Radiography for Foundation Dentists



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BDS/BSC (HONS) RADIOGRAPHY

Aim

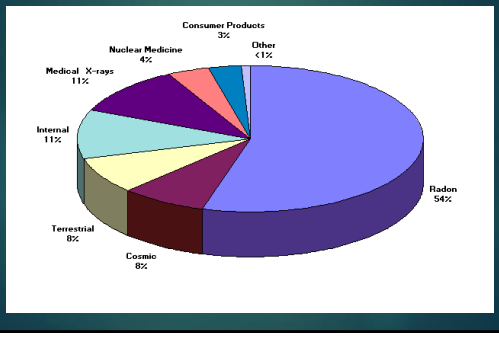
To provide foundation dentists with the information to practice dental radiography safely, efficiently and effectively

Objectives

- (1) Understand and explain radiation regulations and who they protect
- (2) Organise and maintain a QA programme for dental radiography
- (3) Understand and apply routine positioning techniques used in dental radiography
- (4) Apply current guidelines for quality assessment of dental radiographs
- (5) Recognise and correct common image faults in dental radiography
- (6) Modify radiographic technique according to individual patient needs

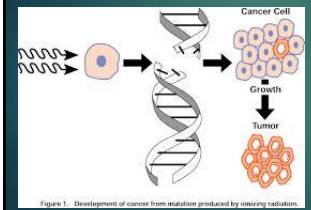
From what sources do we receive radiation exposure?

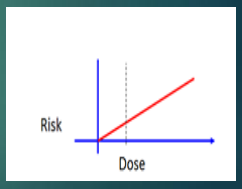
Radiation all around us



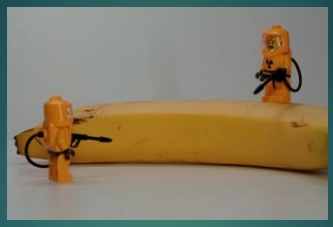
Stochastic effects

- Effects can appear in both the exposed person (somatic) or future generations (genetic)



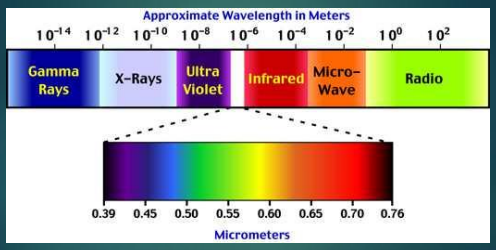


BED (Banana Equivalent Dose)



One dental x-ray?	50
Flight from London to NY?	400
Fatal dose without treatment?	80 million

EM Spectrum



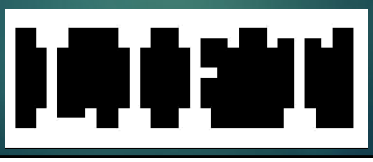
X-rays are "packets" of energy known as photons, which are short wavelength, high frequency radiation

Introduction to Radiography

- Integral part of clinical dentistry
- Clinicians "Main Diagnostic Aid"
- Knowledge divided into 4 main sections
  - ***Basic Physics and Equipment***
  - ***Radiation Protection***
  - ***Radiography***
  - ***Radiology***

VIEWING AND INTERPRETATION







Roles of Radiography

- Diagnostic Aid
  - (eg) Apical pathology?
- Treatment Planning
  - (eg) Orthodontic Treatment
- Post-treatment Appraisal
  - (eg) RCT / Apicectomy check
- Medico-legal cases

Radiograph assessment



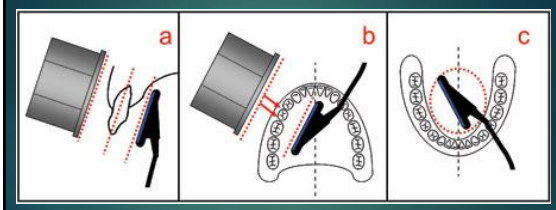
- Identification – not on dental x-rays
- Marker – pip raised when x-ray laid flat
- Area – correct area included?
- Projection – distortion? elongated? shortened?
- Contrast – black/white/grey
- Collimation – info collimated off image?
- Artefacts – dentures/necklaces/glasses etc
- Variation – anatomy normal?

Ideal Positioning

(1) Object and image receptor ***in contact*** or as close as possible

(2) Object and image receptor ***parallel*** to eachother

(3) Tubehead positioned so primary beam meets both object and image receptor at ***right angles***



Routine Radiographic Views in Dentistry

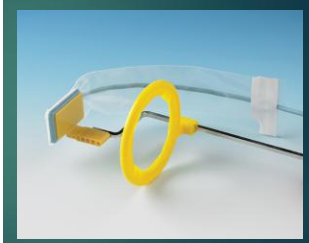
- Intraoral Periapicals (IOPA)
- Bitewings
- Orthopantomograms (OPT)
- Cone-Beam CT (CBCT)

(1) Intraoral Periapicals (IOPA)













Intraoral Periapicals (IOPA)

Indications

- Apical infection / inflammation
- Periodontal status
- Trauma to teeth and alveolar bone
- Presence and position of unerupted teeth
- Root morphology before extraction
- During endodontics (RCT)
- Preoperative assessment and postoperative appraisal of apical surgery
- Detailed evaluation of apical cysts/other lesions within bone
- Evaluation of implants postoperatively

What do you do if the patient cannot tolerate a film holder in their mouth?

BISECTING ANGLE TECHNIQUE

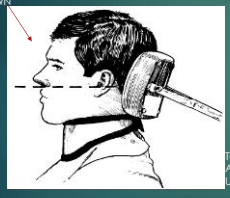
What is Bisecting angle?

- No film holder required
- Patient holds film with index finger into floor of mouth or palate
- Occlusal plane of required jaw positioned parallel to the floor
- Round collimator used instead of rectangular
- Specific angles used to get good profile view of each individual tooth
- Primary beam centred through long axis of tooth required (perpendicular)

HEAD POSITION FOR UPPER TEETH BISECTING ANGLE

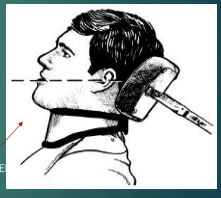
TRAGUS OF EAR → ALA OF NOSE

TUBE ANGLE DOWN



HEAD POSITION FOR LOWER TEETH BISECTING ANGLE

TRAGUS OF EAR → ANGLE OF MOUTH



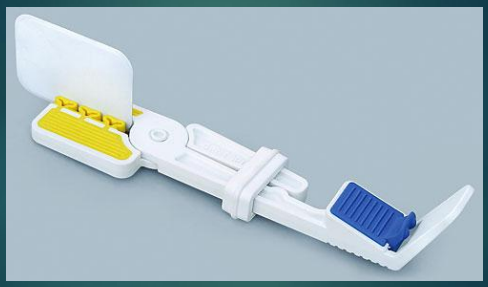
TUBE ANGLE UP



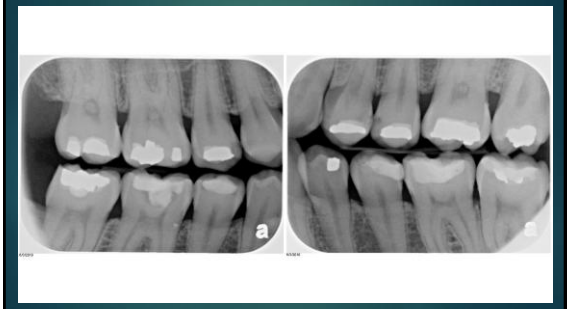
BISECTING ANGLE TECHNIQUE FOR UPPER TEETH (IN THIS CASE UPPER INCISORS)

X-RAY TUBE ANGLED DOWN FOR UPPER TEETH

	Maxilla	Mandible
Incisors	60	30
Canine	50	20
Premolars	40	10
1st and 2nd Molars	30	5
3rd Molars	25	0



(2) Bitewings



Bitewings



Indications

- Carious lesions
- Progression of dental caries
- Existing restorations
- Periodontal status

(3) Orthopantomogram (OPT)



Orthopantomogram (OPT)

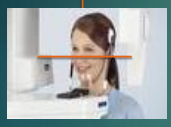
- Panoramic radiography has become very popular in dentistry for these main reasons:
  - All the teeth and their supporting structures on one image
  - Technique is relatively simple
  - Radiation dose is relatively low, especially using with modern DC units, intensifying screens or digital image receptors
  - BUT less detailed / inferior quality than IOPA's, and some areas out of focus due to movement



OPG IDEAL POSITIONING



MEDIAN SAGITTAL PLANE
CHECK IF ROTATED LEFT/RIGHT



FRANKFORT PLANE
SUPERIOR BORDER EAM TO LOWER ORBITAL MARGIN- CHECK CHIN UP/ DOWN POSITION



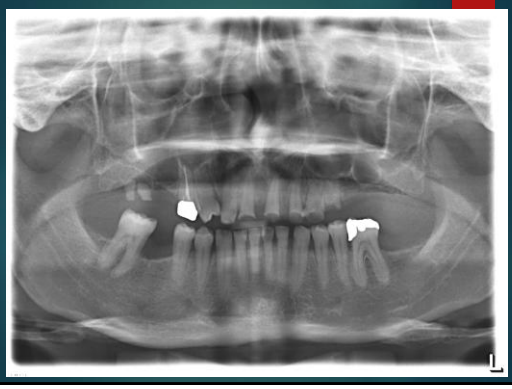
ANTERIOR TEETH GUIDE LIGHT CHECK IF TO FAR IN OR OUT OF MACHINE

NOTE **(a) OPT not suitable for <6 years old (due to length of exposure and need to stay still)**

(b) Lead apron not required – No justification for using and can interfere with final image

Orthopantomogram (OPT)

- Indications
  - Pathology of jaws
  - Maxillofacial injuries
  - TMJ disease
  - Antral disease
  - Third molar assessment – near canal, position, root morphology etc
  - Periodontal assessment
  - Bone assessment for implants
  - Orthodontic assessment
  - Prosthetic assessment





(4) CBCT

- 3D reconstruction
- 3 planes (sagittal, coronal and axial)
- **Much higher radiation dose to patient**
- **Much better detail** for specific information
- 3D imaging must have good justification for the additional radiation dose the patient will receive

Fields of View (FOV)

- Measured in cm
  - 4 x 4
  - 5 x 5
  - 5 x 8
  - 6 x 6
  - 8 x 8
  - 10 x10
  - 12 x 10

Dose Comparison

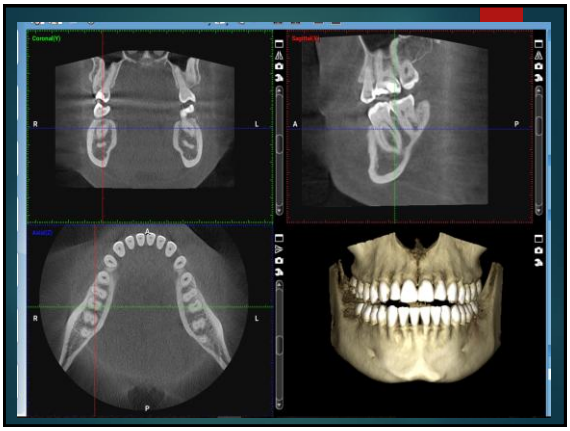
OPT – Dentition only approx. 38mGycm2

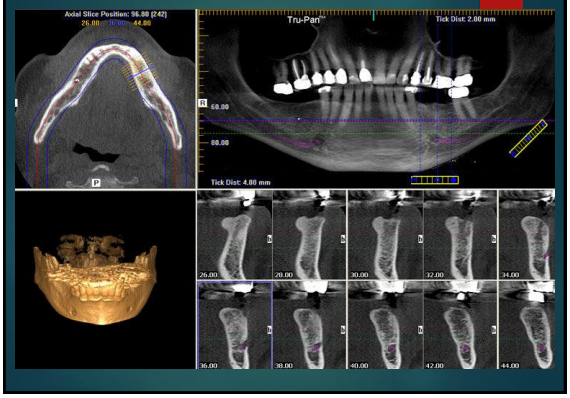
CBCT – 4 x 4cm - 3 or 4 teeth approx. 154mGycm2

- Most common is likely 4 x 4cm due small area for reporting and reduced radiation dose to patient

CBCT Main Uses

- Implant planning
- Proximity of roots to IAN
- Assessment of pathology (eg. Large cysts)
- Assessment of unerupted teeth or supernumeraries





Normal Radiographic Appearances

- Anatomical shadows (OPT)
  - **REAL SHADOWS** (aka Actual Shadows)
    - Of structures in, or close to the focal trough
  - **GHOST SHADOWS** (aka Artefactual Shadows)
    - Created by the tomographic movement
    - Cast by structures on the OPPOSITE SIDE or a long way from the focal trough
    - The 8 degree upward angle of the beam means they appear at a higher level than the structures that have caused them

OPT anatomy?



Answers

1. Coronoid Process
2. Sigmoid Notch
3. Mandibular Condyle
4. Condylar Neck
5. Mandibular Ramus
6. Angle of Mandible
7. Inferior Border of Mandible
8. Lingula
9. Mandibular Canal
10. Mastoid Process
11. External Auditory Meatus
12. Glenoid Fossa
13. Articular Eminence
14. Zygomatic Arch
15. Pterygoid Plates
16. Pterygomaxillary Fissure
17. Orbit
18. Inferior Orbital Rim
19. Infraorbital Canal
20. Nasal Septum
21. Inferior Turbinate
22. Medial Wall of Max. Sinus
23. Inferior Border of Max. Sinus
24. Posterolateral Wall of Max. Sinus
25. Malar Process
26. Hyoid Bone
27. Cervical Vertebrae 1- 4
28. Epiglottis
29. Soft Tissues of Neck (Look Vertically For Corotid Artery Calcifications Here)
30. Auricle
31. Styloid Process
32. Oropharyngeal Air Space
33. Nasal Air Space
34. Mental Foramen
35. Hard Palate

Maxillary, Temporal and Zygomatic structures

1	pterygopalatine fossa
2	pterygoid plate
3	ext auditory canal
4	zygomatic arch
5	lateral wall maxilla
6	zygomatic buttress (dashed line)
7	inferior wall maxilla
8	hard palate
9	inferior concha (arrowheads)



Mandibular Structures

1	condyle
2	neck
3	sigmoid notch
4	coronoid process
5	ramus
6	inferior dental canal
7	angle
8	body
9	mental foramen
10	symphysis mentis
11	external oblique ridge



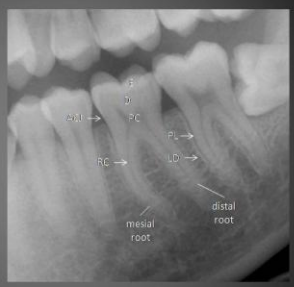
Surrounding Structures

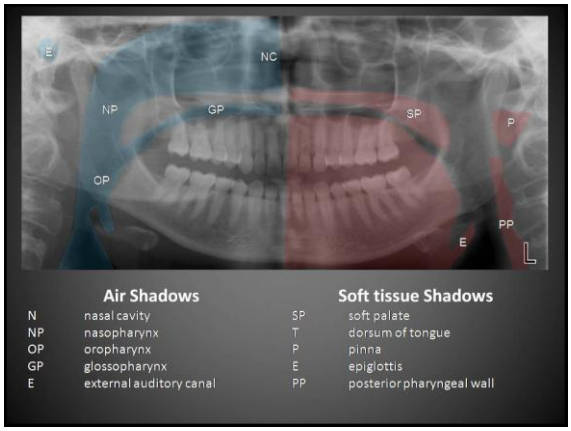
1	articular eminence
2	glenoid fossa
3	anterior arch of C1
4	styloid process
5	body of C2
6	hyoid bone



Dental Anatomy

E	enamel
D	dentine
PC	pulp cavity
RC	root canal
ACJ	amelo-cemental junction
PL	periodontal ligament
LD	lamina dura





Air Shadows

N	nasal cavity
NP	nasopharynx
OP	oropharynx
GP	glossopharynx
E	external auditory canal

Soft tissue Shadows

SP	soft palate
T	dorsum of tongue
P	pinna
E	epiglottis
PP	posterior pharyngeal wall



Ghost Shadows

HP	hard palate
M	posterior mandible
CS	cervical spine

Quality Assurance

' The purpose of Quality Assurance (QA) in dental radiology is to ensure consistently adequate diagnostic information, whilst radiation doses are controlled to be as low as reasonably practicable' (ALARP)

Guidance Notes for Dental Practitioners on the safe use of X-Ray Equipment

Quality Assurance or Quality Control?

- Quality Assurance
  - "An organised effort by the staff operating a facility to ensure that the diagnostic images produced are of sufficiently high quality so that they consistently provide adequate diagnostic information at the lowest possible cost and the least possible radiation exposure to the patient" (WHO)
  - The arrangements to ensure that the quality control measures are effective and that they lead to relevant change and improvement
- Quality Control
  - The specific measures for ensuring and verifying the quality of the radiographs produced

Quality Assurance

- Ensuring that standards are maintained at the highest level possible
  - Setting up a QA system
  - Maintaining the system
  - Clinical audit of radiographs

Quality Audit

- The process of external reassurance and assessment that quality control and quality assurance mechanisms are satisfactory and that they work effectively
- At least annual review of whole QA programme
  - Responsible person

Setting up a QA System

ALL necessary procedures should be laid down in writing, including:-

- **(1) Implementation**
  - Responsibility of a named person
- **(2) Frequency**
  - How often operations are should be defined
- **(3) Records**
  - Content of the essential supporting records should be defined
  - Frequency for the formal checking of such records

Aims of a QA Programme

- To produce diagnostic images of a consistently high standard
- To reduce the number of repeated radiographs
- To determines sources of error
- To reduce radiation dose to the patient
- To increase efficiency
- To reduce costs

Maintaining a QA System

- This is achieved by a large number of items being implemented and maintained
  - Equipment Upkeep and Patient Dose
  - Examination Rooms
  - Image receptors and processing
  - Viewing and Reporting
  - Staff Training / Working procedures
  - Image Quality and Film Reject Analysis
  - Audit

- Every dental practice should have a QA programme
- Should include a Radiation Survey
  - At least once every 3 years on a routine basis

- Exceed DRL
- Image quality fails to meet NRPB guidance
- Other significant performance weakness

Remedial action should be taken

Equipment tested more often until acceptable performance achieved

Patient Dose

- Patient dose must be monitored at all times
  - ALARP
- **Diagnostic Reference Levels (DRL's)**
  - Patient dose should be measured regularly and compared to national DRL's (IOPA = 1.2mGy)
  - Image quality audit → Reduce exposure time → Re-audit
- Equipment needs to comply with regulations in order to achieve this

- Equipment log and records
  - Installers written reports – checks, results and action
  - Results of all equipment checks in chronological order
  - Routine / Special maintenance details
- **Up-to-date Inventory**
  - Required by IR(ME)R 2018
    - Name of manufacturer
    - Model Number / Serial number
    - Year of manufacture / installation

IPEM Report '91

- Institute of Physics and Engineering in Medicine (IPEM)
- Specific dental radiography chapter (9)
- Routine performance tests on x-ray equipment in practice or hospital



Performance Tests

- Simple tests (Level A)
  - Dental Practice Staff
- Complex tests (Level B)
  - Trained personnel from equipment suppliers
  - Periodic testing by medical physicists
  - Other agencies which provide advisory services to dentists

Dental Radiography

Level A	Level B
• Condition of digital detectors	• Tube voltage
• Image quality	• Exposure time
• I/O image uniformity	• I/O beam size/collimation
• Panoramic uniformity and reproducibility	• I/O limiting spatial resolution
• Panoramic beam alignment and synchronisation of exposure with tube motion	• I/O dose at collimator tip for adult molar radiograph
	• Panoramic beam size/collimation
	• Panoramic DAP

Daily Room Checks

- Exposure Warning Light Function
- Audible Alarm Function
- Counter Balance Arm Function
- Date and sign to confirm checked



QA Tests

- Constancy test
- Uniformity and Beam Alignment
- DENTest Phantom
  - Image Quality of whole system
- Monitor Calibration
- Exposure Release
- Emergency Stop

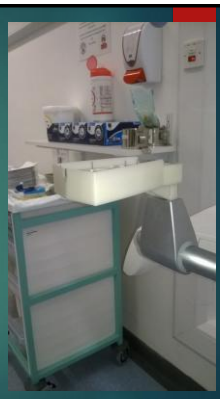
Instructions and Record Sheets

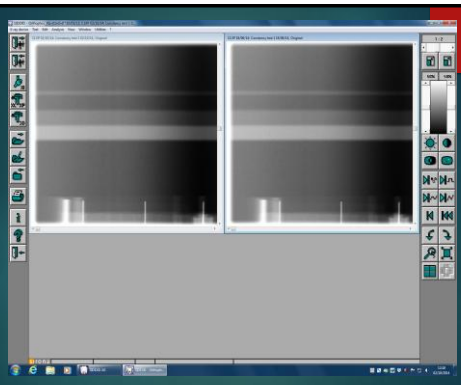
- Written Protocol for each specific test (reproducible)
- Should include frequency
- Clear instruction of what to do with results
- Can generate graphs etc to identify trends
- Baseline/Action levels should be outlined
- Active sign off

Constancy Test (OPT)

- Carried out every month
- Needle phantom used for exposure
  - Set exposure values
  - Phantom supplied with unit
- Test image produced
  - Compared to previous month







2D Constancy Check

Uniformity and Beam Alignment (OPT/Ceph)

- Select QA patient on system
- Select <u>same</u> exposure each time (eg. paeds exposure)
- 1mm copper plate
- Take exposure and view image
- Check for artefacts and non-uniformities
- Check edge of radiation field visible on image
- Record PASS or FAIL

<u>BASELINES</u> SHOULD ALWAYS BE TAKEN INITIALLY AND USED TO COMPARE SUBSEQUENT TEST IMAGES TO



OPT UNIFORMITY IMAGE



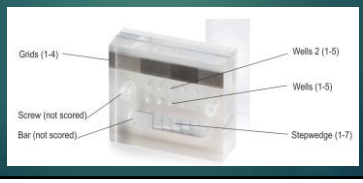
CEPH UNIFORMITY AND BEAM ALIGNMENT

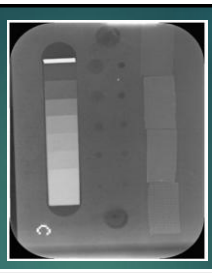
DENTAL X-RAY UNIFORMITY AND RADIATION ALIGNMENT TEST

DATE	UNIFORMITY		COMMENTS	TESTED BY	REPORTED TO
ROOM 3 OPT	PASS	FAIL			
ROOM 3 OPT	RADIATION ALIGNMENT				
	PASS	FAIL			

DENTest Phantom

- Select QA patient
- Select same exposure factors (lower anterior)
- Place phantom on Size 2 PSP
- Align rectangular collimator to phantom
- Make exposure and assess test image





Group	Guide	
Step wedge	Count the number of distinct steps seen	All 7 steps and bar should show clearly
Grids	Count how many grids are clearly seen	Usually 3 of the 4 show well
Wells	Count the row of wells large to small	All 5 should show clearly
Wells 2	Count the row of small wells	All 5 should show clearly

APPENDIX A

MONTHLY DENTEST QA PHANTOM RESULTS SHEET

DATE	STEP WEDGE	GRIDS	LARGE & SMALL WELLS	SMALL WELLS	PASS OR FAIL	TESTED BY	REPORTED TO
ROOM 1 and VISTASCAN COMBI PLUS RECEPTION							
ROOM 2 and VISTASCAN COMBI PLUS DARKROOM							

Digital Radiography

- Similar QA procedures to film-based radiography
- Theoretically, image quality should be improved:
  - Chemical processing errors eliminated
  - Most exposure errors can be compensated for by using computer software particularly when using PSP
- Very easy to repeat radiographs
  - Properly justified?
  - Recorded ?
  - Included in QA statistics?

Digital Image Receptors

- 2 different types
  - **Phosphor Storage Plates (PSP)** - have no wires
  - **Charge-Coupled Devices (CCD)** - wired
- Cleaning
  - Recommended cleaner according to manufacturer (eg) Durr
- Checking
  - Scratches / frayed edges
  - Damaged receptors removed from circulation
- Handling
  - Gloves prevent damage
  - Double bag receptors?

TABLE 5.1 **Recommended schedule of QA tests for digital image receptors**

Test	Frequency	Fail criteria
1 Visual inspection	Three-monthly, or whenever damage is suspected	Damage to wires, casings or phosphor
2 Image uniformity	Three-monthly, or whenever damage is suspected	Evidence of significant deterioration compared to baseline image. Any artefact that may affect clinical image quality
3 Subjective check of image quality	Three-monthly, or whenever damage is suspected	Evidence of significant deterioration compared to baseline image





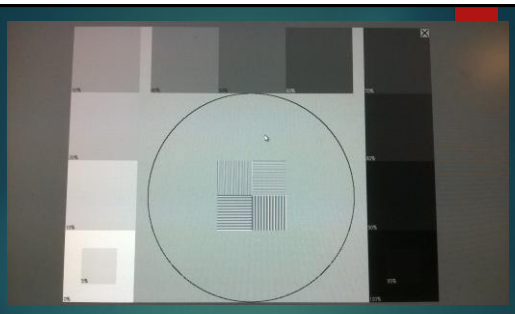

Viewing Radiographic films

- Viewing Boxes
  - Fluorescent Tubes
  - Cleaning
- Screen Quality (monthly)
  - Better resolution means more accurate diagnosis
  - Medical grade screens
  - "Monitor Calibration Test"

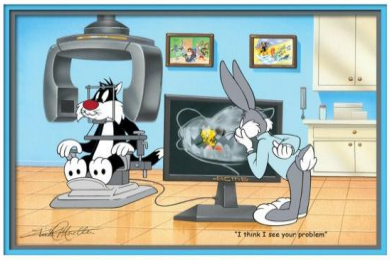


Medical Grade Screens

- Guidance available
  - Royal College of Radiologists (RCR)
- Minimum recommended screen resolution
  - 1.3 Megapixels (1280 x 1024)
- Resolutions up to 3 Megapixels (1500 x 2000)
- Screens at SOD = **1.9 Megapixels** (1600 x 1200)



- **Should be clear definition between 0 and 5% image (lower left)**
- **Should be clear definition between 95 and 100% image (lower right)**
- **Colour change between each box should be visually apparent**
- **Circumference of circle should be clearly defined (no large steps)**
- **Vertical and Horizontal lines should be clearly defined**



Working Procedures

- **Local Rules**
- **Employers Procedures**
- **Systems of Work**
  - Written procedures for all actions that INDIRECTLY affect radiation safety and diagnostic quality
- **Procedures Log**
  - To record review of the above with regards to QA programme
  - Ideally <12 month review

Staff Training

- Register of all Staff
  - Name, Responsibility, Date/details of training, recommended date for training review
- Training register should include:
  - Details of training provided for staff under IRR (NI) 2000
- All IR(ME)R practitioners and operators must:
  - Be adequately trained
  - Undertake CPD

Clinical Audit

- Annual Review of full QA Programme (at least)
- Written records
  - Every procedure within the programme
  - Carried out by person responsible for programme
- Possible Clinical Audits
  - QA programme and associated records
  - Justification and Authorisation
  - Clinical Evaluation of radiographs

Image Quality audit

- Carried out twice a year
- Should include at least 100 images
- **Different types of examinations should be looked at separately where possible**
  - (e.g. OPTs not included with periapicals and BWs)



FILM REJECT ANALYSIS

- To calculate the amount of reject images as a percentage and from this to investigate the reasons for the rejects and how improvements can be made
- To establish a baseline for the QA programme
- To provide a means for early detection of changes/errors
- Once per month to look at errors and causes

QA Manual

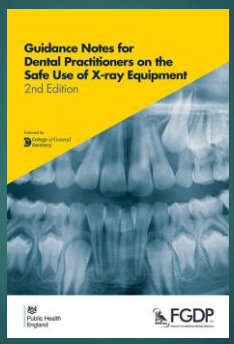
- Folder containing all QA material
- Local QA policy
- Responsible staff list
- Protocols
- Result Sheets
- Baseline values
- Testing equipment list
- Reference material
- Contact names/numbers

Image Quality Assessment

Current professional dental guidance for assessing the quality of radiographs:

- Grading System
  - Grade A – Diagnostically Acceptable
  - Grade N – Not acceptable

PROFESSIONAL GUIDANCE



Good Quality Image?



Radiograph assessment

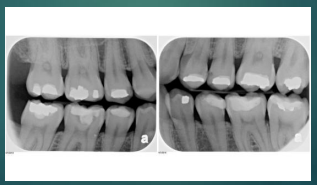


- Identification – not on dental x-rays
- Marker – pip raised when x-ray laid flat
- Area – correct area included?
- Projection – distortion? elongated? shortened?
- Contrast – black/white/grey
- Collimation – info collimated off image?
- Artefacts – dentures/necklaces/glasses etc
- Variation – anatomy normal?

Gold standard



- Excellent Quality
- **No errors of patient preparation, positioning, exposure, processing or film handling**



Quality Standards for **Periapical Radiography** (IOPA)



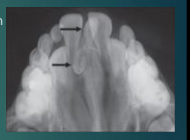
- Evidence of optimal image geometry
  - No overlap / elongation / shortening etc
- Correct anatomical coverage
  - Teeth in question from crown to root apex
- Adequate number of films
  - To cover area required
- Adequate processing and film handling techniques
  - No scratches / streaks etc

Quality Standards for **Bitewing Radiography**



- Evidence of optimal geometry
  - Contact points should be clear
  - No overlap
  - Cusps should be superimposed
- Correct anatomical coverage
  - From 1st premolar to 2nd molar (4-7)
- Good density and contrast
  - Caries can be diagnosed easily
- Adequate processing and film handling techniques
  - No scratches / streaks etc

Quality Standards for **Occlusal Radiography**



- Evidence of optimal geometry
  - No elongation/foreshortening of anterior teeth
- Correct anatomical coverage
  - As far back as possible
- No rotation
  - Centred to patient's midline, head straight
- Good density and contrast
- Adequate processing and film handling techniques

Quality Standards for **Panoramic Radiography** (OPT)



- Patient preparation / instruction adequate
  - No earrings / jewellery, tongue to roof of mouth
- No patient positioning errors
  - Mid-sagittal plane vertical, frankfort plane horizontal
- Correct anatomical coverage
- Good density and contrast
- No image receptor problems
- Adequate processing techniques

Quality Standards for **Cephalometric Radiography**



- Patient preparation / instruction adequate
  - No glasses, back teeth together etc
- No patient positioning errors
  - Not rotated, sides of mandible superimposed etc
- Correct anatomical coverage
  - Soft tissue border included, lower border of mandible, bridge of nose etc
- Good density and contrast
- No image receptor problems
- Adequate processing techniques

Diagnostically Acceptable (A)



- Excellent or Good Quality
- **No errors of patient preparation, positioning, exposure, processing or film handling**

OR

- **Some errors of patient preparation, positioning, exposure, processing and film handling**
- Image is of **adequate diagnostic quality** for the intended purpose and is therefore accepted! Clinical query can be answered!

Not Acceptable (N)



- Poor Quality
- Significant error(s) of patient preparation, positioning, exposure, processing and film handling
- These errors render the image diagnostically unacceptable, as the clinical query cannot be answered
- Repeat radiograph will be required
- Record of date, nature of deficiency, known or suspected cause, number of repeat radiographs for reject analysis

Minimum Targets for Radiographic Quality

NEW GUIDANCE is…..

GRADE A (min 95%)
GRADE N (max 5%)

OLD GUIDANCE TARGETS

QS Rating	% of radiographs taken
Grade 1 (excellent)	Not less than 70%
Grade 2 (acceptable)	Not more than 20%
Grade 3 (unacceptable)	Not more than 10%

TABLE 5.2 **Subjective image quality ratings of dental radiographs and CBCT images**

Quality rating	Basis	Target (percentage of radiographs or CBCT images in sample)	
		Digital imaging	Film imaging
Diagnostically acceptable ('A')	No errors or minimal errors in either patient preparation, exposure, positioning, image (receptor) processing or image reconstruction and of sufficient image quality to answer the clinical question	Not less than 95%	Not less than 90%
Diagnostically not acceptable ('N')	Errors in either patient preparation, exposure, positioning, image (receptor) processing or image reconstruction which render the image diagnostically unacceptable	Not greater than 5%	Not greater than 10%

Remedial action

Not meeting guidelines

↓

Reason deduced from audit

↓

Corrective action carried out

↓

Equipment fixed | **Improved technique** | **Staff training**

Quality Assessment

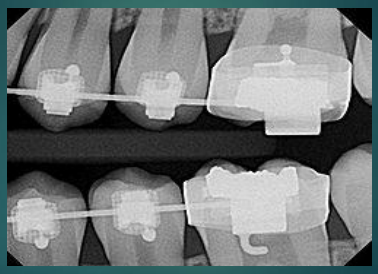
Are these dental radiographs……

-Gold standard
-Acceptable (A)
-Not acceptable (N)?

Radiograph 1



Radiograph 2



Radiograph 3



Radiograph 4



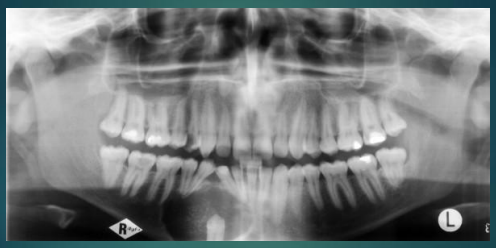
Radiograph 5



Radiograph 6



Radiograph 7



Radiograph 8



Radiograph 9



Ionising Radiation Regulations

- Ionising Radiation Regulations 17
  - **IRR17**
- Ionising Radiation (Medical Exposure) Regulations 2018
  - **IRMER18**



Who do they protect?

- IRR17
  - Staff
  - General Public
- IR(ME)R18
  - Patients



*IRR 17

- Regulations that protect staff members and the general public from ionising radiation
- **Local Rules** are required by these regulations
- Enforced by **HSENI**

"Local Rules"

- Under current Health and Safety legislation, the dentist/trust as an employer is responsible for ensuring the safety, health and welfare at work of his or her employees and others who may be affected by his or her work activities
- Individual workers also have certain responsibilities and these are included in the ***Local Rules***
- ***Radiation Protection Supervisor*** (RPS)
  - Ensures compliance of staff with these rules

(1) **Restriction of Exposure / Personnel Monitoring**
- Dosimeters
- Trunk / chest / waist
- Warning lights / notices
- Locks / Emergency off
- Clearly marked controls
- Exposure switches require continuous pressure
- PPE

(2) **Employee Investigation Level**
- If exceeded.....RPS investigation

Dosimeters

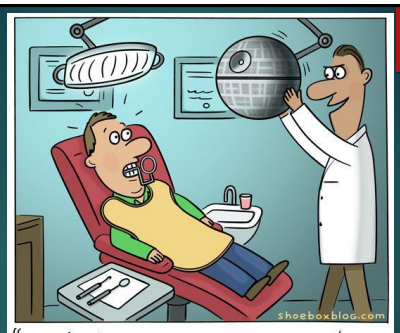


- Trunk (chest or waist) level
- Under protective clothing
- Change at appropriate time
  - No longer than 3 month period
  - Returned by the RPS
  - Approved Dosimetry Service (ADS)
- Do not
  - Leave in controlled area
  - Leave in extremes of heat/humidity
  - Get wet
  - Wear when subject to own medical exposure

- Damaged or lost dosimeters should be reported to RPS and replaced immediately
- Inadvertent irradiation – report to RPS
- Unforeseen exposure of anyone – RPS
- Records kept for 2 years
  - Available for inspection
  - Regularly reviewed by RPS
  - Ensures Dose investigation level not likely to be exceeded



(3) **Controlled areas / Restriction of access**
- Only remain in controlled area if presence required for procedure or training purposes
- Must use protective clothing/screens
- Any Direction within **1.5m** of the tube head



(4) **Systems of Work**
- Dose Investigation Level
- Personal Dosimeters according to guidelines
- Requirement to put procedures in place to estimate doses to members of the public

GENERAL

- Staff should not expose themselves or others more than necessary for work purposes
- Protective Equipment and Dosimeters (always)
- Exposure factors should be minimised to reduce patient radiation dose (ALARP)
- Remain outside controlled areas until warning light out
- Can **ONLY** expose if entitled/trained to do so
- Trainees must be supervised by senior staff
- Senior staff must ensure Local Rules are followed
- All staff should know Employers Procedures (IRMER)

- X-ray equipment must not be deliberately misused or tampered with
- Do not direct beam at doors or protective screens
- All staff should be aware of ***"Emergency Off"*** and mains isolation switches
- Turn off all X-ray equipment at end of day
- Faults reported immediately to RPS
  - Can lead to additional radiation exposure
    - Exposure fails to terminate
    - Emergency stop activated
    - Other parameters fall outside limits

STAFF PREGNANCY

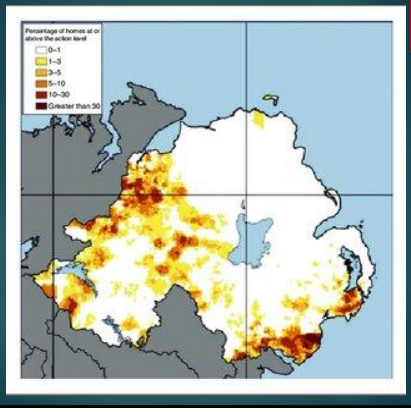
- Staff who become pregnant should inform employer via RPS in **writing ASAP**
- Risk to the foetus assessed/duties adjusted
- **CANNOT** support patients



Background Radiation

- ***Average annual dose in NI = 2.5mSv (adults)***
- 1-8 mSv depending on where you live
- Radon not thought to affect baby, so when excluded from background radiation = 1-3 mSv/year

Therefore, ***MOVING HOUSE COULD RESULT IN A LARGER INCREASE IN FOETAL RADIATION DOSE THAN MOST OCCUPATIONAL DOSES!!!***



EXPOSURE OF FEMALE PATIENTS OF REPRODUCTIVE CAPACITY / PREGNANT PATIENTS

- Intraoral, panoral or cephalometric examinations can be carried out ***without*** enquiry into pregnancy
- If patient is concerned about radiation in pregnancy, lead apron can be used as reassurance (but is not a necessity)

CONTINGENCY PLANS

Significant event – needs to be reported to HSE

- Reasonably foreseeable accidents, occurrences or incidents involving the radiation sources
  - Failure of an X-ray unit to terminate exposure
  - Unintentional dose of ionising radiation
- If fault suspected
  - Isolate x-ray unit from the mains supply via emergency off button
  - DO NOT use again until unit investigated and serviced
  - Notice should be placed on unit to inform staff

ACCIDENTAL OVEREXPOSURE

- Report immediately to RPS/line manager
  - Initial Investigation
- Details of incident recorded
- RPS will liaise with RPA and Employer (if not clear)
  - Detailed Investigation

CHECKS OF PROTECTIVE APRONS

- Each apron must be uniquely identified
- Examined visually **at least once per year** to ensure that they remain undamaged
- **DO NOT FOLD APRONS!!!**
  - Store flat or hung over a rail

CHANGES TO BUILDINGS, EQUIPMENT OR PROCEDURES

- RPA must be informed
  - Review risk assessment
  - Review adequacy of person protection
  - Review designation of work areas
  - Critical examination of new installations

RECORDS

- Radiation risk assessments
- Equipment
  - Inventory
  - Critical examinations
  - Maintenance/modification and fault log
  - QA
- Medical Physics work and actions taken
  - Radiation Protection Surveys
  - Equipment Performance Surveys
  - Patient Dosimetry Surveys

Operating Rules

- **Operator Position**
  - Outside dental surgery
  - Behind walls/protective panel
  - As far from X-ray tube as possible
- **Warning lights**
  - Under observation at all times
- **Beam Direction**
  - Never pointed at doors, windows or operator position

RPS Duties

- Ensure work in accordance with Local Rules
- Liaison with Clinical Lead and RPA
- Critical Examination of equipment before use
- Ensure tests of engineering controls, design features, safety features and warning devices are carried out at suitable intervals
- Notify RPA if changes to equipment, room layout or technique that may affect radiation protection

- Consult with RPA on radiation safety matters
- Adequate staff training
  - Especially before new equipment/procedures
- Keep up-to-date records
  - PPE examination / Supporting patients / Pregnancy notification
- Supervise dosimeter usage
- Report overexposure incidents
  - Line manager and RPA
- Review Local rules

RPA Duties

- A suitably trained RPA must be appointed in writing and consulted for advice under IRR 99/2000
- Should be an **EXPERT** in radiation protection
- Advice for compliance with the regulations
  - Controlled areas
  - Installation of new or modified equipment
  - Periodic examination and testing of engineering controls, safety features and warning signals
  - Systems of work
  - Risk assessment
  - Contingency plans
  - Staff training
  - Assessment and recording of doses received by patients

Significant Events

- Significant events must be recorded and analysed
- Advice of the RPA should be involved
- Also record near misses
- In accordance with IRR17
  - **Significant event is one that triggers a contingency plan**
    (eg) Having to hit the emergency stop during an exposure

*IR(ME)R 2018

- Regulations that protect patients from ionising radiation
- **Employers Procedures** (for the undertaking of medical dental x-ray exposures) are required by these regulations
- Regulated by **RQIA** in Northern Ireland

IR(ME)R 2018

- 4 Duty Holders
  - ***Employer***
  - ***Referrer***
  - ***Practitioner***
  - ***Operator***

- (1) **EMPLOYER**
  - Carries out or engages others to carry out medical exposures or practical aspects at a given installation
  - Sets written procedures/rules for other staff to follow
- (2) **REFERRER**
  - Refers the patient
  - Must supply sufficient medical information for practitioner to justify exposure

- (3) **PRACTITIONER**
  - Justifies the ionising radiation exposure
  - Benefit vs Risk Assessment
- (4) **OPERATOR**
  - Carries out practical aspects of exposure
  - Pressing button, collimating beam, identifying patient, QA measurements
  - Entitlement forms may be required

ENTITLEMENT

Registrant Group	IR(ME)R Duty Holder	Qualifications/Training/Experience required
Dentist	Referrer	Registration with GDC *with additional training if requesting CBCT*
	Practitioner	Registration with GDC and undergraduate dental degree
	Operator	*Undergraduate dental degree and* local equipment training
Dental Nurse	Operator	*Diploma or certificate in Dental nursing (include radiography if taking radiographs) and* local equipment training
Dental Hygienist/Therapist	Referrer	Registration with GDC and *appropriate qualification e.g. Diploma in Dental Hygiene and Dental Therapy with additional skills development*
	Operator	*Appropriate qualification and* local equipment training

ENTITLEMENT FORM

Operator tasks at XXXXX Practice	Assigned as competent Date & signature/initials of duty holder and assessor
Competent to authorise all dental exposures for which guidelines have been provided by a practitioner	
Competent to undertake all dental examinations	
Competent to undertake intra oral examinations	
Competent to undertake OPG / Lat Ceph examinations	
Competent to undertake cone beam CT dental examinations	
Competent to process dental films	
Competent to change chemicals in a dental processor	
Competent to process CR plates	
Competent to process a digital image	
Competent to clinically evaluate all dental examinations undertaken at the practice	
Competent to clinically evaluate all dental examinations undertaken outwith the practice	
Competent to clinically evaluate cone beam CT dental examinations	

ASSESSOR CAN BE ANOTHER EXPERIENCED DCP

RQIA IR(ME)R INSPECTIONS

- Approx. number of films taken per year
- Protocols for all procedures (signed, dated and review date)
- Exposure chart for each unit (signed and dated)
- Records of CPD training – Dentists and DCPs
- Inventory of equipment – make, model, serial number, year of manufacture, year of installation
- Competency checks for training in IRMER roles – Dentists and DCPs
- Entitlement forms – all duty holders
- Evidence of QA programme/Image Quality Audit
- Copies of Employer's procedures
- Radiation Protection Policy

Justification

- Every exposure must be:
  - **Justified by the Practitioner**
  - **Authorised by the Practitioner** (physical recording that the exposure is justified – usually signed)
- Research exposures must be approved by an NHS Research Ethics Committee
- Medico-legal exposures must comply with the Employers Procedures

Dose Optimisation

- Doses kept **ALARP** (As Low As Reasonably Practicable)
- Responsibility of Operator and Practitioner
- Operator to pay special attention to QA, patient dose and DRL's set out in Employers Procedures
- Research – voluntary, informed of associated risks, dose constraints adhered to

"Employers Procedures"

- **Accepting a referral for dental exposure**
  - Referring to yourself
- **Identifying patients correctly**
  - Operator is responsible
  - If patient cannot identify themselves, ask relative, nurse or carer

- **Identification of IR(ME)R Roles**
  - Referrer = Registered Dental Practitioner
  - Practitioner = Registered Dental Practitioner
  - Operator = Registered Dental Practitioner, hygienist, therapist, trained dental nurse. Suitably trained medical technical officer or clinical scientist (purposes of QA measurements)

- **Medico-legal / 3rd Party Exposure**
  - Exposure where primary benefit is **not** for health reasons
  - Written protocols
  - Diagnostic Reference Levels (DRL)
  - Optimisation
- **Females of child-bearing age**
  - Not routinely asked in dental.....Not directed at pelvis
  - Exposure justified? Yes.....can proceed with consent, No.....delay
  - Explain risk/dose to foetus is negligible
  - Can use lead apron if patient wishes (reassurance)

- **Ensuring QA Programmes are followed**
  - **BOTH WRITTEN PROTOCOLS AND EQUIPMENT**
  - Employers procedures, DRL's and written protocols for dental x-ray examinations (reviewed annually)
  - EQUIPMENT QA important to ensure optimal doses are being given to patients
- **Assessment of patient dose**
  - Operators should set exposure factors according to standard exposure charts beside x-ray equipment

- **Use of Diagnostic Reference Levels (DRL)**
  - Proposed by the NRPB for Intra-orals / Panorals
  - If over these levels:
    - RPS – thorough review of radiographic procedures
    - RPA – Improve current techniques, justify continual use
- **Research (Biomedical or Medical)**
  - Special consideration for research exposures
  - **RPA (Radiation Protection Advisor) MUST BE CONSULTED BEFOREHAND**

- **Benefit and Risk information**
  - Given to patients before exposure
  - Posters
- **Recording of clinical evaluation of each dental x-ray examination**
  - Referrer is responsible
  - Requires dentist signature (and operator if different)
- **Exposures much greater than intended**
  - Operator must notify employer
  - Employer investigation with RPA advice
  - Steps to prevent reoccurrence

- **Ensuring that the probability and magnitude of accidental or unintended exposures are minimised**
  - ID checked
  - Operators are properly trained
  - Equipment isolated from mains when not in use
  - Equipment maintenance (checked before re-use)
  - QA programmes in line
  - Operators adhere to written protocols for examinations using each piece of equipment

- **Radiation Incident Reporting**
  - RPS informed if any incident where unintended or accidental exposure
- **Clinically Significant unintended or accidental exposure**
  - Patient needs to be informed if deemed significant
  - Speak to Medical Physics Expert
- **Carers and comforters**
  - Knowingly and willingly incur radiation exposure while helping or supporting others
  - **Individually justified** as part of justification process
  - Dose constraints and guidance required for carers and comforters

- **Equipment QA**
  - Adequate testing
    - Before use
    - Regular intervals
    - After major maintenance
  - Implement measures to improve inadequate or defective equipment
- **Patient dose and risk information**
  - Enforcing authority should provide a report relevant to radiation protection in respect of medical exposures
  - Lessons learned from significant events and accidental/unintended exposures
  - (eg) IRMER annual report from the CQC or RQIA

- **Medical Physics Expert (MPE)**
  - Appointed and involved in exposures
  - Must be registered and meet competence criteria
  - Must be involved in….
    - Individual radiation protection matters
    - Advice on regulation compliance
    - Equipment performance and QA
    - Optimisation
    - Analysis of accidental/unintended exposures
- **Audit**
  - IRMER audits need to be carried out regularly for patient protection
  - Specify audits carried out in practice

Equipment QA and IRMER

QUALITY AND SAFETY CHECKS ON EQUIPMENT

- Co-ordinated by responsible person (probably RPS of department/practice)
- Radiation Safety Assessment of equipment at intervals **NOT MORE THAN 3 YEARS**

FILM PROCESSING

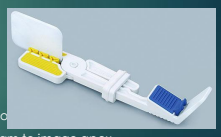
- Appropriate tests in the QA Programme should be carried out at recommended interval
- Manufacturers instructions
- Fully Documented
- Ensures ADEQUATE IMAGE QUALITY

Problematic Clinical Scenarios

- Mandibular third molars
- Gagging
- Endodontics
- Edentulous ridge
- Children
- Special needs

Mandibular third molars

- Problems
  - Placement of image receptor far back (gagging)
  - Getting whole tooth on film
  - Paralleling holder may not work
- **Solutions**
  - "Snap-a-ray" (specially designed ho
  - Can use different angulation of beam to image apex





New Angle (aiming

Initial Angle (90

Gagging

- Problems
  - Pronounced gag in some patients
- **Solutions**
  - Anaesthetic lozenge
  - Concentrate on deep breathing
  - Bisecting angle Technique
  - Distraction techniques

Endodontics

- Problems
  - Placement of receptors when rubber dam, files etc
  - Identification and separation of canals
  - Assessing root canal lengths when elongated or foreshortened images
- **Solutions**
  - Endodontic holders (endoray)
  - Canals can be separated by parallax (2 views)
  - Accurate pre-op paralleling radiograph
    - Reduced distortion than BSA



Edentulous ridge

- Problems
  - Image receptor placement
  - Loss of height in palate or FOM
- **Solutions**
  - Bisecting angle techn
  - Cotton wool rolls



Children

- Problems
  - Difficulty placing image receptor
  - Small mouths
  - Difficulty with co-operation
- **Solutions**
  - Holders for patients with large enough mouths
    - Reproducible for trauma review
  - Bisecting angle technique (modified occlusal?)
  - Careful patient selection
  - OPT may be required if child cannot tolerate intraorals

Special needs

- Problems
  - Difficulty obtaining co-operation
  - Anatomical difficulties
    - Large tongue
    - Small mouth
    - Tight oral musculature
    - Limited neck movement
    - Narrow dental arches
    - Shallow palate
  - Neurological disabilities
    - Communication/Learning difficulties
    - Tremor
    - Palsy

- **Solutions**
  - Careful patient selection
  - Be realistic about patient tolerance/co-operation
  - Choose image receptor of correct size and type
  - Modify technique as required (?BSA)
  - Utilise assistants
    - Relative/Friend if possible
  - X-ray under GA before treatment
  - Avoid OPT if patient cannot stay still for long
  - Paralleling technique where possible
    - Not reliant on head position

- Personal experience
  - Bitewings difficult in those under 5
    - Mouth too small
    - Cannot maintain bite on holder
  - Autism may affect sensory
    - Enhanced gag
    - Cannot tolerate holder in mouth
  - Movement artefact
    - Need to be quick!! ☺

Clinical Tips

- As few people in room as possible
- Don't dive in too quickly
  - Small talk
- Speak to them on their level
- Explain the procedure

- Get parent involved
  - Determined parent may be helpful
- Position carefully
  - Ideally want success after first time
- Be quick once child decides to co-operate



If all else fails?

Reasons for Rejected Films

- Patient Factors
- Exposure Faults
- Positioning Errors
- Opacities
- Equipment Faults
- Digital Processing errors

(1) Patient Factors

- Patient Movement
- Thin (dark) / Thick (pale) patient tissues
- Patient biting **too hard** on film packet
- Gag reflex



PATIENT MOVEMENT



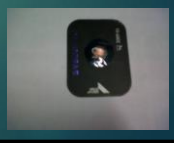
Vertical movement during exposure

(2) Exposure Faults

- Underexposed
  - Wrong exposure time set by operator
  - Exposure switch not depressed for whole exposure
  - Faulty equipment (eg) timer
- Overexposed
  - Wrong exposure time selected by operator
  - Faulty equipment (eg) timer
- Double Exposure

(3) Positioning Errors

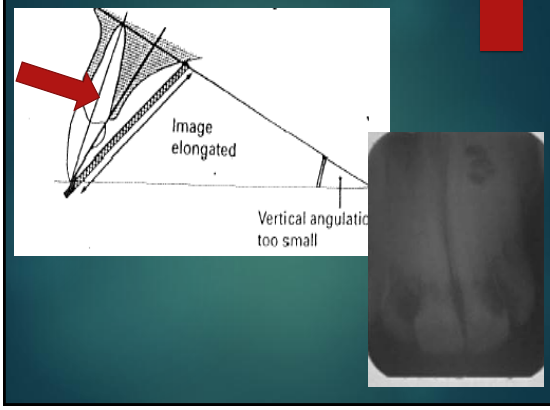
- IOPA
  - Improper VERTICAL angulation of tubehead
    - Elongation / Foreshortening of roots
  - Improper HORIZONTAL angulation of tubehead
    - Contact points overlapped
  - Distortion of teeth due to film bending in corner of arch
  - Black lines caused by bent film
  - Areas collimated off image
  - Film around WRONG way

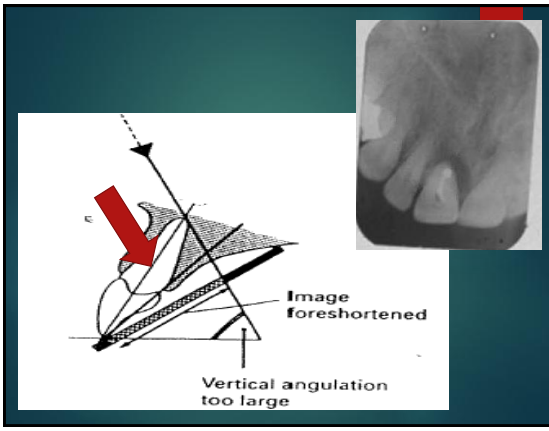




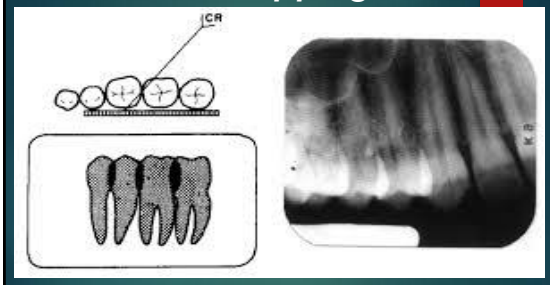
Elongation and Foreshortening

- Elongation
  - X-rays perpendicular to object (tooth), but ***not to film***
- Foreshortening
  - X-rays perpendicular to film, but ***not to object***
- Distortion
  - Object and film perpendicular
  - X-rays ***not perpendicular to either***





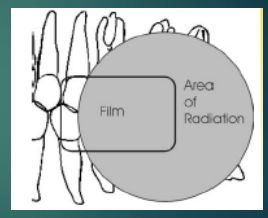
Overlapping

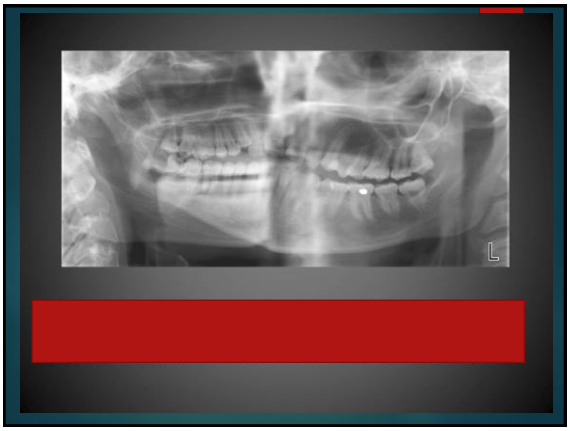


Not good for IOPAs! Cannot accurately diagnose caries☹

Coning off anatomy









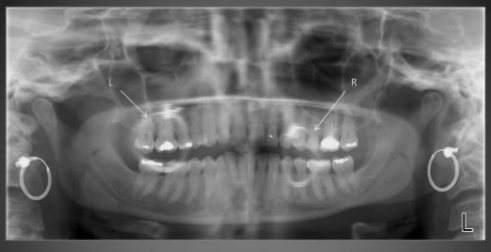
Chin up

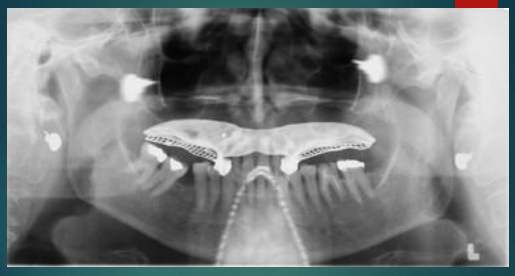
Chin down



(4) Opacities

- Earrings
- Necklaces
- Piercings
- Dentures
- Orthodontic Appliances
- Glasses
- Inappropriate use of lead apron





Nightmare! Not one you would be proud of ☺
All that's missing is glasses!



Oh wait! There they are☺



What on earth could this be?

Thyroid shield

(5) Equipment Faults

- Faulty exposure timer
- Counter-balanced arm faulty



(6) Digital Processing errors

- Peeling of PSP edges
- Fingerprints / Fingernails
- Bending of films
- Scanner errors



Spot the film faults!!!

None of us are perfect all of the time



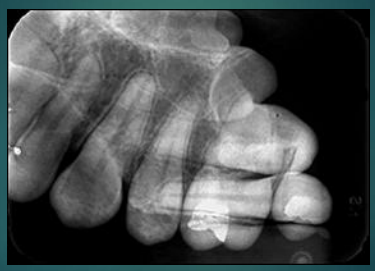
1.



2.



3.



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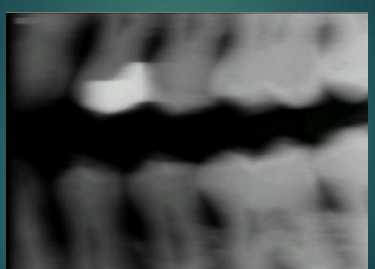
5.



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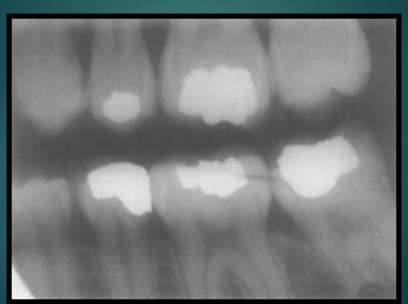


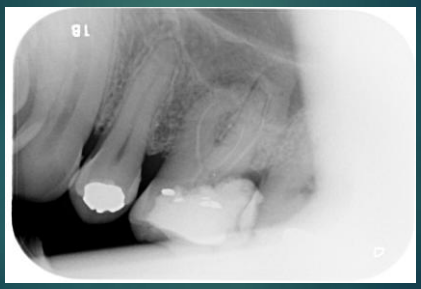
7.



8.



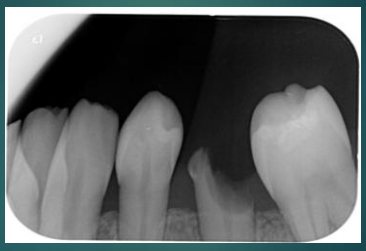
9.



10.



11.



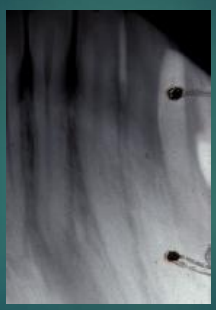
12.



13.



14.



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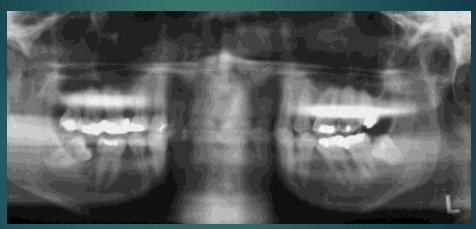
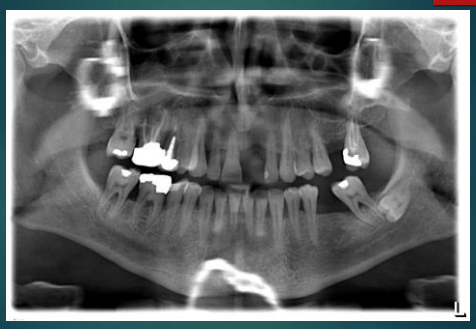


16.



17.



Any Questions?




THANKS FOR LISTENING!
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