Radiation protection II (in dental radiology)

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Radiation protection in dental radiology

Introduction

- Dental examinations are the most frequent type of radiological procedure, and account for 21 % of the total on a global scale.
- X-rays examinations help dentists to diagnose, plan treatments and monitor both treatments and lesion development.
- There are four types of dental radiological procedure
  1. intraoral (bite wing, periapical and occlusal) radiography
  2. panoramic radiography
  3. cephalometric radiography
  4. cone-beam CT (CBCT)

Radiation protection in dental radiology

Introduction

- Individual doses are small but collective doses cannot be ignored due to the high volume of procedures.
- The estimated annual number of dental examinations is about 520 million, with a frequency ranging from less than one to more than 800 per 1000 population per year.

Radiation protection of patients

A good radiation protection practice in dentistry

- The most effective way to reduce dose in dental radiography is to avoid unnecessary X-ray examinations by justification.
- Routine dental X-ray examination for all patients is not justified.
- The patient dose for each X-ray examination should be optimized so that it is As Low As Reasonably Achievable (ALARA) and consistent with producing the required image quality.
- It is important that the equipment is subject to formal acceptance testing, routine quality control, undergoes proper maintenance, and has all the standard dose reduction features.

Radiation protection of patients

An use of lead aprons and personal protective devices

- With well-designed and optimized equipment and procedures there is no need for routine use of lead aprons for the patient in dental radiology.
- Lead aprons may provide some protection in the rare case of the vertex occlusal examination, especially in a patient who is, or may be, pregnant.
- On the other hand, the use of a lead apron may reassure patients that every effort is being made to ensure their safety, and may reduce the amount of time that needs to be taken to reassure them.
- Certainly, a lead apron should be provided for any patient who requests one.

Radiation protection of patients

An use of lead aprons and personal protective devices

- It may also be advisable to consider using them on a cautionary basis where equipment and/or technique have not been verified by a radiation protection specialist, and where they will not otherwise interfere with the examination.
- Thyroid collars should be used in all examinations where the thyroid may be exposed to the main beam or to a considerable amount of scatter radiation.
- Lead aprons must be provided for a person who is required to support a patient during the radiographic procedure (i.e., a comforter or carer).
- Assisting adults should be positioned so that all parts of their body are out of the main beam.

Radiation protection of patients

Safety measures for children undergoing dental radiography

- Many actions are similar to those recommended in adult procedures.
- Although radiation exposure arising from dental radiology is low, a child may undergo many repeated procedures during childhood and adolescence.
- Therefore, the accumulated effect of the radiation exposure should be taken into consideration.
- The salivary and the thyroid glands are among the organs at risk in dental radiology.
- The salivaries are often within the primary beam, while the thyroid receives dose mainly due to scattered radiation.

Radiation protection of patients

Safety measures for children undergoing dental radiography

- Since the thyroid is one of the most radiosensitive organs in children, it may be necessary to consider shielding it from time to time.
- Useful guidance in this regard is available in European Guidelines on Radiation Protection in Dental Radiology published by European Commission (2004).

Radiation protection of staff

Typical staff dose levels in dental radiology

- Employees performing dental radiography should not normally receive significant radiation dose provided normal radiation protection measures are employed, such as distance and shielding.
- A report from UK estimates a mean level of less than 0.1 mSv per year, in the practice conditions that prevail there.
- In the USA the mean dose received by dental workers is reported to be 0.2 mSv.
- For CBCT (cone beam computed tomography), in the absence of shielding, scatter doses between 4.1 and 46.8 μSv at 1 m have been reported; therefore, this modality should be installed in a protected enclosure.

Radiation protection of staff

A need for personnel monitoring in dental practice

- Given the low doses received by staff involved in dental radiography, routine personnel monitoring is generally considered to be desirable but not necessary.
- Different national regulations should be taken into consideration.
- UK guidance recommends that monitoring is not normally required unless the risk assessment indicates that individual doses are likely to exceed 1 mSv per year.
- However, national guidance in other countries recommends personal monitoring for all dental practices using X-ray equipment.

Radiation protection of staff

A need for personnel monitoring in dental practice

- Where regulations do not require individual personnel monitoring, it may be valuable to monitor the practice through monitoring one or more individuals from time to time.

Radiation protection of staff

A pregnant employee in the dental radiology department

- It is unusual for any member of staff in dentistry to get the foetal dose limit of 1 mSv from work.
- A female staff member should understand the importance of notifying her employer if she becomes pregnant.
- If notified, the employer should ensure that the pregnant employee's working conditions are optimised and that the prescribed dose limits are not exceeded.
- Generally, the working conditions, after declaration of pregnancy, should be such that it is unlikely that the foetal dose will exceed 1 mSv during the remainder of the pregnancy.

Radiation protection of staff

A pregnant employee in the dental radiology department

- In a dental setting, extensive modifications of the working environment are usually not needed; general protection measures (e.g. personal shielding) suffice.
- A qualified expert can be contacted to estimate the projected foetal dose based on equipment factors and workload.

Radiation protection of staff

Holding a dental film (or a digital image receptor) during radiography

- Film (or other image receptor) should not be hand held by a member of the dental practice staff.
- If necessary it should be held by the patient, but only when it cannot otherwise be kept in position.
- If the patient cannot hold it, and a comforter/carer must be involved, then this should be done using forceps or other device (eg., a specifically designed dental film holder) so that fingers are not in primary beam.

Radiation protection of staff

An use of portable (handheld) intra-oral radiography equipment

- Handheld portable X-ray equipment for intraoral radiography should be used only for examinations where it is impractical or not medically acceptable to transfer patients to a fixed unit.
- Examples are patients in nursing homes, residential care facilities or homes for persons with disabilities; in forensic practice; or for military operations abroad without dental facilities.
- The use of portable X-ray equipment in other settings (e.g. dental clinic) is discouraged.

Radiation protection of staff

A structural shielding in dental radiography department

- The purpose of facility design includes ensuring that prescribed dose limits are not exceeded.
- This requires consideration of workload, the size of the facility, the duration for which people are in the surrounding area, and is best achieved with the advice of a radiation protection expert.
- Formal approval and/or licensing for the structural shielding and other radiation safety measures may be required, depending on national regulations.

Radiation protection of staff

A presence of persons in the room during radiographic exposure

- In the case of a single-chair room, persons must not be present in the room during a radiographic exposure unless their presence is necessary for conduct of the examinations.
- Persons present must be located behind a shield allowing a view of the patient and the “exposure on” indicator, or wearing protective apron, or at least 2 m from the source of scattered radiation, i.e. the patients head, and not in line with the primary beam.
- In the case of the multi-chair room, there should be adequate shielding between the chairs.

Radiation protection of pregnant women

Typical foetal doses in dental radiographic procedures

- The foetal dose from a dental X-ray exam, including CBCT, has been estimated to be between 0.009 μSv and 7.97 μSv. (A threshold for malformations is 100 mSv!)
- This is usually less than the estimated daily natural background dose received by the foetus.
- The use of an apron with lead shielding and/or a thyroid shield can reduce the dose to the foetus even further.
- However, the use of shielding should be done with proper care, to assure that the radiograph is of adequate diagnostic quality (i.e. keeping the shielding outside of the X-ray beam) and that it does not lead to overexposure (for equipment using some form of automatic exposure control – AEC).

Radiation protection of pregnant women

Possible pregnancy of a woman before a dental radiological procedure

- Information on possible pregnancy should be obtained from the patient.
- A female of reproductive capacity should be considered pregnant unless proved otherwise.
- If the patient is pregnant the possibility of obtaining information from a non-radiological investigation should be considered.
- If the radiological examination is considered essential it should be performed and due consideration should be given to optimisation.

Radiation protection of pregnant women

Possible pregnancy of a woman before a dental radiological procedure

- Because of the widespread fears of radiation induced damage to the unborn child, it is reasonable to counsel the woman on level of radiation exposure and associated risks prior to performing the procedure.
- It is essential to have pregnancy warning signs in the waiting rooms.

Radiation protection of pregnant women

The risk to the foetus from a dental X-ray procedure on a pregnant woman

- The risk to the foetus from a few μSv of radiation exposure arising from a dental radiographic procedure is extremely small.
- The cancer risk to the unborn child resulting from a 10 μSv foetal dose is several thousand times less than the background risk of childhood cancer.
- The risk of inducing a genetic abnormality is an even smaller fraction of the background risk of genetic disorder.
- Hence patient doses received in the normal practice of dental radiology would never warrant consideration of a termination, and patients with concerns in this regard should be counselled accordingly.

Radiation doses

A radiation dose of X-rays

- Radiation dose is a measure of how much energy is absorbed when something or someone is exposed to X-rays.
- This is important because it is this absorption of energy that can cause damage to a person.
- Different quantities are used to express dose, see below.
- The basic quantity is absorbed dose.

$$D = \frac{d\bar{\varepsilon}}{dm}$$

- The quantity of energy (dε) deposited by the radiation per unit mass of tissue (dm).
- The unit of absorbed dose is the gray (Gy) and one gray is equal to 1 joule of energy deposited in 1 kg of tissue.

Radiation doses

A quantity used to relate radiation dose to risk

- A commonly used quantity to express the dose to a person is effective dose, which takes into account the dose to different organs/tissues which are exposed (as different organs/tissues have varying sensitivity to radiation). The SI unit is the sievert (Sv).

$$E = \sum_T w_T . H_T$$

- w_T – tissue weighting factor (a factor representing the radiosensitivity of a particular tissue or organ)
- H_T – equivalent dose $H_T = w_R . D_{TR}$
- w_R – radiation weighting factor (for X-rays = 1)
- D_{TR} – mean absorbed dose in tissue or organ

Radiation doses

A quantity used to relate radiation dose to risk

- Effective dose is related to the risk for stochastic effects (cancer and genetic effects).
- The approach internationally adopted for risk estimation is the “linear-no-threshold (LNT)” model, which assumes a linear relation between exposure and risk down to zero dose.
- Effective dose and its associated risk should not be applied to individuals, but can be used to compare between modalities, techniques and other sources of exposure (e.g. natural background levels).
- Non-stochastic effects (tissue reactions / deterministic effects) may also occur at organ dose levels above a specific threshold.

Radiation doses

Quantities used to measure the dose from dental X-ray equipment

- Since the effective dose cannot be measured, in practice, other dose quantities that are directly measurable are used for the purpose of optimization, dose monitoring, and quality assurance.
- They are specific to a certain imaging modality.
- The measurable quantity is the entrance surface air kerma/dose. Note: kerma is numericaly equal with dose for energies of X-rays used in medicine.
- The unit of entrance surface kerma is the gray (Gy), but in dental radiology the dose levels are usually a small fraction of one gray – milligray (mGy), or even microgray (μGy).

Radiation doses

Quantities used to measure the dose from dental X-ray equipment

- In cephalometric, panoramic radiography and in CBCT the measurable quantity is usually the product of kerma (dose) and the X-ray field, called Kerma-area product, measured in mGy · cm^2.

Radiation doses

Typical doses from dental radiological procedures

- In the scope of quality assurance, measurable doses from radiological procedures are often expressed as diagnostic reference levels (DRL), based on local surveys of typical patient doses.
- DRL values for adult exposures from various national surveys are in the following ranges:

Intraoral radiography
entrance surface kerma: 0.65–3.7 mGy
kerma-area product: 26–87 mGy · cm^2
Panoramic radiography
entrance surface kerma: 3.3–4.2 mGy
kerma-area product: 84–120 mGy · cm^2
Lateral cephalometric radiography
kerma-area product: 41–146 mGy · cm^2 (adults)
kerma-area product: 25–121 mGy · cm^2 (children)

Radiation doses

Typical doses from dental radiological procedures

- Typical effective doses are for:
  - intraoral dental X-ray imaging procedure 1–8 μSv
  - panoramic examinations 4–30 μSv
  - cephalometric examinations 2–3 μSv
  - CBCT procedures (based on median values from literature): 50 μSv or below for smaller medium-sized scanning volumes, and 100 μSv for large volumes

Radiation doses

Typical doses from dental radiological procedures

- Thus the doses from intraoral and cephalometric dental radiological procedures are lower, usually less than one day of natural background radiation.
- Doses for panoramic procedures are more variable, but even at the high end of the range are equivalent to a few days of natural background radiation which is similar to that of a chest radiograph (E ≈ 0,02 mSv).
- CBCT doses cover a wide range, but may be tens or even hundreds of μSv of effective dose higher than conventional radiographic techniques, depending upon the technique.
- Rapid technological improvements to CBCT equipment mean that typical dose ranges are likely to change.

Radiation doses

Providing of detailed information regarding doses

- Only a qualified expert (e.g. medical physicist) can measure the abovementioned dose quantities, and is able to provide more detailed information regarding these subjects.

Justification

Avoiding unnecessary examinations

- It is done by making sure that radiographs are selected for each individual patient based on clinical need.
- An use of a “routine” protocol for X-rays of patients should be avoided and the patient must always be examined before choosing any X-ray procedures.
- Just as a physician prescribes drug therapy, such as antibiotics or painkillers, to suit a patient’s diagnosis, so he should try to select any X-ray examinations according to their clinical need.

Justification

An advice to help with a selection of X-ray examinations

- Guidelines that can support you and the patient in this decision, called referral criteria (or selection criteria), have been developed by various professional organizations (EC-RP136; Haute Autorité de Santé; SEDENTEXCT Provisional Guidelines; Espelid et al., 2003; Harris et al., 2002; Isaacson et al., 2008; Pendlebury et al., 2004 (http://www.sedentexct.eu/system/files/sedentexct_project_provisional_guidelines.pdf)).
- These are systematically developed statements of “good practice” for radiology in specific clinical dental situations.
- Even though they are not rules, they can give you a framework against which to consider your patient’s needs.

Justification

A monitoring the dental development of children by a panoramic radiograph

- There is no justification for this routine practice!
- Radiography may be required when a clinical examination suggests the presence of an abnormality, or when interceptive and active orthodontic treatment is being considered.
- Clinical indicators, used to identify patients who might benefit from a panoramic radiograph, are effective in excluding children for whom an X-ray examination is not likely to be of value.

Optimization

Routine quality assurance (QA) checks of X-ray equipment

- Professional societies in collaboration with national authorities often recommend that users make regular image quality performance checks on X-ray equipment (and viewing screens where relevant).
- This is particularly important for dental cone-beam CT systems and panoramic X-ray equipment.
- To enable users to do this, manufacturers should provide details of the test procedures and the expected results in the equipment's instruction manual.
- Any test objects or phantoms that are necessary for these tests and specific to individual equipment models or manufacturers should be provided with the equipment as standard.

Optimization

The most important features of dental X-ray for dose reduction

- Professional societies, in collaboration with national authorities should publish guidance for users of dental X-ray equipment on how to optimize the radiation exposure of patients during justified X-ray examinations.
- For each imaging modality, there are many actions that can be taken to achieve a significant reduction in dose.
- These are listed below for intra oral; panoramic and cephalometric, dental CBCT.
- In addition, ensuring high quality clinical images a significant means of protecting patients by maximizing the benefits of the X-ray examination.

Optimization

The most important features of dental X-ray for dose reduction

For intra oral equipment

- Using tube voltage in the range 60 (minimal) to 70 kV.
- Nominal focal spot size should range between 0.4 mm and 0.7 mm.
- Tube current usually ranges between 3.5 to 8 mA, the exposure time should be below 1s in every exposition.
- The X-ray tube filtration should be sufficient to reduce entrance skin dose to the patient consistent with producing satisfactory image quality.

Optimization

The most important features of dental X-ray for dose reduction

- Rectangular collimation is strongly recommended, it approximates the size and shape of the receptor reduces dose significantly in comparison to circular collimation; a dose reduction exceeding 60 % can be achieved in dental radiology by using rectangular collimation.
- A position indication device which ensures a minimum focus-to-skin distance of 20 cm should be attached to the tube head (eg. by use of a long collimator/cone as opposed to a short conical one).

Optimization

The most important features of dental X-ray for dose reduction

- Exposure settings used should be the minimum consistent with the speed of the imaging system used. Advice on exposure settings should be provided in the manual for the X-ray equipment, which should be available in the user's native language and written in easily understood terminology.
- The fastest available film consistent with achieving satisfactory diagnostic results should be used. E-speed and F-speed films reduce dose by more than 50 % compared with D-speed films.

Optimization

The most important features of dental X-ray for dose reduction

- Digital detectors have the potential for further dose reduction, even compared with F-speed film, provided the repeat rate and use of higher exposure factors than necessary are controlled.
- Portable intra-oral X-ray units should only be selected in specific situations (Berkhout et al. 2015; UK PHE 2016; HERCA).
- Where old X-ray equipment is used, it may be possible to take immediate action to achieve a significant reduction in patient dose.

Optimization

The most important features of dental X-ray for dose reduction

For panoramic and cephalometric equipment

- The X-ray beam for cephalometric imaging should be collimated to the area of clinical interest.
- Modern panoramic systems also allow the field to be limited to the area of clinical interest, thereby offering a significant potential for dose reduction. If available, limitation of field size to the area required for diagnosis should be used for panoramic radiography.

Optimization

The most important features of dental X-ray for dose reduction

- Where available, paediatric examination modes should always be used for examinations of children. If not available, the exposure factors (such as kV, mA, exposure time) should be suitably adjusted. This may result in a dose saving to the patient of 50 % or more [Lecomber et al.1993].
- The inclusion of wedge filters in cephalometric equipment reduces exposure to the soft-tissue facial profile and allows optimal imaging, while the provision of asymmetric collimation allows the exposed area to be confined to the area of clinical interest.

Optimization

The most important features of dental X-ray for dose reduction

- Only the fastest screen-film combinations (at least 400) that are compatible with imaging requirements should be used for conventional panoramic and cephalometric imaging. Note that the intensifying screen and film must be spectrally matched, for example, if the screen emits light in the green region of the spectrum, the film used should be one that is sensitive to green light. Furthermore, the physical condition of screens deteriorates over time and it is important that their condition is monitored and that badly damaged screens are replaced.

Optimization

The most important features of dental X-ray for dose reduction

- The use of photostimulable phosphor (PSP) receptors should be discouraged due to inferior image quality (Benediktsdottir et al. 2003).

Optimization

The most important features of dental X-ray for dose reduction

For dental CBCT equipment

- The Field of View (FOV) should be adapted to the clinical indication ensuring that a region of interest can be covered with a reasonable margin of error, without exposing areas which are not needed for diagnostics [EC, 2012].
- CBCT units should at least offer a small-FOV option (not larger than 6 × 6 cm), but do not necessarily need a large-FOV option.

Optimization

The most important features of dental X-ray for dose reduction

- Exposure parameters (kV and mAs) should be optimized for each clinical application and patient. Specifically, high-, medium- and low-mA settings should be available in order to optimize scans for patients with different head sizes.
- Regarding scan/exposure time, a high-speed scan option (10 s scan time or faster, regardless of the exposure time) should be available for patients at risk for movement (e.g. small children).

Optimization

The most important features of dental X-ray for dose reduction

- Users should be aware that the voxel size is one of many parameters determining image sharpness, and not compare units based on this parameter. While smaller voxel sizes do not always yield a diagnostic benefit [Uzun et al. 2015, Kamburoğlu et al. 2015], it is recommended that CBCT units have a high-resolution mode with a voxel size below 0.2 mm, in order to properly visualize trabecular bone [Pauwels et al. 2015a] as well as other anatomical details and small pathologies [Kolsuz et al. 2015, Lukat et al. 2015].

Optimization

The most important features of dental X-ray for dose reduction

- There are number of projections and reconstruction algorithm. Some CBCT systems allow the operator to opt for imaging based on a reduced number of basis projections. Such options should be used where the resulting image quality is acceptable for the clinical situation.
- When considering buying a CBCT unit, you should check to see whether it is able to comply with national reference doses for dental CBCT where available.

Optimization

An influence of digital image receptor on patient dose in dental radiology

- Two types of digital system are used in intraoral, panoramic and cephalometric imaging. One involves imaging sensors based on charge-couple devices (CCD) and another uses photostimulable storage phosphor (PSP) plates (see the image of a PSP in its plastic cover below).
- Radiographic technique for digital imaging should be adjusted for the minimum patient doses required to provide the required image quality for each examination type.

Optimization

An influence of digital image receptor on patient dose in dental radiology

- Intraoral digital radiography offers a potential for significant dose reduction; some studies report that, depending on the diagnostic task, a lower exposure may be used when density and contrast is adjusted using the software features.This is one of the benefits of digital radiography where image quality can be optimized after the image has been taken.

Optimization

An influence of digital image receptor on patient dose in dental radiology

- Although digital radiography offers possibility of significant dose reduction, it can, in practice, lead to increased patient dose.
- This can arise from, for example:
  - using an image quality higher than is necessary
  - use of unduly long exposure times
  - retakes by staff (e.g. due to bad positioning) that may go undetected
  - lack of concern for collimation.
- Furthermore, due to smaller sensor size, more than one exposure may be required to cover the anatomical area imaged using a single conventional film.

Optimization

An influence of digital image receptor on patient dose in dental radiology

Optimization radiographic quality

- If a patient is exposed to X-rays for the purpose of producing a radiograph, but the resulting image is not of adequate quality for clinical use, then the patient has been put at risk for no benefit. Ensuring adequate quality is, therefore, a fundamental part of radiation protection.

Optimization

A good standard of radiographs

- It is needed to compare one's performance by reviewing his radiographic quality against a recognized standard.
- Such quality standards for clinical images, and guidance on the audit process, are available in European guidelines on radiation protection in dental radiology (https://ec.europa.eu/energy/sites/ener/files/documents/136.pdf).
- As a minimum target, the aim should be to ensure that no greater than 10 % of radiographs are of unacceptable quality.
- If it fails this test, then actions can be taken to reduce the proportion of unacceptable radiographs, with a target of a 50 % reduction at each successive audit cycle.

Optimization

A getting high quality intraoral radiographs

- Choosing the correct exposure factors, ensuring accurate patient and X-ray source position (using film holders), along with careful processing should together contribute to achieving excellent results in radiography.
- For intraoral radiography a simple test tool – an image of a step wedge is useful for maintaining high image quality (see the image – Sensitometric steps).
- During installation, a reference standard radiograph of the step wedge should be made using the optimized exposure setting for an adult/child.

Optimization

An ensuring of a getting high quality intraoral radiographs

- Subsequent radiographs of the step wedge/phantom should be made during clinical use and compared with the reference one to ensure that image quality is maintained.

Optimization

An ensuring of a getting high quality panoramic radiographs

- By achieving accurate patient positioning and by good processing of the film.
- These are the two commonest causes of poor panoramic radiographic quality.
- Accurate positioning is helped by using all the positioning aids correctly and by adequate training.
- Test tools for panoramic radiography are available.

Optimization

An ensuring of a getting high quality cephalometric radiographs

- By using a cephalostat (a head-positioning device) and a fixed X-ray source/patient/image receptor relationship.
- This is achieved using a dedicated cephalometric attachment to panoramic X-ray equipment.
- In cases where there is no alternative to using a dental X-ray set as the source, it is very important to ensure correct collimation of the beam and alignment with the cephalostat.

Optimization

Issues in a switching from film to a digital imaging receptor

- An increased number of rejected films may happen.
- The retake rate can increase mainly due to wrong positioning of the X-ray tube and small image receptor with respect to region of interest (ROI).
- Furthermore, repeating the exposure is much easier when using digital receptors and this has been reported to lead to increased reject rates.
- Careful positioning using sensor-holders with a beam-aiming device and audit of clinical image quality will avoid and or reduce retakes.

Optimization

Measures of a reducing very high patient doses

- Older models are more likely to operate below 60 kV, either by design or due to deterioration of the X-ray tube head over its working life.
- Older models are also more likely to have low values of total filtration (= inherent and added filtration).
- Both low operating potential (kV) and low filtration are strongly associated with high patient doses, as is the use of speed group D, which is often observed to be used with older X-ray equipment.
- Therefore, an immediate saving in dose can be achieved by taking the following steps, pending the future replacement of the X-ray equipment:

Optimization

Measures of a reducing very high patient doses

- Move to the use of E-speed film.
- To improve the effective X-ray beam quality and provide a lower radiation output rate consistent with the use of E-speed film, a further 1.0 mm of aluminium beam filtration should be added to the X-ray tube head, as close as possible to the X-ray beam window in the tube head. This may require the help of a technician.
- Continue to use the exposure settings you were using before, unless image quality is severely affected. In this case, the help of a medical physics expert should be sought. The above steps should provide a reduction in dose of at least 70 %.

Optimization

Measures of a reducing very high patient doses

- Poor film processing conditions may have as great an impact on patient doses as the X-ray equipment, and so attention should also be paid to ensure that all aspects of processing are carried out in accordance with the advice provided in (see European Guidelines on Radiation Protection in Dental Radiology, RP 136, published by European Commission, Luxembourg (2004)) and that proper quality assurance methods are in place.

Means for the dental office to minimize radiation exposure

Means	Comments
Exposure justification	The exposure should yield diagnostic information that will influence patient care.
Image receptors	**Film:** use the fastest speed available – currently F-speed. Film should be processed according to the manufacturers instructions. A proper safe light should be used.
	Digital: Charged Couple Device (CCD), Complementary metal-oxide semiconductor (CMOS) and photostimulable storage phosphor (PSP) receptors are acceptable.
Receptor holders	Use to optimize alignment and minimize repeat exposures.
Beam collimation	For intraoral radiographs limit beam diameter to 6 or 7 cm or smaller at the patient's face and preferably with rectangular collimation. For all other radiographs, collimate the beam to the area under investigation.

Means for the dental office to minimize radiation exposure

Means	Comments
kV, mA & exposure time	For intraoral radiographs preferably use 60–70 kV to optimize contrast and reduce depth dose. Reduce exposure time and/or mA when applicable. Use machines with automatic exposure controls (AEC) when available. If not, use technique charts or other appropriate means to minimize over- or underexposures.
Operator protection	Operators should stand out of the primary beam, at least 2 m away from the source, and behind a protective barrier whenever possible.
Hand-held units	Where permitted, hand-held units should be stored in a locked facility when not in use and should always be used with a shielding ring and held close to the patient's face.
CBCT	When indicated and when lower-dose techniques are not sufficient, use the smallest field of view sufficient to answer the clinical question and doseminimizing procedures such as half-cycle exposures when appropriate. Imaging data sets may need to be interpreted by an oral and maxillofacial radiologist.

Means for the dental office to minimize radiation exposure

Means	Comments
Patient shielding	Use leaded aprons and thyroid collars whenever possible (according national/local regulations).
Quality Assurance	Protocols should be developed and followed for assessing the integrity of the x-ray machine, film processor, digital image receptors, panoramic cassettes, and darkroom.
Image viewing	Radiographs should be viewed and evaluated on appropriate, quality assured viewing boxes (film) or monitors (digital) in a darkened environment.
Education and training	Persons operating x-ray devices must have appropriate training, education and certification.

MUNI MED

FAKULTNÍ NEMOCNICE BRNO

Klinika radiologie a nukleární medicíny Fakultní nemocnice Brno a Lékařské fakulty Masarykovy univerzity