Radiation Protection: CBCT

Dose, Risks & Optimisation

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Radiation Dose

Dose is created by ionising radiation being absorbed by any substance… for us this is biological tissues

Absorbed Dose: the amount of energy absorbed from the radiation beam per unit mass of tissue i.e. energy deposited in tissue (Gy)

Equivalent dose: takes account of the ionising intensity of different types of radiation.
Equivalent dose = absorbed dose × radiation weighting factor (Sv)
(W_R = 1)

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Radiation Dose – cbct

Effective dose: takes account of the dose received by individual tissues, the radiosensitivity of those tissues & the different parts of the body irradiated **(Sv), usually mSv or µSv.**

In dental radiology, when comparing examinations, ***effective dose*** *is generally the relevant quantity.*

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Effective Dose

Tissue	Tissue weighting factor, wT	ΣwT
Bone-marrow (red), colon, lung, stomach, breast, remaining tissues(*)	0.12	0.72
Gonads	0.08	0.08
Bladder, oesophagus, liver, thyroid	0.04	0.16
Bone surface, brain, salivary glands, skin	0.01	0.04
	Total	1.00

(*) Remaining tissues: Adrenals, extrathoracic region, gall bladder, heart, kidneys, lymphatic nodes, muscle, oral mucosa, pancreas, prostate (♂), small intestine, spleen, thymus, uterus/cervix (♀)

Reference: ICRP, 2007. The 2007 Recommendations of the International Commission on Radiological Protection. ICRP Publication 103. Ann. ICRP 37 (2–4)

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Effective Doses

TABLE 1 Typical patient doses from x-ray examinations of the head

Examination	Effective dose (µSv)[1]	Dose as a multiple of the dose from a typical panoramic exam
Panoramic	24	1
Small FOV* CBCT	46 – 652	2 - 27
Large FOV* CBCT	86 – 1073	3 – 45
CT scan (dental programme)	534 – 2130	22 – 89

*FOV = Field of view

Guidance on Safe Use of Dental Cone Beam CT, HPA, October 2010

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Dose Measurement for CBCT

DAP = Absorbed Dose x Area of Irradiation

Unit: Gycm2/mGycm2 (diagnostic radiography doses)

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Diagnostic Reference Levels (DRLs)

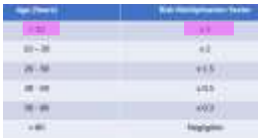
- Reference levels for optimising our equipment
- **Typical** dose figure for a **particular** diagnostic radiographic **exposure** of a **standard sized individual** with a **particular type** of **equipment**
- Based on local, regional and national data collection of doses



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National DRLs for dental radiography





European Guidelines on Radiation Protection in Dental Radiology, The Safe Use of Radiographs in Dental Practice, Issue 136, Europeam Commission, 2004

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Deterministic effects

Osteoradionecrosis @ 35-73Gy

Cataracts @ 0.5Gy

Mucositis







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Stochastic effects

- Concerned about these in diagnostic radiography
- Random, chance effects
- Risk of cancer induction from even a low dose diagnostic radiography exposure
- "Linear no threshold" theory

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Principles of radiation protection

- **Justification**
- **Optimisation** (ALARP Principle)
- Dose **Limitation**

ICRP
INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION

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JUSTIFICATION



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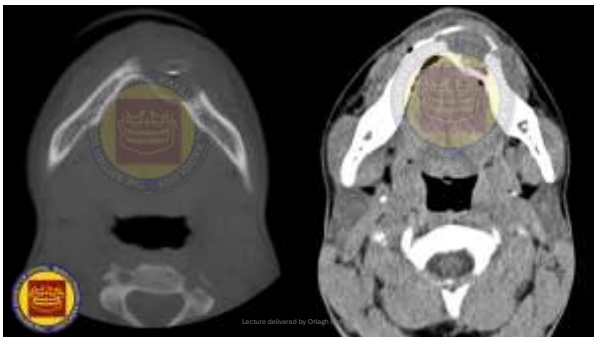
Selection criteria & guidelines

- FGDP Selection Criteria
- SEDENTEXCT Guidance
- Patient Selection → Age, PMH, Capacity
- Is CBCT the right choice? Plain Film answers most clinical Qs!

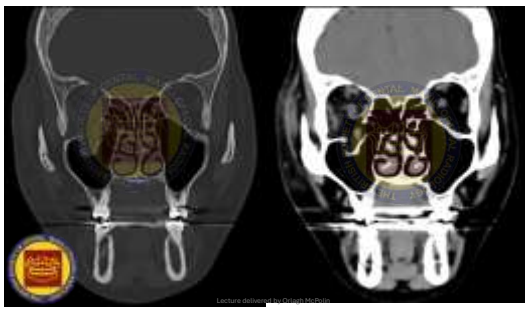
- CBCT LIMITATIONS...

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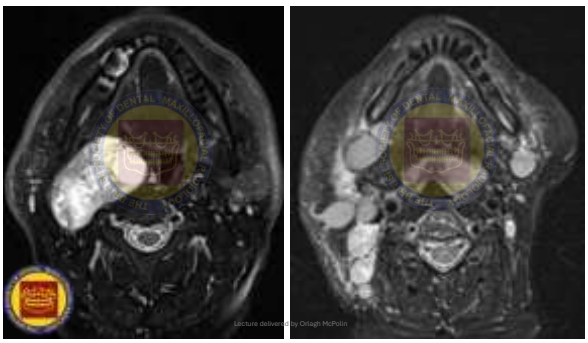
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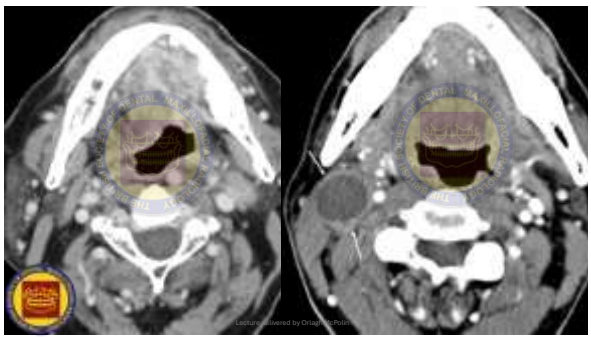
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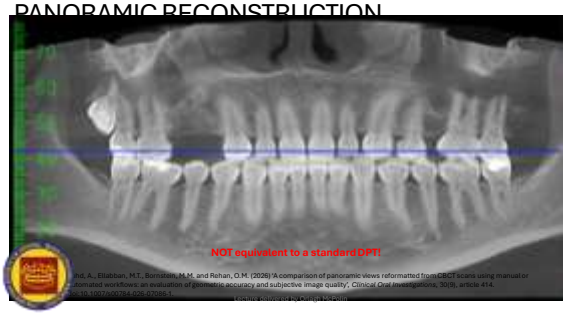

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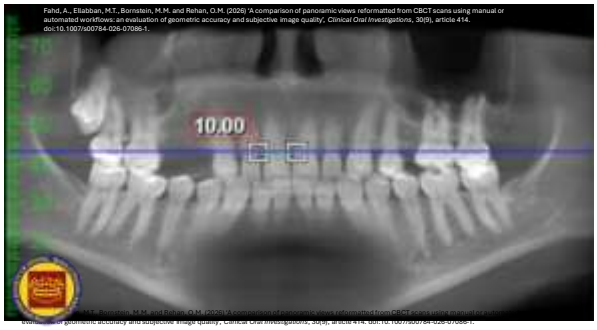

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PANORAMIC RECONSTRUCTION

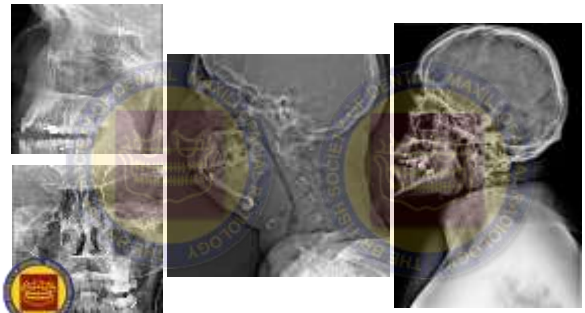


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Fahd, A., Eliabban, M.T., Bornstein, M.M. and Rohan, O.M. (2026) 'A comparison of panoramic views reformatted from CBCT scans using manual or automated workflows: an evaluation of geometric accuracy and subjective image quality', *Clinical Oral Investigations*, 30(9), article 414. doi:10.1007/s00784-026-07086-1.

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Optimisation

- Keep dose as low as possible while providing a diagnostic image
- **ALARP**
- ACCEPTABLE not highest possible quality!

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Practical Aspects of Dose Limitation

- Patient prep (right patient, right site, removal of jewellery, pins, dentures etc – unless required for implant planning)
- Stabilise patient
- Suitable patient
- Explain scan (reminder to stay still, reassurance etc.)
- Be efficient with time – kids!

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Scout Images

- **Ensures scan volume is centred on the area of interest & ensures region of interest is included**
- Lateral View/Lateral + AP View



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Dose Limitation

- **Smallest FOV to answer clinical Q should be selected**
- Larger FOV → increased dose
- Smaller FOV → less scatter, usually smaller voxel size, smaller area irradiated, smaller volume to report and therefore less risk of including unfamiliar anatomy
- Ensure correct FOV to cover region of interest – avoid repeat scans where possible!

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Voxel Size

- Smaller Voxel Size → Higher Resolution Image – better quality?
- **Larger Voxel Size** → Lower Resolution Image but also **Lower Dose**!
- Accepting a Lower Resolution Study *usually* still answers the clinical question!



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Imaging Protocol

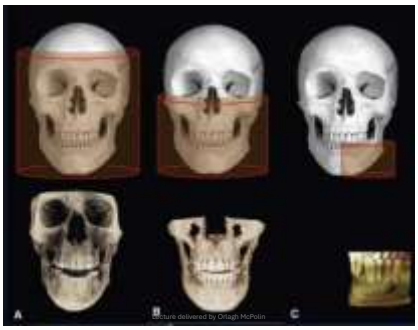
1. FIELD OF VIEW (FOV)

- Set according to the region of interest
- Linked to voxel size
- Larger FOV often lower resolution and therefore larger voxel size /lower resolution study



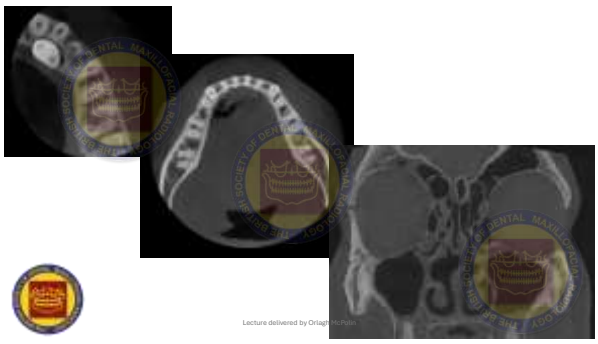
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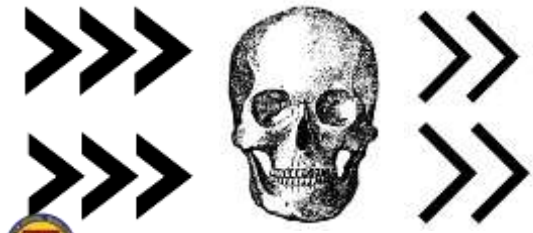
Exposure factors - **kV and mA**

kV = Tube Voltage

- Increased kV – Increase Maximum & Average Energy of X-Rays (same number of x-rays)
- Increase only if needed for larger patients/patients with dense bone

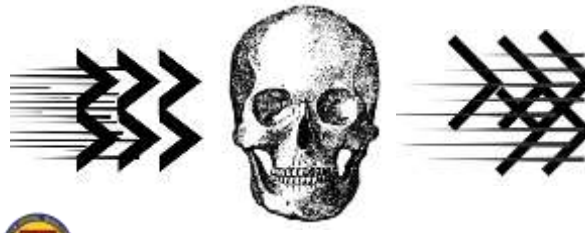
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Exposure Factors – mA/time i.e. mAs

- mA = Tube Current
- Increase mA → increased NUMBER of x-rays
- *NB Increased dose to patient!*



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Exposure type

1. Constant Exposure



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2. Pulsed beam



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3. Modulated beam

kV and mA automatically modulated in near real time

Feedback mechanism detects the intensity of the beam @ detector → Automated Exposure Control



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Arc of rotation



Shortened scan time

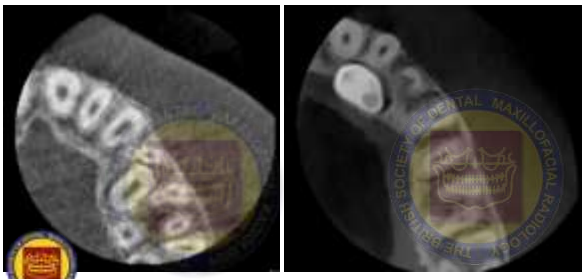
Reduced risk of patient movement! (less risk of need for repeat imaging)

Reduced dose

Reduced image quality - fewer basis projections and noisier images (i.e. grainy image)

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Quality Assurance in CBCT

Image Quality	Geometric Accuracy	Dose
Noise	Distance/measurement accuracy	Radiation output
Image density/grey-scale	Slice thickness where applicable	kV
Uniformity	Field size	Repeatability/reproducibility
High-contrast spatial resolution		DAP
Artefacts		CTDI where applicable
Display performance		

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QA Test Objects

- Alignment & Positioning
- Spatial Resolution
- Contrast Resolution
- Geometry



Leeds Test Object – CBCT 161 Mini

NB The exact appearance of test objects and inserts varies between manufacturers (QRM/Leeds etc).

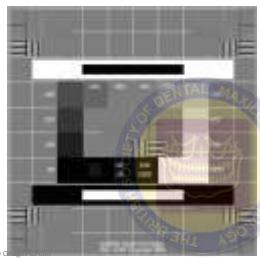
Each section of the phantom tests a different aspect of image quality & performance.

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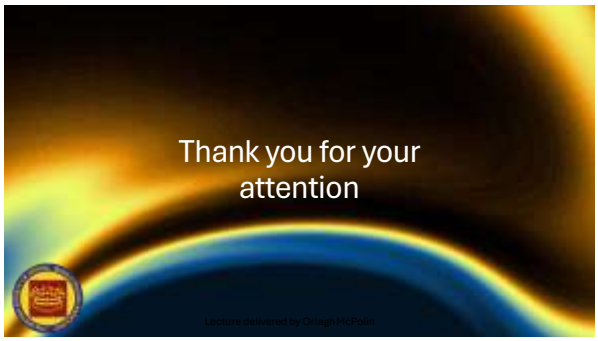
Quality Assurance – Digital Display

- **SMPTE test pattern = quality control tool** for display monitors
- Helps detect issues such as incorrect grayscale rendering, poor contrast, or resolution problems that could obscure subtle pathology



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Thank you for your attention
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