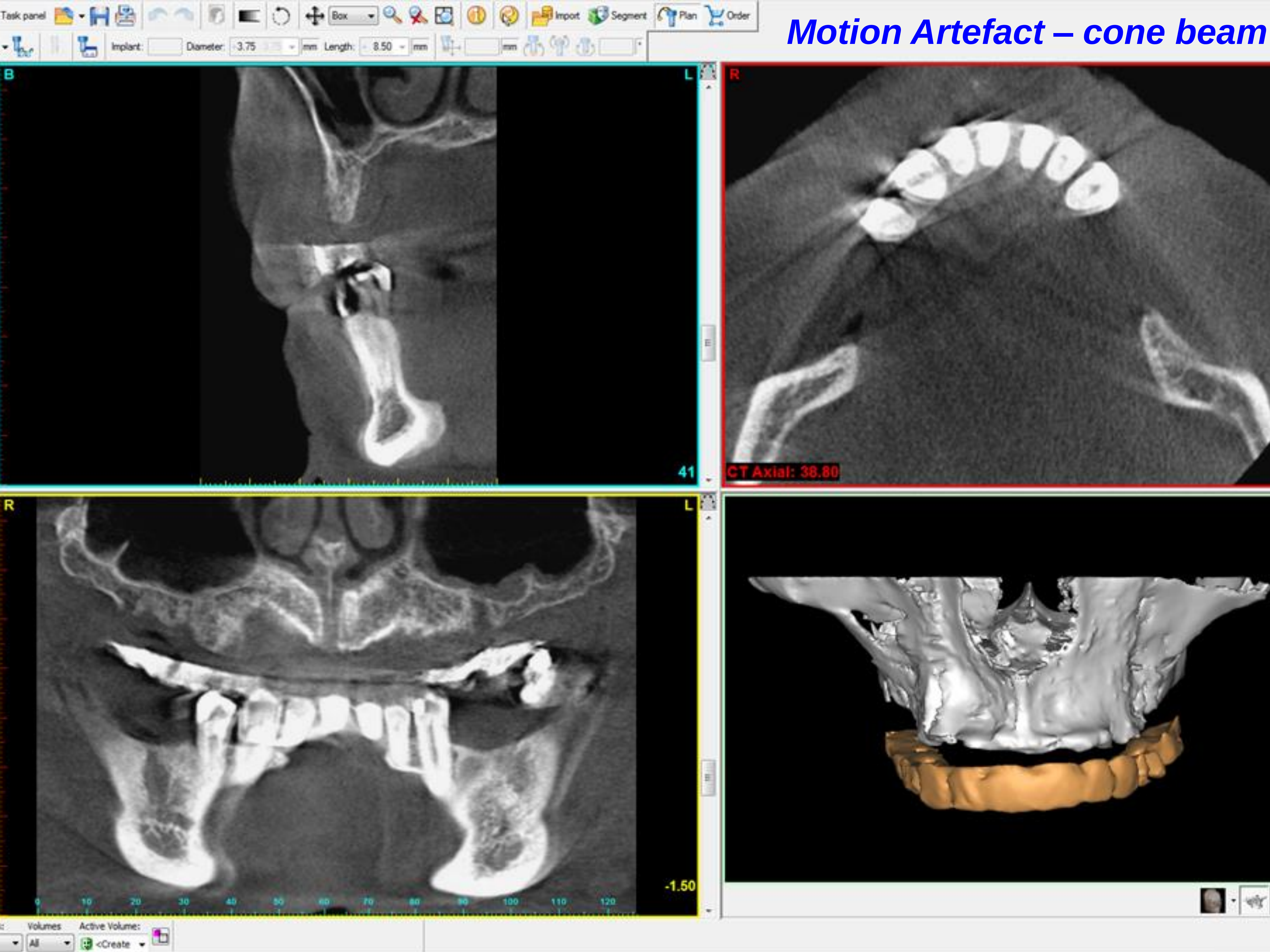
Artefacts in CT images

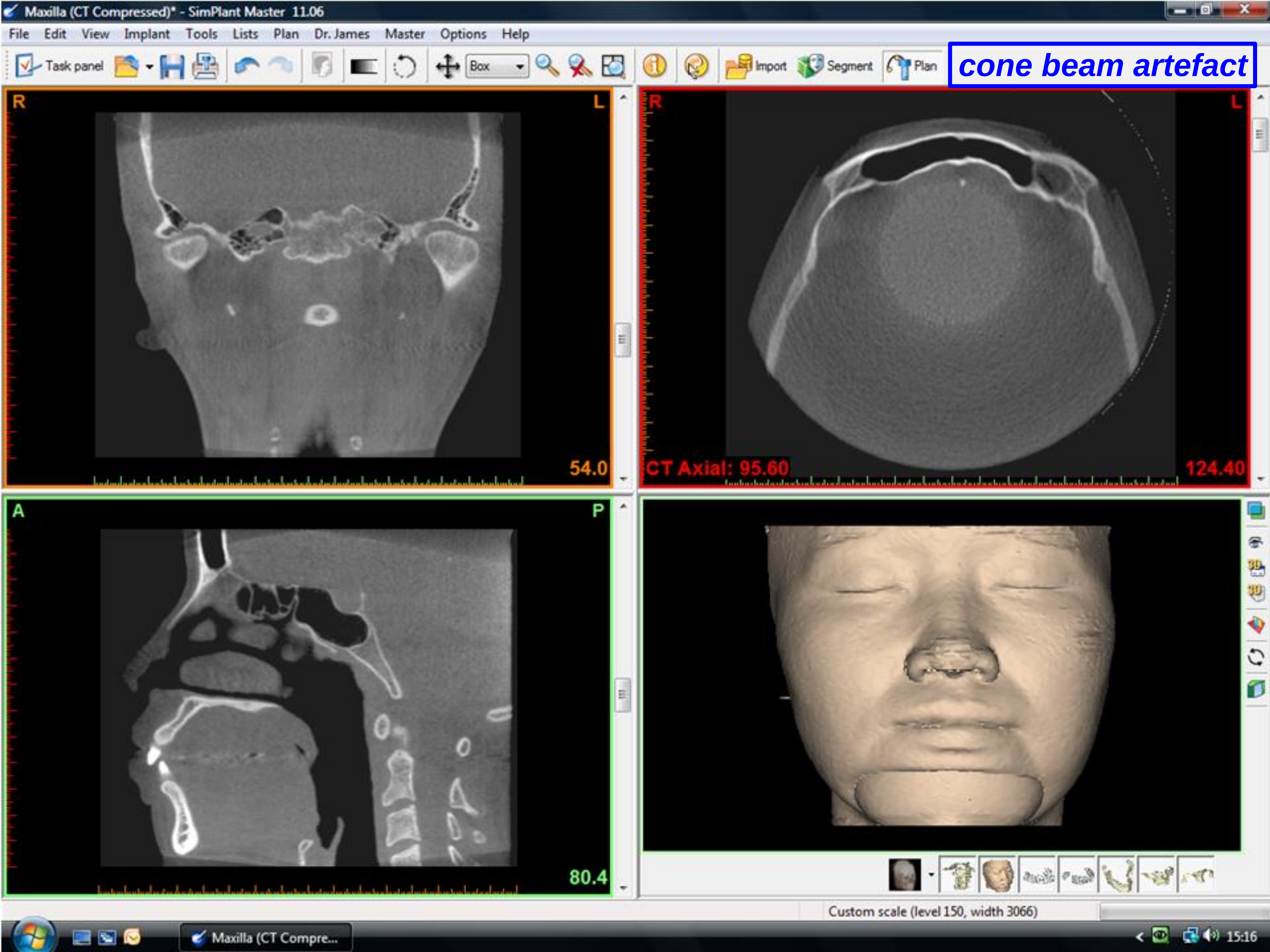
Artefact = structured contribution to the image which has no counterpart in the object.

- **Motion artefact**
- **Spiral artefacts**
- **Cone beam artefacts**
- **Ring artefacts**
- **Starburst artefact**
- **Beam hardening**

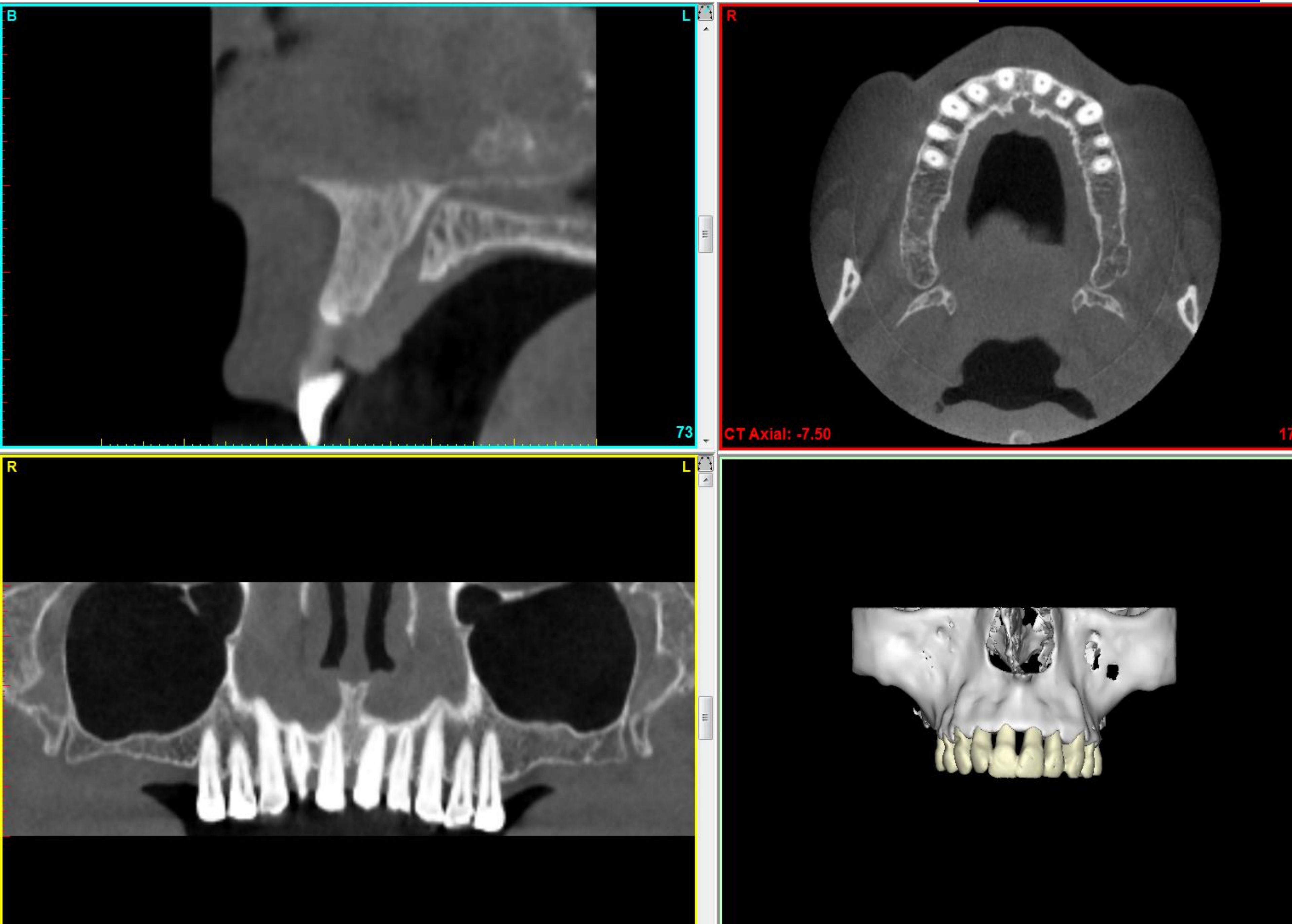
Motion Artefact – cone beam CT

Motion Artefact – cone beam



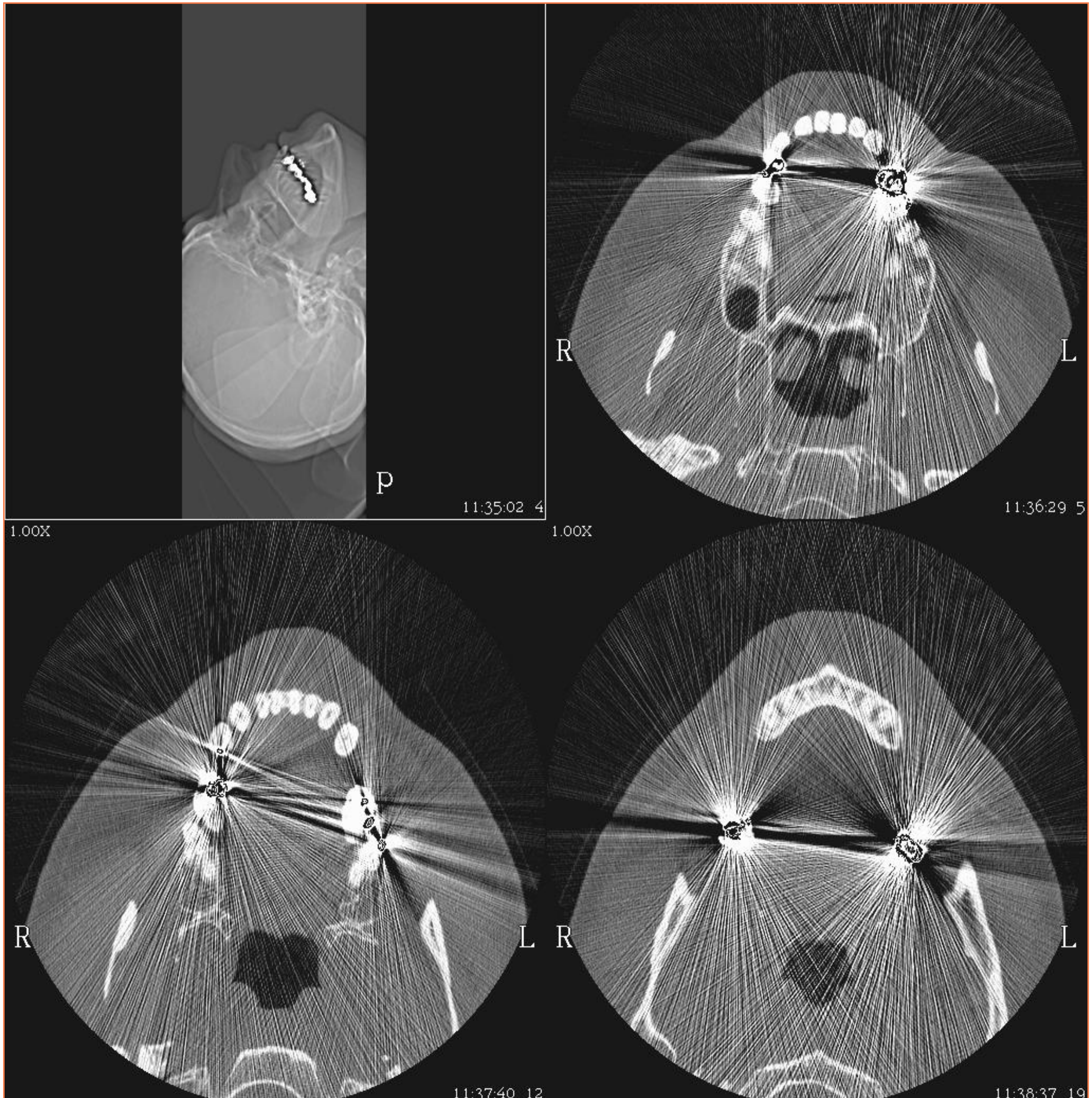

Maxilla (CT Compressed)* - SimPlant Master 11.06
File Edit View Implant Tools Lists Plan Dr. James Master Options Help
Task panel
Box
Import
Segment
Plan
cone beam artefact
R
L
54.0
R
L
CT Axial: 95.60
124.40
A
P
80.4
Custom scale (level 150, width 3066)
Maxilla (CT Compre...
15:16

ring artefact



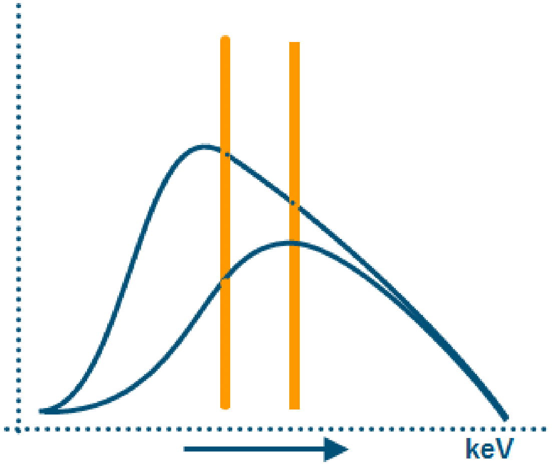
STARBURST ARTEFACT

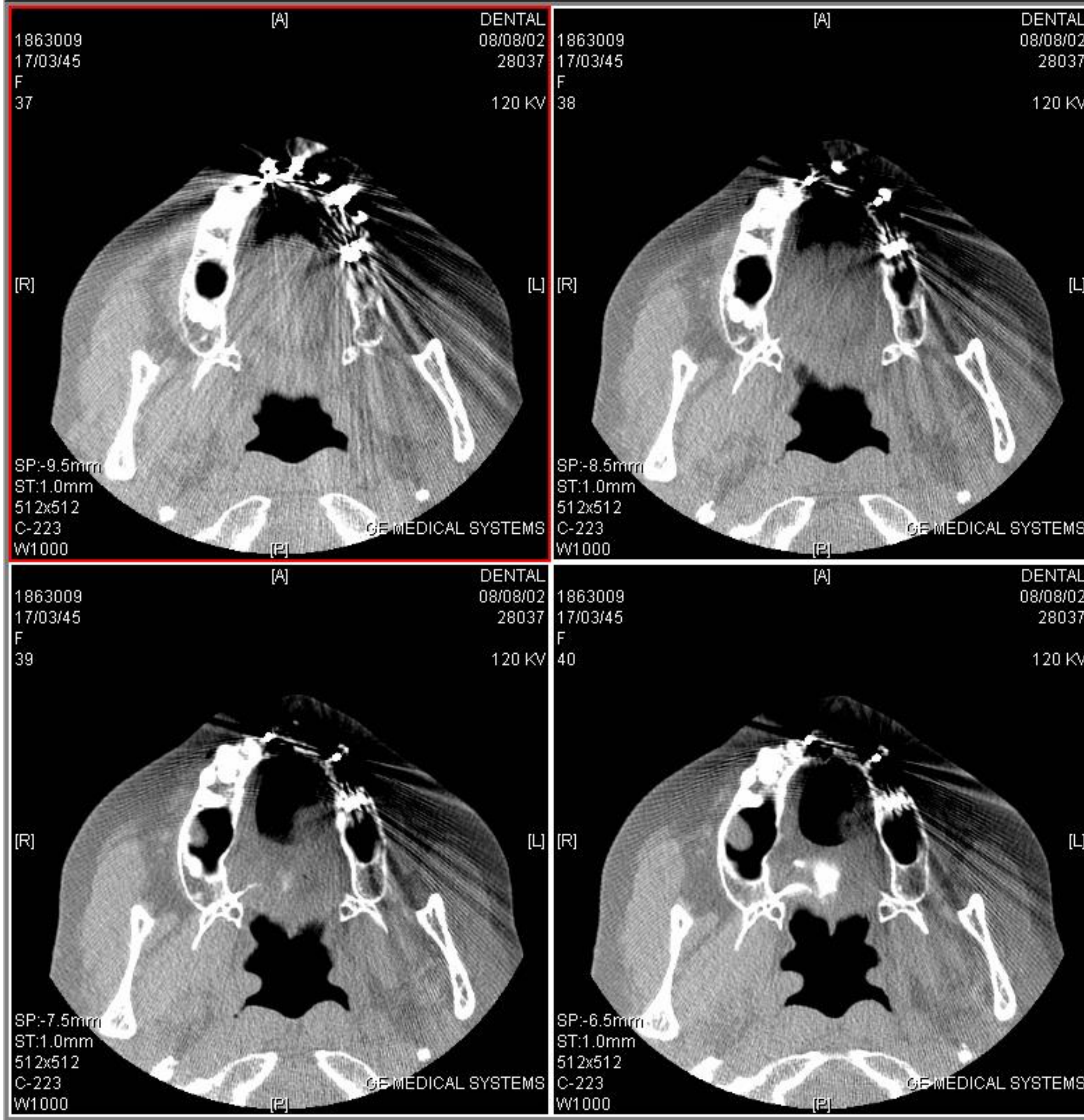
- **Starburst artefacts arise in CT scans when sharp changes in density are present, e.g. between air and bone or between bone and dense metals**
- **Starburst artefacts are caused by limitations in high frequency sampling**
- **Starburst artefacts are not caused by scattered radiation**


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 also 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
GE MEDICAL SYSTEMS
W1000
[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
GE MEDICAL SYSTEMS
W1000
[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
GE MEDICAL SYSTEMS
W1000
[P]
[A]
DENTAL
1863009
08/08/02
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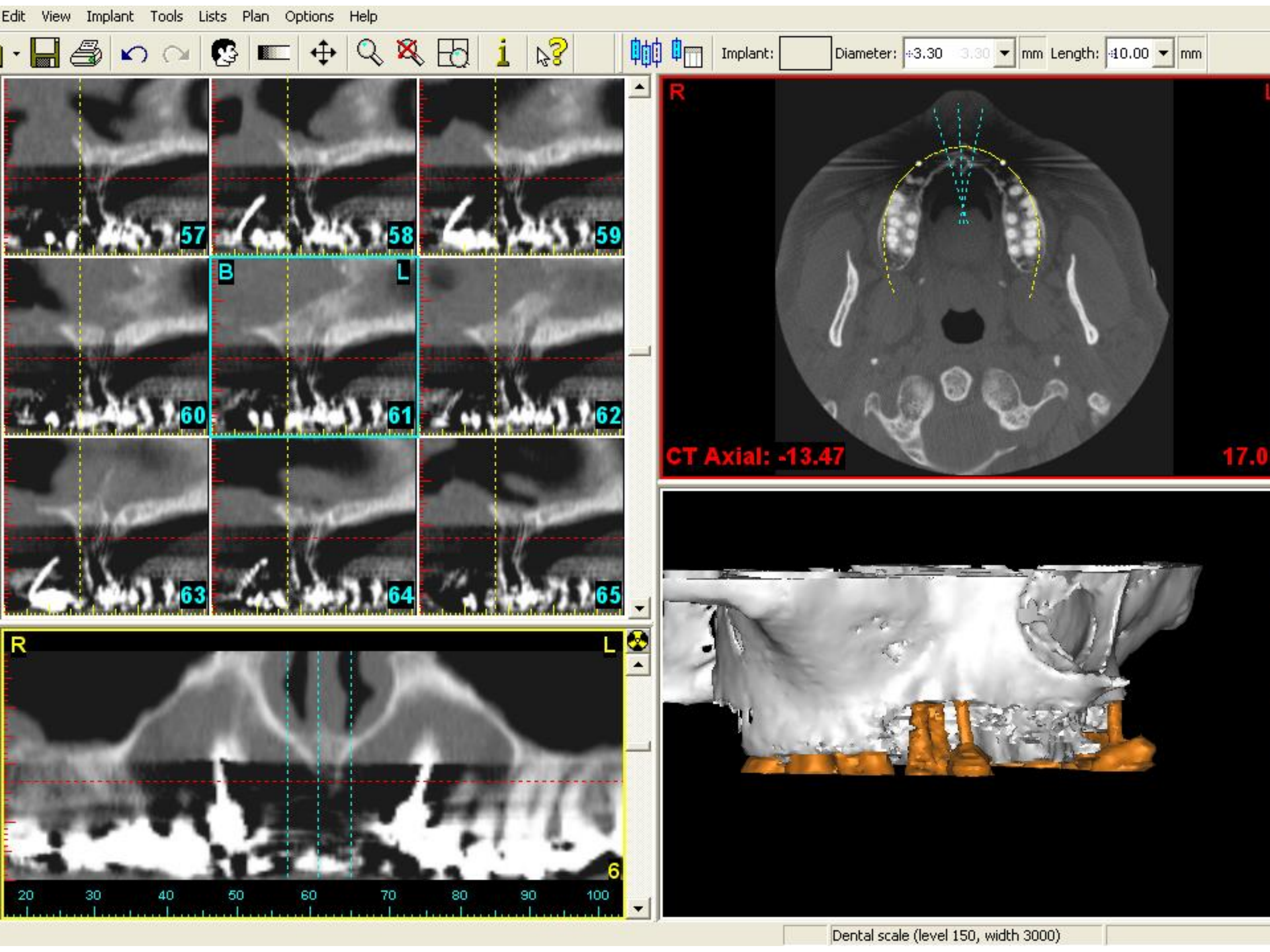
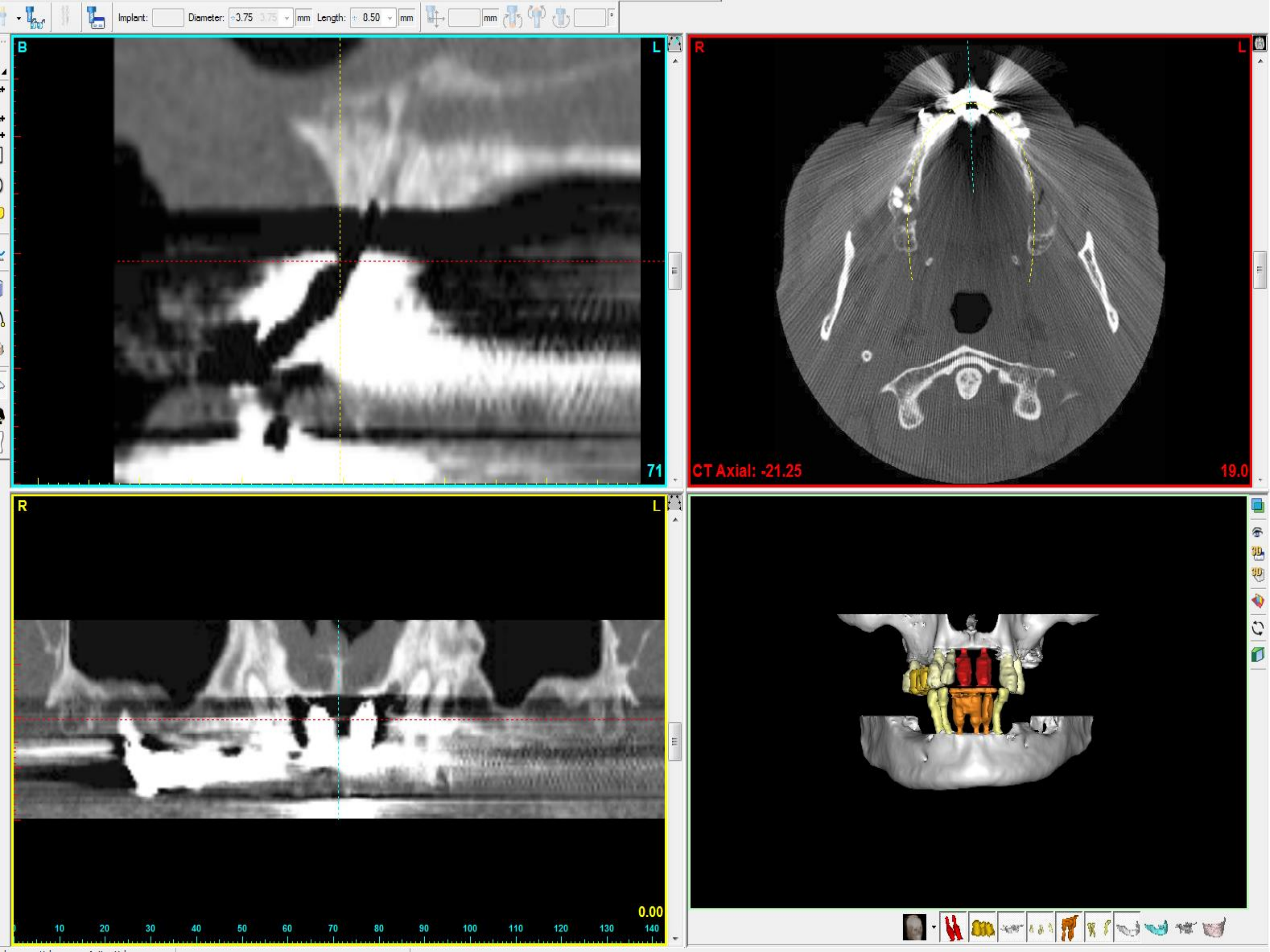
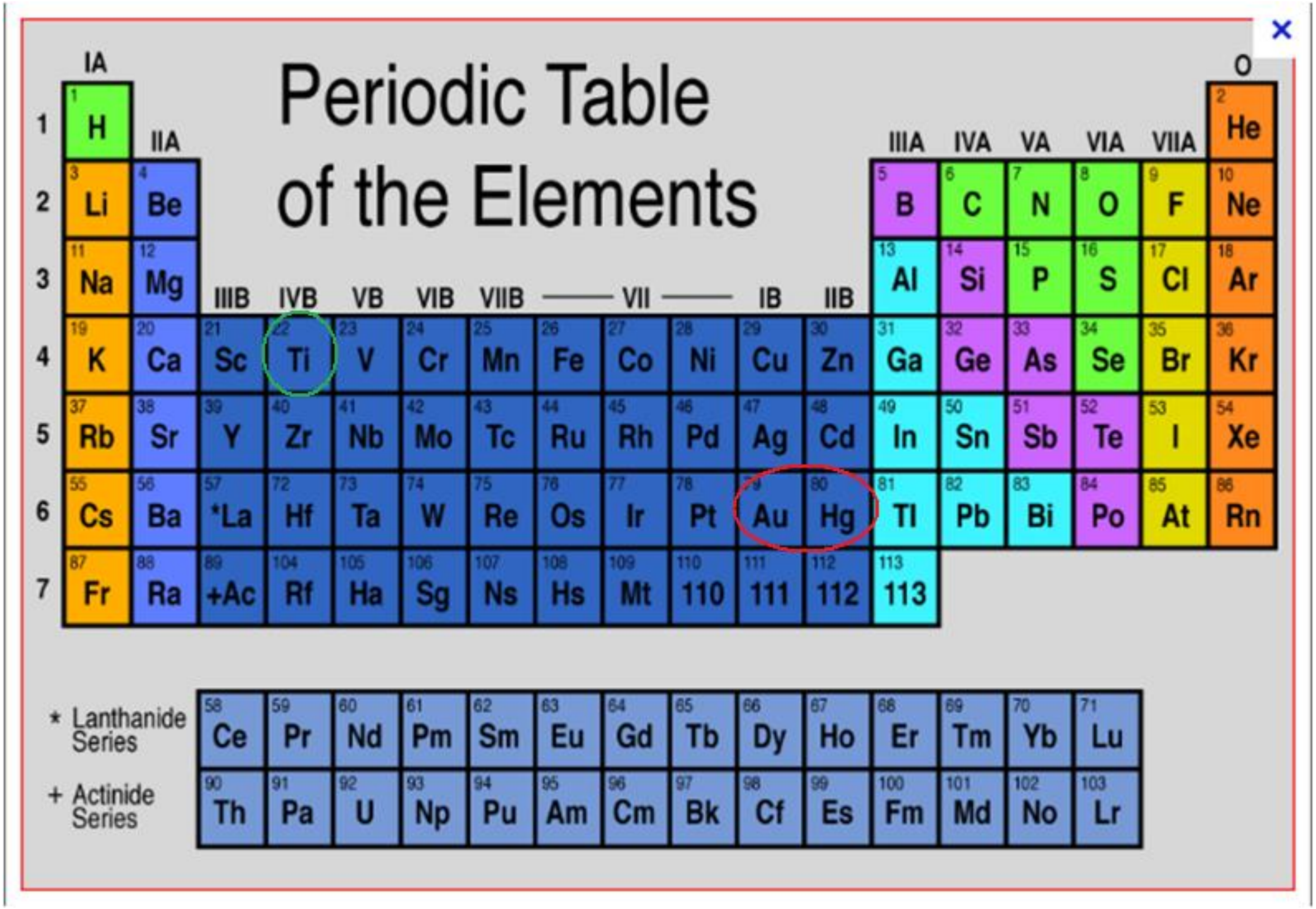
28037
F
40
120 KV
[R]
[L]
SP:-6.5mm
ST:1.0mm
512x512
C-223
GE MEDICAL SYSTEMS
W1000
[P]


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
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 clasps, reinforcements or chrome cobalt bases**
- **Replace amalgam with composites, especially if the tooth will be sacrificed anyway.**

Other things that affect Image Quality

✔**Noise**

- ***depends on radiation dose***

✔**Artefact**

- ***metal objects within the patient***
- ***depends on machine calibration and operator technique***

- Spatial Resolution (resolution at high contrast)

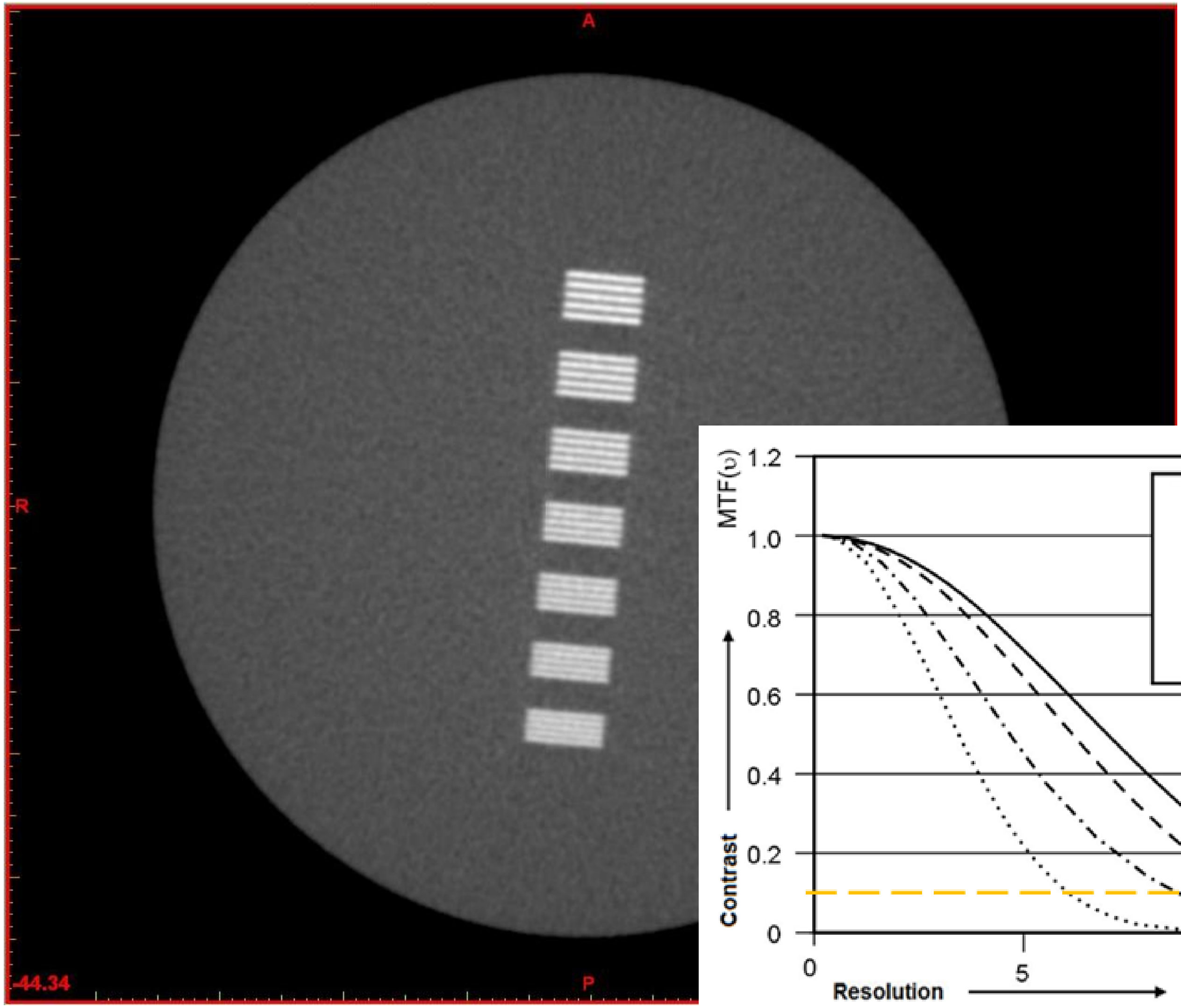
- ***depends on machine design***
  (focal spot size, detector elements, sampling, mechanical stability)
- ***voxel size can only limit the resolution – cannot increase it!***

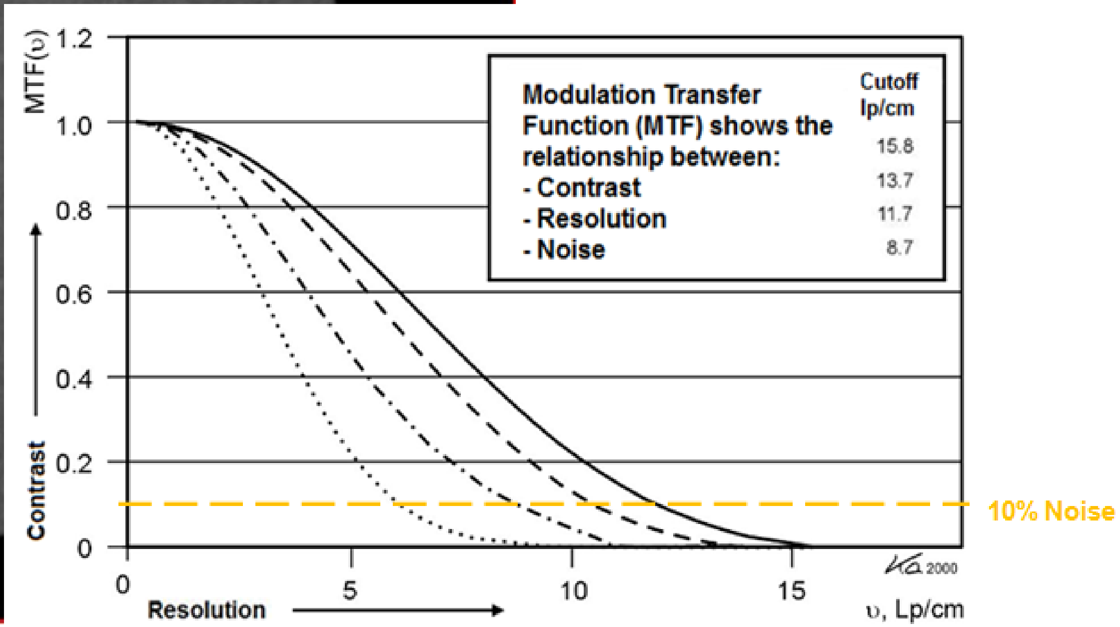
- Contrast Resolution (resolution at low contrast)

- ***depends on filtration and kVp***
- ***limited by the noise***

Spatial Resolution

Detail at high contrast

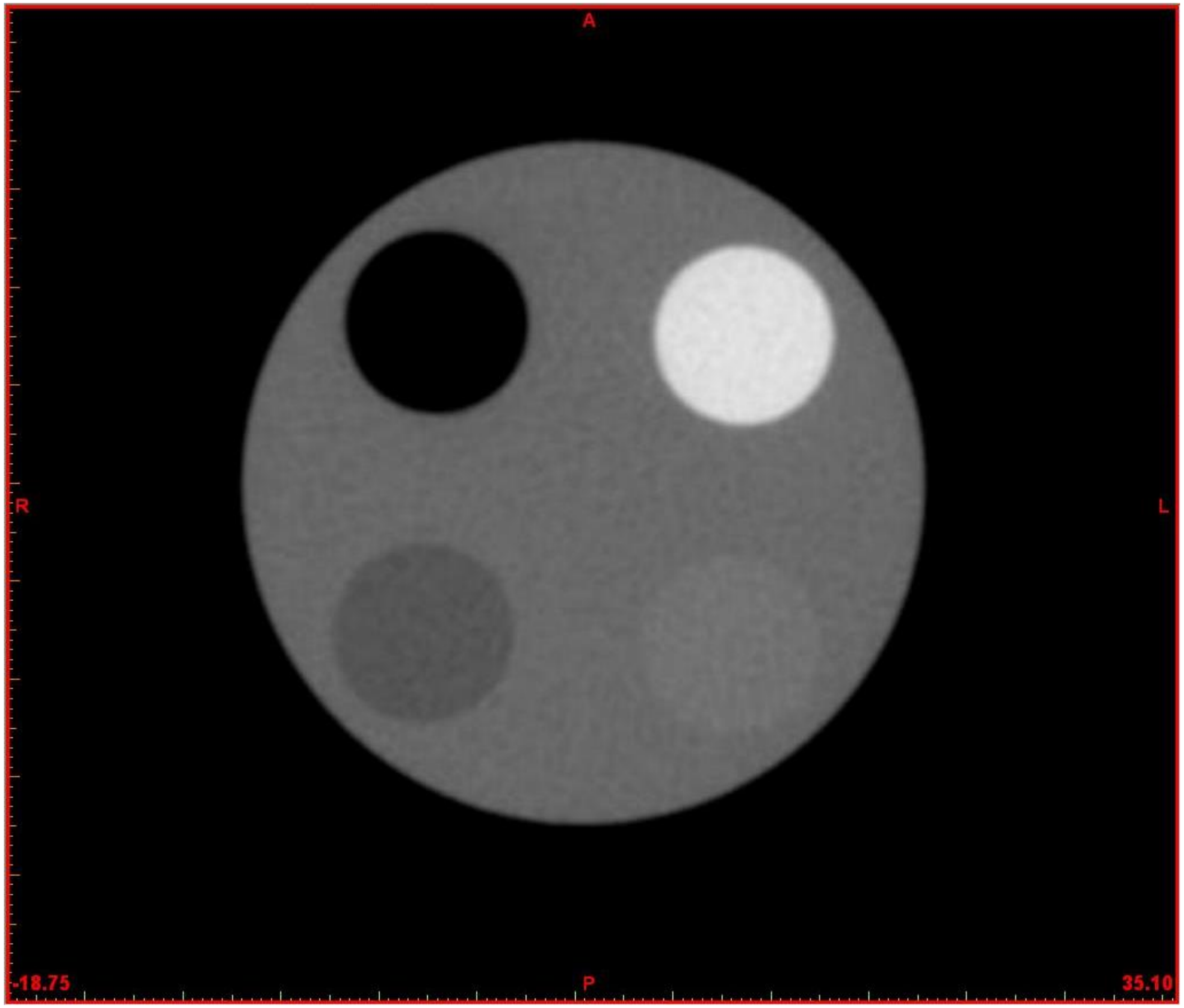




Spatial Resolution

Contrast Resolution

Detail at low contrast



Contrast Resolution

Spatial and Contrast Resolution are both important

Comparison of Five Cone Beam Computed Tomography Systems for the Detection of Vertical Root Fractures

Bassam Hassan, BDS, MSc,[*‡] *Maria Elissavet Metska, DDS, MSc,*[†‡] *Ahmet Rifat Ozok, DDS, PhD,*[†] *Paul van der Stelt, DDS, PhD,*[*] *and Paul Rudolf Wesselink, DDS, PhD*[†]

Abstract

Introduction: This study compared the accuracy of cone beam computed tomography (CBCT) scans made by five different systems in detecting vertical root fractures (VRFs). It also assessed the influence of the presence of root canal filling (RCF), CBCT slice orientation selection, and the type of tooth (premolar/molar) on detection accuracy. **Methods:** Eighty endodontically prepared teeth were divided into four groups and placed in dry mandibles. The teeth in groups Fr-F and Fr-NF were artificially fractured; those in groups control-F and control-NF were not. Groups Fr-F and control-F were root filled. CBCT scans were made using five different commercial CBCT systems. Two observers evaluated images in axial, coronal, and sagittal reconstruction planes. **Results:** There was a significant difference in detection accuracy among the five systems ($p = 0.00001$). The presence of RCF did not influence sensitivity ($p = 0.16$), but it reduced specificity ($p = 0.003$). Axial slices were significantly more accurate than sagittal and coronal slices ($p = 0.0001$) in detecting VRF in all systems. Significantly more VRFs were detected among molars than premolars ($p = 0.0001$). **Conclusions:** RCF presence reduced specificity in all systems ($p = 0.003$) but did not influence accuracy ($p = 0.79$) except in one system ($p = 0.012$). Axial slices were the most accurate in detecting VRFs ($p = 0.0001$). *(J Endod 2010;36:126–129)*

Key Words

Cone beam computed tomography scan, diagnosis, root canal filling, vertical root fracture

From the Departments of *Oral and Maxillofacial Radiology and †Cariology Endodontology Pedodontology, Academic Centre for Dentistry Amsterdam, Amsterdam, The Netherlands

‡Bassam Hassan and Maria Elissavet Metska contributed equally to this manuscript.

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0099-2399/$0 - see front matter

doi:10.1016/j.joen.2009.09.013

The clinical and radiographic diagnosis of vertical root fractures (VRFs) is often complicated. A local deep pocket, dual sinus tracts, and a halo type of lateral radiolucency are among the symptoms (1–8). Often these symptoms are not convincing to justify tooth extraction, which usually is the elected treatment because the prognosis of VRFs is poor. Therefore, the exact diagnosis of a VRF is crucial to avoid erroneous extraction. However, because of the two-dimensional nature of periapical radiographs (PRs) and the inherent superimposition projection artifacts, visualizing a VRF is difficult, especially when the fracture line is mesiodistally oriented (9). The presence of a VRF is only confirmed by direct visualization (10). This may sometimes be accomplished by means of a surgical diagnostic flap, which is quite invasive.

Cone beam computed tomography (CBCT) scans specifically designed for the maxillofacial region have become largely accessible to clinicians and have replaced conventional computed tomography scans for dentomaxillofacial applications because of their reduced radiation dose and installation and maintenance costs (11–13). Prototype flat-panel CBCT systems were found useful in detecting VRFs (14, 15). Those systems, however, cannot be used to scan patients. Recently, a CBCT system was found more accurate than PR in detecting VRFs in root-filled teeth (16). The superiority of CBCT over PR is primarily because of the high contrast and three-dimensional nature of tomographic imaging, which permits direct visualization of fracture lines otherwise masked in PR.

Several dentomaxillofacial CBCT systems are currently on the market. Those systems differ from each other in detector design, patient scanning settings, and data reconstruction parameters (17–21). Several scanning and reconstruction factors including scan field of view (FoV) selection and voxel size, the number of basis projections (acquisitions) used for reconstruction, and image artifacts have significant influence on image quality in CBCT. CBCT systems vary in their image quality and ability to visualize anatomic structures (22–27). This variation is most prominent with small and delicate anatomic structures such as periodontal ligament and trabecular bone (28). It is, therefore, probable that different CBCT systems vary in their ability to detect VRFs because the fractures are small. The influence of the presence of root canal filling (RCF) on VRF visibility could also vary among the different scanners. Additionally, the selection of the reconstruction plane (axial, sagittal, or coronal) used for the detection or the type of tooth could have an influence on VRF detection. This study aimed to compare the accuracy of five clinical CBCT systems for detecting VRFs in endodontically prepared teeth and to assess the influence of the presence of a RCF, slice orientation selection, and the type of tooth on accuracy for detecting VRF in each system.

Material and Methods

Sample Preparation

We used the method described by Hassan et al (16). Briefly, 40 extracted premolars and 40 molars were inspected on a stereomicroscope (Wild Photomakroscop M400; Wild, Heerbrugg, Switzerland) for the absence of VRFs. Endodontically prepared root canals (size F3, ProTaper; Dentsply Maillefer, Tulsa, OK) were divided into two experimental (Fr-F and Fr-NF) and two control groups (control-F and control-NF). Each group consisted of 10 premolars and 10 molars ($n = 20$). The teeth were decoronated to eliminate a bias of enamel fractures.

Comparison of Five Cone Beam Computed Tomography Systems for the Detection of Vertical Root Fractures

Bassam Hassan, BDS, MSc,[*‡] *Maria Elissavet Metska, DDS, MSc,*[†‡] *Ahmet Rifat Ozok, DDS, PhD,*[†] *Paul van der Stelt, DDS, PhD,*[*] *and Paul Rudolf Wesselink, DDS, PhD*[†]

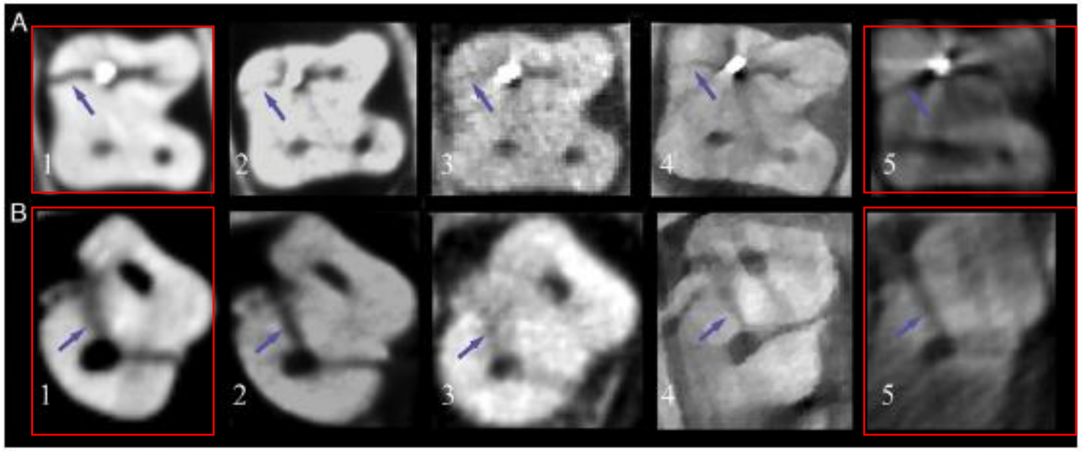

Figure 1. An example of an axial cross-section showing a vertical root fracture line (arrow) in an endodontically filled root (row *A*) and in a nonfilled root (row *B*). CBCT systems from left to right: (1) Next Generation i-CAT, (2) Scanora 3D, (3) NewTom 3G, (4) AccuiTomo MTC-1, and (5) Galileos 3D.

Image 1 has good Spatial Resolution and good Contrast Resolution

Image 5 has poor Spatial Resolution and poor Contrast Resolution

Conclusions

- **If your patient will truly benefit from a CT or CBCT Scan the risks are likely to be minimal or very low compared to the benefits.**

- **A certain amount of Dose is essential for good image quality but other factors are important too.**

5 things to discuss with CBCT salesmen

1. **There's no dose to the parts of the patient not visible in the images.** FALSE
2. **A Small Field Of View (SFOV) always means a lower dose.** FALSE USUALLY BUT NOT ALWAYS.
3. **A CBCT scanner always has a lower dose than a medical CT scanner.** FALSE

   USUALLY BUT NOT ALWAYS.
4. **The dose from my SFOV scanner is so low that stitching 3 fields together is better than scanning the whole arch on a LFOV machine.** FALSE
5. **My CBCT scanner has a low kV so that means a lower dose.** FALSE

5 things to discuss with your colleagues

1. **The smaller the voxel size, the better.** FALSE
2. **A smaller voxel size always means a higher dose.** USUALLY BUT NOT ALWAYS. FALSE
3. **A longer scan time can never be justified.** FALSE
4. **The CT images were non diagnostic but I shouldn’t ask for a repeat because of the dose.** FALSE
5. **My patient had a CT scan last week – she should wait at least 6 months before she has another one.** FALSE

Thank You!

- **Any Questions?**