MFDS PART 1 · MODULE 4 · LECTURE 19

Ionizing Radiation Protection & Quality Assurance

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EXAM-DAY SUMMARY

everything on this page → detail in §§ overleaf

BIOLOGIC EFFECTS → §1

- Direct = photon → molecule · indirect = water → free radicals
- Deterministic: not immediate; ↑rate → ↑risk · stochastic: rare, random (leukaemia, mutations)
- Fetus: low dose → mental retardation · high → congenital abnormalities

CANCER RISK → §1

- 6.8 %/Sv men · 5.5 %/Sv women · standard age 30
- Multipliers: <10 y ×3 · 10–20 ×2 · 20–30 ×1.5 · 30–50 ×0.5 · 50–80 ×0.3
- Lead apron: no value in dental; assistant only; ≥0.25 mm Pb

PRINCIPLES & LIMITS → §2

- Justification (net benefit) · optimization (ALARP) · limitation
- Annual: worker 20 mSv · trainee <18 y 6 mSv · public 1 mSv
- DRL = flags unusually high/low routine dose → optimization tool

DOSES & DOSIMETERS → §2

- Intraoral 0.3 · LC 2.2 · pano 2.7 · CBCT 11 µSv
- Dosimeter if >100 IO or >50 pano/week; worn 3 m; records 2 y
- Modifiers: PSP ×0.25 · CCD/rect ×0.5 · DC ×0.8 · 10 mm FSD ×1.5 · 50 kV, D-speed ×2

CONTROLLED AREA & EQUIPMENT → §3

- RPA designs · 1.5 m from tube · >7.5 µSv/h or >6 mSv/y
- Collimation: rectangular · FSD 200 mm (kV>60), 100 mm (kV<60)
- Filtration: 1.5 mm Al <70 kV · 2.5 mm >70 · kV 60–70 (<50 withdraw ASAP, <45 now)

LEGAL ROLES → §4

- IRR99 → Local Rules · IRMER2000 → LP's Procedures = RP File
- IRMER practitioner = justification · operator = practical aspects
- Referrer never a DCP · RPS supervises Local Rules · RPA external, in writing · MPE = patient dose

RISK ASSESSMENT & TRAINING → §5

- RA before new work · involve RPA · recorded if ≥5 employees · review ≤5 y
- Nurse/hygienist/therapist exposing → Cert. in Dental Radiography
- CPD: 5-yearly cycle, ≥5 h verifiable

TESTS ON EQUIPMENT → §6

- Critical exam — installer (+RPA) · acceptance — before use, baseline
- Routine ≤3-yearly; annual after fault · day-to-day checks logged 6-monthly

IMAGE-QUALITY QA → §6

- 1 excellent ≥70 % (interim 50) · 2 acceptable ≤20 (40) · 3 unacceptable ≤10 %
- Analyse ≤6-monthly (prospective all films / retrospective sample)
- Reject log: date, deficiency, cause, repeats · step-wedge after each chemistry change

SELECTION: CHILDREN & ORTHO → §7

- TMJ click alone → none; trauma/occlusion change/deviation/trismus → panorama 1st line
- One 6 carious → BW quadrant · >one 6 → pano
- Canine 11 y: buccal-normal none · palatal PA+refer · not palpated >11 y → parallax ×2
- Ortho: pano + LC; asymmetry + PA view; root resorption 6 m → occlusal

SELECTION: CARIES, ENDO, IMPLANTS → §7

- Caries → bitewing; recall high 6 m · mod 12 m · low primary 12–18 m, permanent 24 m
- PA before crown prep · new patient PA: heavily restored, endo-treated
- Immature pulpotomy: PA 6 m, then annually to root closure
- Implants: single PA+pano+CBCT · edentulous full CBCT · annual pano ×5 y

§1 Biological effects of radiation

- **Direct effect**: photon energy transferred **directly** to biologic molecules
- **Indirect effect**: photons absorbed by **water** in biologic molecules → water ionised → **free radicals** released → free radicals interact with biological molecules
- **Deterministic effects**: not immediate even with overexposure · no injury ≠ no harm · ↑rate of exposure → ↑risk
- **Stochastic effects**: rare · random · law of chance · **somatic** e.g. ★**leukaemia** · **genetic** e.g. mutations
- **Fetus (stochastic)**: low doses → ★**mental retardation** · high doses → congenital abnormalities
- **Lead apron**: no value in dental radiography — beam doesn't point at abdomen
  - only protective value → anybody **assisting** the patient during radiography · lead equivalence ≥ ★**0.25 mm**
- **Cancer risk**: **6.8 %/Sv men** · **5.5 %/Sv women** · risk ↓ with age · standard age = 30

Table 1 — Multiplication factors for cancer risk by patient age (standard = 30 y)

Age of patient	Risk multiplier
<10 y (slide prints ">10")	× 3
10–20 y	× 2
20–30 y	× 1.5
30 y	× 1
30–50 y	× 0.5
50–80 y	× 0.3

★ EXAM PEARL

Risk runs **opposite to age**: the child (<10 y) carries ×3 the standard risk, the 50–80 y patient ×0.3. The slide's ">10 years old ×3" is a typo for **<10 y** — the factors are otherwise a strictly descending ladder with age.

§2 Protection principles, dose quantities & dose limits

- **General guiding principles (3)**:
  - **Justification** — each exposure must have a ★**net positive benefit**
  - **Optimization** — dose as low as reasonably practicable (ALARP)
  - **Limitation** — dose must not exceed recommended limits
- **Diagnostic reference level (DRL)**: level used in medical imaging to indicate whether, in routine conditions, patient dose / radiopharmaceutical amount for a specified procedure is **unusually high or unusually low** · DRLs = practical tool to promote **optimization**

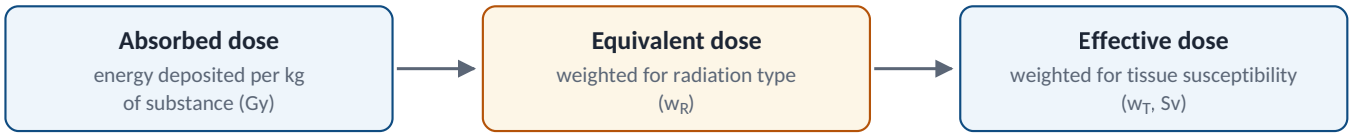

Diagram 1 — Dose quantities: absorbed → equivalent (radiation weighting w_R) → effective (tissue weighting w_T).

Table 2 — Annual dose limits by class of worker

Class of worker	Annual limit
Employee >18 y — classified worker	**20 mSv**
Trainee <18 y — non-classified worker	**6 mSv**
Any person <16 y + all members of public	**1 mSv**

- **Dosimeters**: only needed if weekly workload exceeds ★**100 intraoral films or 50 panoramas**
  - wear period **3 months** · results discussed with RPA · records kept ★**2 years**

Table 3 — Effective doses in dental radiography (lecture values)

Examination	Effective dose
Intraoral radiograph	0.3 µSv
Lateral cephalogram (LC)	2.2 µSv
Panorama	2.7 µSv
CBCT	**11 µSv**

- **Standard equipment assumed for the dose estimates**: 65 kV · 20 mm FSC · E-speed film

Table 4 — Equipment modifications and their effect on effective dose (multiplier)

Modification	Dose ×
Digital system — PSP	**× 0.25**
Digital system — CCD	× 0.5
Rectangular collimator	× 0.5
DC unit	× 0.8
10 mm FSD	× 1.5
50 kV	× 2
D-speed film	× 2

★ EXAM PEARL

Dose **reducers** (PSP, CCD, rectangular collimation, DC) sit below ×1; dose **inflators** (short 10 mm FSD, low 50 kV, slow D-speed film) sit above. PSP ×0.25 is the biggest single saving — a classic "which change reduces dose most?" single-best-answer.

§3 Controlled area & equipment standards

- **Controlled area**: designed by the **RPA** · extends ★**1.5 m from the x-ray tube** · dose criterion >3/10 of annual dose limit (>7.5 µSv/h or >6 mSv/y)
  - operator: must be able to **see warning light** · prevents anyone entering the area
- **Collimators**: open-ended · **rectangular** preferred (dose ×0.5)
  - FSD ★**200 mm if kV > 60** · 100 mm if kV < 60
- **Filtration (aluminium)**: ★**1.5 mm Al if kV < 70** · 2.5 mm Al if kV > 70, of which **1.5 mm permanent** · filter usually located at end of the PID attaching to tube head
- **kV range**: should be **60–70 kV**
  - sets below 50 kV → withdrawn as soon as possible
  - sets below 45 kV → **immediately withdrawn**

★ EXAM PEARL

The slide prints ">50 withdrawn ASAP · >45 immediately withdrawn", but the operating range it has just given is 60–70 kV — the withdrawal rules target sets running **below** 50/45 kV (low kV = ×2 dose, Table 4). Read the cut-offs as **<50 ASAP, <45 immediately**.

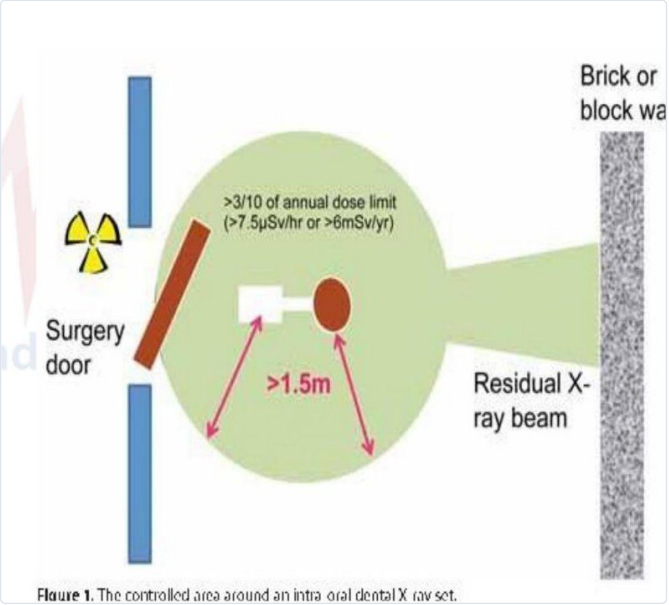

Fig. 1a — Controlled area around an intraoral set: >1.5 m radius, >3/10 annual dose limit (>7.5 μSv/h or >6 mSv/y), residual beam continues to brick/block wall.

Fig. 1b — Statutory sign: controlled area · authorised persons only · no entry when red light is on · names the RPS.

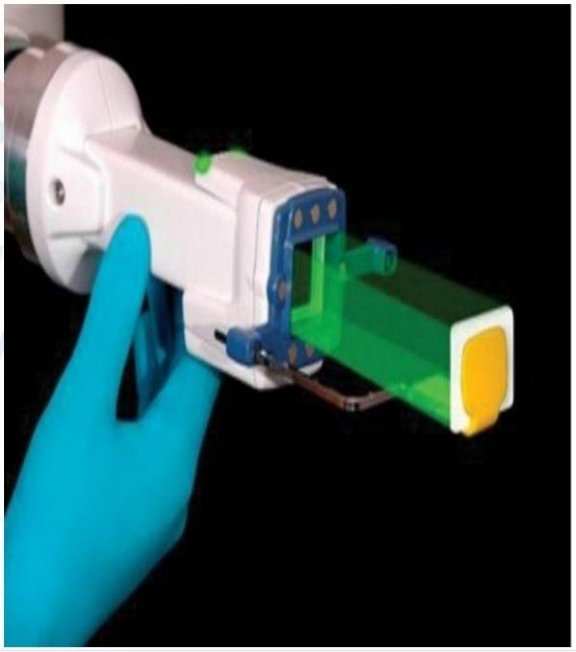

Fig. 2 — Open-ended rectangular collimator on the PID — halves effective dose vs round.

Fig. 3 — Aluminium filter sits at the end of the PID where it attaches to the tube head.

§4 Legal framework & staff appointments

- **Guideline documents (3)**: **IRR 1999** · **IRMER 2000** · Guidance Notes for Dental Practitioners on the Safe Use of X-Ray Equipment, ★**June 2001**
- **Legal Person ("employer")**: clearly defined person taking legal responsibility for implementing **both** sets of regulations
  - under **IRR 99** → provides written **Local Rules**: key working instructions ensuring staff exposure restricted
  - under **IR(ME)R 2000** → provides framework for IRMER practitioners/operators = **Legal Person's Procedures**
  - both best kept in a single document = ★**Radiation Protection File** (Local Rules + Legal Person's Procedures)

- **Radiation Protection Supervisor (RPS)**: appointed by Legal Person (one or more) · supervises arrangements set out in the **Local Rules** · appropriate appointee = dental practitioner or PCD (professional complementary to dentistry) e.g. dental nurse
- **Referrer**: registered medical/dental practitioner or other health professional who refers individuals for medical exposure to an IRMER practitioner · in dental surgery normally the dental practitioner · **DCP may ✗ NOT act as referrer**
- **IRMER Practitioner**: registered medical/dental practitioner or other health professional · primary function = ★**justification of individual exposures**
- **Operator**: any person carrying out practical aspects of the radiographic examination:
  - patient identification · positioning film, patient & tube head · setting exposure parameters · pressing exposure button · processing films · clinical evaluation of radiographs · exposing test objects for the QA programme
  - dental practice: referrer + IRMER practitioner commonly the **same person**, who may also act as operator · dental nurses/DCPs perform some operator functions
- **Radiation Protection Adviser (RPA)**: external — consulted whenever Legal Person needs advice · appointed **in writing**, appointment states scope of advice · provides **routine radiation surveys** of dental equipment
- **Medical Physics Expert (MPE)**: science degree (or equivalent) + experience of physics applied to diagnostic/therapeutic ionizing radiation · role = **measurement & optimization of patient dose** · a properly certificated RPA can act as MPE or suggest an appropriate person

> ★ EXAM PEARL
> Role-matching is the exam staple: **justification → IRMER practitioner**; **practical aspects → operator**; **refers → referrer (never a DCP)**; **supervises Local Rules → RPS (in-house)**; **surveys & advice → RPA (external, in writing)**; **patient dose measurement → MPE**.

§5 Risk assessment & training

- **Risk assessment (RA)**: Legal Person must undertake → identifies measures to restrict exposure of himself + others · should involve an **RPA** · must be **recorded if ≥5 employees**
- **Three basic provisions**:
  - RA required **prior to any new work** with dental x-ray equipment
  - involve RPA · may also consult employees & workers' safety representatives
  - routine review at intervals ★**not exceeding 5 years**
- **Extra review triggered by significant change**: first panoramic/cephalometric/digital equipment · significant changes to working methods · new legislation
- **Training duty**: Legal Person ensures every IRMER practitioner & operator adequately/appropriately trained + continuing education after qualification
- **Adequate training — IRMER practitioner**:
  - UK graduate → undergraduate degree conforming to dental curriculum in dental radiology & imaging
  - non-UK graduate → Legal Person establishes the degree matches those requirements · practitioner = Legal Person → seek advice of Dental Practice Adviser and/or Postgraduate Dental Dean
- **Adequate training — operators**:
  - selecting exposure parameters / positioning film–patient–tube head: dental practitioners → IRMER-practitioner requirements · dental nurses, hygienists, therapists → ★**Certificate in Dental Radiography**
  - film processing & QA duties: preferably Certificate in Dental Nursing (or equivalent) · failing this → adequate **documented** task-specific training
  - nurse/DCP "pressing the button" → only in **continued presence + direct supervision** of that operator
- **Continuing education**: update knowledge especially when installing panoramic/digital equipment first time · implementing new techniques (e.g. paralleling) · QA identifies serious or persistent image-quality deficiencies
  - formal radiation-protection courses within ★**5-yearly recertification cycle** · ≥ **5 h verifiable CPD**

§6 Equipment testing & quality assurance

- **Three statutory tests**:
  - **Critical examination** — by the **installer**, following installation
  - **Acceptance test** — adequate test **before clinical use**

  - **Routine tests** — at appropriate intervals + after any major maintenance
- **Critical examination**: installer's responsibility · installer must consult an RPA · Legal Person ensures adequate report obtained
  - report concludes: (a) safety features operating correctly · (b) installation provides sufficient protection from x-rays · (c) statement that user given adequate information on proper use, testing & maintenance
- **Acceptance test**: Legal Person's responsibility, RPA consulted · done **immediately after installation** · provides ★**baseline values** for comparison with subsequent routine tests
- **Routine test**: confirms no significant change to equipment description/location + ongoing acceptability of location
  - at least every ★**3 years** · **annually** if previous test showed a fault
- **QA — x-ray equipment**: day-to-day checks of protection-critical features — warning lights, audible alarms, safety devices, counterbalance holding tube position · equipment log with periodic record (**6-monthly recommended**) confirming checks done
- **QA — films & processing**: **step-wedge test** · suitable check after **every change of processing solutions**
- **Unacceptable radiographs**: record the reason whatever the cause — (a) date · (b) nature of deficiency · (c) known/suspected cause · (d) number of repeat radiographs (if taken)
  - regular analysis → identifies problems causing unnecessary exposure: equipment maintenance, technique improvement, staff training

Table 5 — Subjective quality rating of radiographs

Rating	Label	Meaning
1	Excellent	No errors
2	Diagnostically acceptable	Some errors of preparation, exposure, positioning, processing or film handling — do **not** detract from diagnostic utility
3	Unacceptable	Errors render the radiograph diagnostically unacceptable

Table 6 — Quality targets (achieve full targets within 3 years of QA programme)

Rating	Target	Interim target
1	≥ 70 %	≥ 50 %
2	≤ 20 %	≤ 40 %
3	**≤ 10 %**	≤ 10 %

- **The QA programme**: clearly defined regime — image quality rated, results analysed vs targets · two approaches:
  - **Prospective** — ratings assigned & recorded for **all radiographs** as viewed → analysis at intervals ★**≤ 6 months**
  - **Retrospective** — **representative sample** drawn from clinical records at regular intervals → rated, recorded, analysed · intervals ≤ 6 months

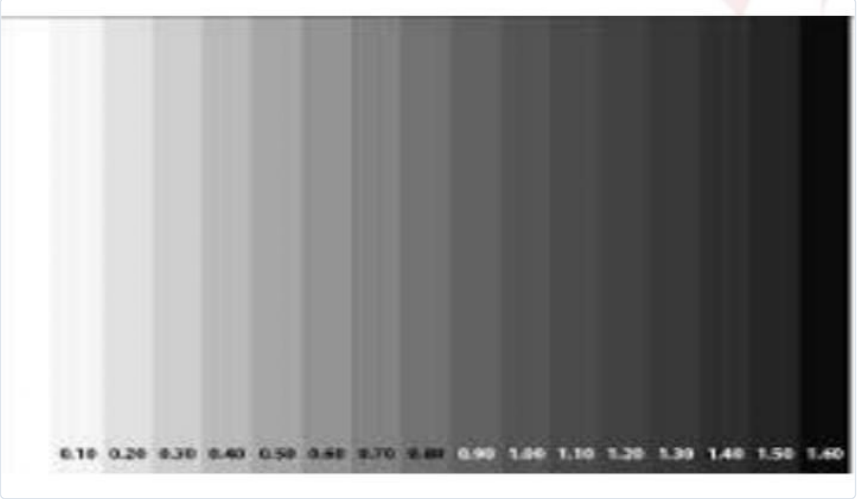

Fig. 4 — Step-wedge test film: graded density steps monitor film + processing consistency; repeat after every chemistry change.

KEY POINTS

Critical examination = installer (consults RPA) · acceptance test = Legal Person, before clinical use, sets baseline · routine test ≤ 3-yearly (annual after fault) · QA equipment checks logged 6-monthly · image-quality analysis ≤ 6-monthly · step-wedge after every solution change.

§7 Selection criteria for dental radiography (FGDP, BDJ)

- **TMJ disorders**: only clicking sound → ✗ **no radiograph**
  - trauma · change in occlusion · jaw deviation · trismus → radiograph — ★**panorama 1st line**

Table 7 — Early mixed dentition: what does the finding justify?

No radiograph	Panorama	Intraoral
Anterior cross-bite · posterior unilateral crowding · crowding	PA of unerupted tooth reveals congenital absence · high caries index · retained deciduous teeth in **>1 quadrant**	Failure of eruption of permanent tooth · retained deciduous teeth in a **single** quadrant · large diastema · delayed eruption of lateral incisor · peg-shaped lateral if canine unerupted · impaction of 6 into E (indicates absence of 5)

- **Late mixed dentition**: one 6 carious → **bitewing for the whole quadrant** · more than one 6 carious → **panorama**
- **Impacted maxillary canine (unerupted at 11 y)**:
  - palpated **buccally**, normal position → ✗ no radiograph · abnormal position → PA
  - palpated **palatally** → PA + refer for specialist opinion
  - not palpated, <11 y → **wait and watch** · >11 y → ★**2 intraoral radiographs — parallax technique**
- **Orthodontics**: primary assessment = ★**panorama + lateral ceph** (LC alone isn't enough) · facial asymmetry → add **posteroanterior view** · root-resorption check **6 months after fixed appliance** → standard occlusal view
- **Dental caries**: occlusal + proximal caries → **bitewing** · FOTI (0.5 mm tip) ✗ never without bitewing
  - enamel caries → preventive measures + follow-up · dentin caries → cavity restoration
  - PA required **before crown preparation**

Table 8 — Radiographic caries follow-up intervals by risk

Caries risk	Interval
High	**6 months**
Moderate	12 months
Low — primary dentition	12–18 months
Low — permanent dentition	**24 months**

- **New patients**: PA routine for — heavily restored teeth · endodontically treated teeth
  - panorama ✗ not routine except: heavily restored dentition · neglected dentition · GA · national breast screening programme (as listed in lecture)
- **Endodontics**: pulp capping / pulpotomy of immature ("premature") teeth → PA follow-up ★**6 months after treatment, then annually till complete root formation**
- **Implantology**:
  - single implant → combination of **PA + panorama + limited-volume CBCT**
  - multiple implants → panorama + limited- or full-volume CBCT · edentulous patient → **full-volume CBCT** · PA may be required during surgery
  - follow-up: ★**annual panorama till 5 years**

> ★ EXAM PEARL
> "No radiograph" answers are as testable as the imaging ones: TMJ click alone, buccally palpated canine in normal position, and anterior cross-bite / crowding in early mixed dentition all take **no exposure** — justification principle in action.