South Carolina Dental Association

Radiation Safety

NEW

Study Guide

Intent and Purpose:

The *South Carolina Dental Association Radiation NEW Study Guide* is a prerequisite to the Positioning, exposure and processing of radiographs. Formal training in proper techniques and skills by a licensed dentist or participation in a structured Radiology course should also be incorporated. Note that *DHEC March 2017 Regulatory Guide B3 Complying with Title B-Dental Facilities* is also required study material for all dental offices and should be included as part of a comprehensive Radiation Safety Training program for all dental practice employees.

Additionally, the ADA and FDA have a document titled, "DENTAL RADIOGRAPHIC EXAMINATION: RECOMMENDATIONS FOR PATIENT SELECTION AND LIMITING RADIATION EXPOSURE". These guidelines were developed to serve as an adjunct to the dentist's professional judgment of how to best prescribe radiographs for each patient. These recommendations are to be used by dentists only after reviewing the patient's health history and completing a clinical examination.

This booklet is designed as a guide for the purpose of study material and is not intended to be a comprehensive document of all aspects of dental radiological technology.

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Introduction:

Each licensed dentist and X-ray employer must take all precautions necessary to provide reasonably adequate protection to the life, health and safety of all individuals subject to radiation exposure. This begins with the dentist's recommendation to prescribe X-rays. This recommendation is based on the patient's health history and completed clinical examination. Dental radiographs provide useful information that in many cases cannot be obtained by a clinical examination alone. By using ionizing radiation, patients are provided with early diagnosis and treatment of dental disease increasing the potential for patients to maintain a functioning dentition for a lifetime.

X-rays

X-rays are a form of electromagnetic radiation, as is visible light, however, X-rays can penetrate or pass through the human body and produce shadow-like images. By using appropriate devices and techniques, X-rays can be safe and produce images of the inner structures of the jaw of the patient. X-rays, also known as radiographs, are a photographic image that can be seen on film/screen. These images are produced by directing X-ray beams, invisible straight lines traveling at a constant speed and made visible by processing the image.

Radiographs are used to help a dentist prevent, monitor and diagnose potential oral health care issues in a patient's mouth before they become a major problem. An X-ray is produced by a machine whose source of energy is electricity. Therefore, the machine must be plugged in and turned on before an X-ray can be produced by pushing the exposure button. The body absorbs some of the X-ray energy. X-rays are invisible beams that travel in straight lines. X-rays pass through soft tissues and are absorbed by dense tissue. Teeth and bone are very dense, so they absorb X-rays, while X-rays pass more easily through gums and cheeks. The very low radiation doses absorbed during imaging procedures generally produce no adverse effects, however, steps should be taken to reduce the doses as much as possible. Radiation can affect body tissues and cells that can carry hereditary materials for future generations.

Intraoral X-rays are the most common type of radiograph taken in dentistry. They give a high level of detail of the tooth, bone and supporting tissues of the mouth. These X-rays allow dentists to address oral health issues across the lifespan:

For Adults:

- Detect areas of decay that the dentist may not be able to see just by looking, such as decay between teeth.
- Detect decay under a filling.
- Detect cracks or other damage in a filling.
- Alert the dentist to possible bone loss from periodontal (gum) disease.
- Show problems in the root of a tooth, such as infection or death of the nerve.
- Help the dentist plan, prepare and place tooth implants, braces, dentures or other dental work.
- Detect other problems, such as cysts, cancer or changes caused by diseases of the body.

For Children and Teens:

- X-rays are used to find decay, damage to fillings, and to monitor tooth growth and development.
- Determine if permanent teeth are developing and coming in properly.
- See if any teeth are impacted (unable to come through the gums).
- Help the dentist plan, prepare and place braces.

Every dental office shall provide the Radiation Safety Office sufficient authority, organizational freedom, time, resources and management prerogative to: identify radiation safety problems; initiate, recommend or provide corrective actions; stop unsafe operations; and verify implementation of corrective actions.

Radiation Dose

The National Committee on Radiation Protection (NCRP) has established recommendations as to acceptable levels of exposure to ionizing radiation. These recommendations are known as the maximum permissible dose (MPD) and are categorized for the general population, the occupational worker, and the pregnant woman. The MPD represents the greatest amount of radiation exposure that is accepted as not producing significant harmful biological effects. No individual under 18 is permitted to work in such a position on the basis that growing and developing tissues are more susceptible to radiation injury. For this reason, regulations have been established with the following annual occupational dose equivalent limits for employees.

The annual occupational dose limit for adults: the total effective dose equivalent being equal to 5 rem (0.05Sv) The annual occupational dose limits for minors are ten (10) percent of the annual occupational does limits specified for adults.

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 absorption of energy that can cause damage to a person. There are two commonly used ways of talking about radiation dose in dental procedures: dose estimated at the patient's skin surface (correctly known as "entrance surface air kerma") and effective dose. Dose estimated at the skin surface is easier to measure and is used in national surveys of X-ray equipment. Effective dose is complicated to calculate, but the value can be related directly to radiation-associated risk. Radiation dose or just dose is often described using the quantity effective dose, expressed in millisievert (mSv). Dental Radiology dose levels are usually a small fraction of one gray (milli gray: mGy or even micro gray).

Effective doses are:

- Intraoral dental X-ray imaging procedure 1-8 µSv;
- Panoramic examinations 4-30 µSv;
- Cephalometric examinations 2-3 µSv;
- CBCT procedures 34-652 µSv; (for small dento-alveolar volumes) and 30-1079 µSv;(for large "Cranio-facial" volumes).

The doses from intraoral and cephalometric dental 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. CBCT doses cover a wide range but may be tens or even hundreds of micro Sv of effective dose higher than conventional radiographic techniques.

The total effective dose equivalent to individual members of the public from the registered operation does not exceed .01 rem (1 mSv) in a year. Every person is exposed to Natural Background Radiation from their surroundings, such as earth, food, and others and even our own body. This type of radiation (gamma rays) depends upon where one lives, an individual can be exposed 1-3 mSv every year.

*The fetal dose from a dental X-ray exam is estimated to be between 0.3 µSv. This is less than the estimated daily natural background dose received by the fetus.

Types of Radiographs

Radiographs are divided into two main categories, intraoral and extraoral. With intraoral radiographs, the radiograph film is inside the mouth. With extraoral radiographs, the film is outside the mouth.

Intraoral Radiographs:
Intraoral Radiographs are the most common type. They give a high level of detail. These radiographs allow dentists to:

- Find cavities.
- Look at the tooth roots.
- Check the health of the bony area around the tooth.
- See the status of developing teeth.
- Monitor tooth health.

For Intraoral Equipment:

- Rectangular collimation is strongly recommended. It approximates the size and shape of the receptor and reduces dose significantly in comparison to circular collimation. A dose reduction exceeding 60 % can be achieved in dental radiology by using rectangular collimation.
- 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.
- 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.
- Using tube voltage in the range 60 (minimal) to 70 kV.
- Nominal focal spot size should range between 0.4 and 0.7.
- Tube current usually ranges between 3.5 to 8 mA, the exposure time should be below 1s in every exposure.
- The X-ray tube filtration should be sufficient to reduce entrance skin dose to the patient consistent with producing satisfactory image quality.
- A position indication device which ensures a minimum focus-to-skin distance of 20 cm should be attached to the tube head (e.g. by using long collimator/cone as opposed to a short conical one).
- 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 and should be available in the user's native language and written in easily understood terminology

The various types of intraoral radiographs show different aspects of the teeth:

Bite-wing Radiographs are used to look at the crowns of the teeth. Dentists take one or two bite-wing radiographs on each side of the mouth. Each X-ray shows the upper and lower molars (back teeth) and bicuspids (teeth in front of the molars). These X-rays are called "bite-wings" because biting down on a wing-shaped device that holds the film in place while the X-ray is taken. These X-rays help dentists find decay between back teeth.

Bite-wing Radiographs

Periapical Radiographs highlight only one or two teeth at a time. A periapical radiograph looks similar to a bite-wing radiograph. However, it shows the entire length of each tooth, from crown to root. These x-rays are used to look for problems with the tooth's root or surrounding jaw bone as well as cavities.

Depending on the oral health and dental history of the patient, the dentist may recommend a **full-mouth radiographic survey**, or FMX. This includes every tooth, from crown to root to supporting structures. They are X-rayed using both bitewing and periapical radiographs.

Periapical Radiograph

Occlusal Radiographs are larger than most X-rays. They highlight tooth development and placement or localization of teeth. Each X-ray shows nearly the full arch of teeth in either the upper or lower jaw. This radiograph shows the teeth and arch from the occlusal surface, as if looking down at the teeth instead of from the side.

Occlusal Radiograph

Extraoral Radiographs:
Extraoral Radiographs are made with the film outside the mouth. These can be considered the "big picture" radiographs. They show teeth, but they also provide information on the jaw and skull. Extraoral radiographs are used to: keep track of growth and development; look at the status of impacted teeth; examine the relationships between teeth and jaws; and examine the bones of the face. Extraoral radiographs are less detailed than intraoral radiographs. For this reason, they are usually not used for detecting cavities or flaws in individual teeth.

Panoramic Radiographs show the entire mouth on a single film. They include all teeth on both upper and lower jaws. This type of X-ray requires a special machine. The tube head that emits the X-rays and the film cassette both circle around the head at the same time. That way, the full, broad view of the jaws is captured on one film. The machine moves in a set path, so the patient must be positioned carefully. Devices attached to the X-ray machine hold the head and jaw in place. All this may look and feel intimidating to the patient, but the process is very safe. Panoramic radiographs require intensifying screens to minimize radiation exposure to patients. This radiograph is used to see emerging teeth, impacted teeth, TMJ or tumors.

Cephalometric projections are X-rays taken of the entire side of the head. They are used to look at the teeth in relation to the jaw and the person's profile. Orthodontists use cephalometric projections to determine the best type of orthodontic treatment.

For Panoramic and Cephalometric Equipment:

- Only the fastest screen-film combinations (at least 400) that are compatible with imaging requirements should be used for 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.
- The X-ray beam for cephalometric imaging should be collimated to the area of clinical interest.
- 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.
- 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.
- Proper training in patient positioning is necessary to ensure that panoramic radiographs are of diagnostic quality.
- Where available, pediatric 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.

NOTE: Facilities using cephalometric and/or dental CT units should refer to Regulatory Guide B2 "Medical Facilities" for assistance in setting standards for performance of the x-ray equipment. Cephalometric units are considered medical units by DHEC and are subject to the requirements for medical units. “Cone beam” or Dental CT units are considered computed tomography units by DHEC and are subject to the requirements for CT units.

Cone-beam computed tomography (CBCT) provides three-dimensional images. The patient can stand or sit while the machine rotates around the head. The beam is cone-shaped, instead of fan-shaped as in a standard medical CT. A cone-beam scan uses less radiation than a medical CT scan but far more than any standard dental X-ray. The cone-beam CT is particularly useful for dental implant selection and placement.

Standard computed tomography (CT) usually must be done in a radiologist's office or a hospital. Typically, the patient will lie down while the image is taken. The radiation exposure is higher for this type of CT than for a cone-beam CT. A standard CT scan may be done to determine size and placement location for implants.

For Dental CBCT Equipment:

- Number of projections and reconstruction algorithm. Some CBCT systems allow the operator to opt for imaging based on a reduced number of basis projections.
- 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.
- CBCT units should at least offer a small-FOV option (not larger than 6x6 cm).
- 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 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).
- 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, 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 as well as other anatomical details and small pathologies.

Digital Imaging:

Digital imaging is one of the newest X-ray techniques. Standard X-ray film is replaced with a flat electronic pad or sensor. The image goes into a computer, where it can be viewed on a screen, stored or printed out. Digital radiographs taken at different times can be compared using a process that highlights differences between the images. Tiny changes therefore can be caught earlier. Used properly, digital radiographs use about half the radiation of conventional film because the sensor is more sensitive to the radiation.

If patients or parents of patients are concerned about the health risk of radiation dental assistants can always reassure patients that the amount of radiation during dental X-rays is extremely small and every precaution for safety is being utilized during the procedure.

Digital Imaging:

- Two types of digital systems are used in intraoral, panoramic and cephalometric imaging. One involves imaging sensors based on charge-couple devices (CCD), and the other use is photo-stimulable Phosphor Storage Plates (PSP) plates.
- Radiographic technique for digital imaging should be adjusted for the minimum patient doses required to provide the required image quality for each examination type.
- 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.
- Although digital radiography offers possibility of significant dose reduction, it can in practice lead to increased patient dose. This can occur for several reasons including: 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; and 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.

Hand-Held Intraoral Equipment

(Intraoral Hand-held dental equipment requires a variance approval from DHEC.
The following requirements must be followed for the use of intraoral hand-held dental equipment:

- The unit must be equipped with a non-removable backscatter shield of not less than 0.25 mm lead equivalent and 15.2 cm (6 inches) in diameter that is positioned as close as practicable to the distal end of the position indication device.
- The facility must maintain documentation that each operator has completed training as specified by the manufacturer and approved by DHEC.
- The Nomad unit must have an Equipment Performance Test completed annually.
- The facility shall adopt and follow protocols provided by the manufacturer and approved by DHEC regarding the safe operation of the device.
- When operating a hand-held intraoral dental radiographic unit, operators shall wear a 0.25 mm lead equivalent apron and thyroid collar.
- If the operator has difficulty in holding the device stationary during the exposure, the operator shall use a stand to immobilize the device.

Limiting Radiation Exposure

When X-rays are absorbed by the tissues, the molecules of the tissues are separated (ionized) into atoms and damage may result. We have trillions of atoms in our bodies and do not usually notice a few are ionized, but large doses of ionizing radiation can cause sickness, cancer, birth defects or even death. There is no difference between the harmful effects that can occur from background radiation that comes from the earth and sun, and the radiation that is manmade that comes from dental X-ray machines. However, because mankind is constantly exposed to various sources of radiation and because we don't know when each individual receives enough repeated exposure (doses) to make the accumulated doses harmful, it is the dental assistant's responsibility to avoid unnecessary or careless radiation exposure to every patient during dental radiography exams.

Primary radiation is x-rays that come from the tube head. Secondary radiation is created when the x-rays come in contact with matter. Scatter radiation results when an x-rays beam has been deflected from its path by the interaction with matter.

In a single-chair room, persons must not be 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; be wearing protective apron or be at least 2 m from the source of scattered radiation (the patients head and not in line with the primary beam.) South Carolina State requirements for Dental Facilities details are in *DHEC's Regulatory Guide B3 Complying with Title B -Dental Facilities.*

Quality Assurance

Quality Assurance plans include Equipment and Performance Tests and Image Processing. Protocols should be developed and implemented for all parts of the dental radiography system (X-ray machine, imaging receptor, film processing, dark room, patient shielding, and operator education) for each dental health care setting.

Equipment Performance Testing for each x-ray unit must be performed, by a Class III Registered vendor, at the time of installation and every two years for dental intraoral units, panoramic units and cephalometric units; annually for handheld intraoral units and Dental Ct units; and at any time DHEC deems necessary.

Manufactures should provide details of the test procedures for routine QA checks of X-ray equipment and the expected results in the equipment's instruction manual. Equipment performance tests results must include numerical data. Items found to be non-compliant during such testing shall be corrected within sixty (60) days of receipt of the report. Records showing the tests results and the correction of any non-compliant items found must be retained for five years or until the next DHEC inspection, whichever is later.

Requirements for Manual Film Processing Systems
When a facility performs manual film processing, the following items are required:
1) The darkroom must be light tight to the dark-adapted eye;
2) Processing tanks should be mechanically rigid and corrosion resistant;
3) A dedicated darkroom thermometer to adjust the film processing time according to solution temperature;
4) A dedicated darkroom timer with an adjustable preset function to adjust film processing time according to solution temperature;
5) Documentation to show when film processing chemicals are changed;
(This documentation must be maintained for two years or until the next DHEC inspection, whichever is later.)
6) If a safelight is used, it needs to be adequate for the film speed;
7) A time-temperature developing chart should be available.
SIGHT DEVELOPING OF FILMS IS PROHIBITED

Requirements for Automatic Film Processing Systems
When a facility uses an automatic process or other closed processing system, the following items are required:
1) The darkroom must be light tight to the dark-adapted eye;
2) The temperature of film processing chemicals must be appropriate for the type of film;
3) Film processing chemicals used, and their replenishing rate must be appropriate for type of film;
4) Documentation to show when film processing chemicals are changed; (This documentation must be maintained for two years or until the next DHEC inspection, whichever is later.)
5) If a safelight is used, it needs to be adequate for the film speed.

Requirements for Digital Imaging Acquisition Systems
When a facility uses a digital imaging acquisition system, the following items are required:
1) The manufacturer's current operating manual is available for DHEC review;
2) Protocol for image quality established by the manufacturer is followed;
3) Records documenting adherence to the manufacturer's protocol is maintained for two years or until the next DHEC inspection, whichever is later.

Requirements for Intraoral and Extraoral Manual and Automatic / Film Processing Systems:
1)Proper storage of film;
2) Cassettes and intensifying screens must be inspected, cleaned, and replaced as necessary.
Documentation of this inspection and cleaning must be maintained for two years or until the next DHEC inspection;
3) Film developing solutions are prepared in accordance with the manufacturer.

Operation of the X-ray Machine

Settings

There are three variable factors—kilovoltage, milliamperage, and time, to consider in the proper setting of the controls on the x-ray machine. Proper settings ensure the correct density and contrast of the film image which determine the "readability" of the radiograph. Due to the variations in dental X-ray machines, correct exposure times for the kilovoltage and milliamperage selected should be established and posted for each X-ray machine. Most newer machines have preset exposure settings for different areas of the mouth.

> **Kilovoltage (kVp)** - the ability that X-rays have to penetrate. This affects the quality of radiographs produced. The kVp setting is determined by the dentist according to the desired image contrast required for the diagnosis of the patient. The dental assistant sets the kVp by turning the kVp knob on the control panel until the needle on the kVp meter indicates the desired setting.
> **Milliamperage (mA) and time** - determines the number of X-rays delivered **(quantity)** from the X-ray machine which are available to strike the film. This determines the darkness or lightness of the image produced.

All three settings of the machine must be properly set before the exposure button is depressed. The operator must firmly depress the button and hold it down until the complete preset exposure has occurred. Should the dental assistant inadvertently release the button too soon, an insufficient amount of X-rays will result and the film will be under exposed and too light.

Safety Components
Filters: Since the X-ray beam consists of X-rays of many different energies and penetrating powers, an aluminum disk is placed within the X-ray tubehead to remove the X-rays that are not able to reach the film. It absorbs and filters out the unwanted, low energy or weak rays. High energy waves pass through with little effect. This filtration device protects the patient by preventing these non-perpetrating rays form stopping at the face of the patient.

Collimation: This reduces patient exposure by restricting the X-ray beam to the area of concern. The collimator is a lead disc with a round or rectangular hole in the center that is placed between the X-ray tube and the cone. The round collimator's diameter is 2 ¾ 'therefore; the X-rays are limited to expose only an area of 2 ¾". By limiting the size of the X-ray beam, radiation exposure to the critical organs of the patient is reduced.

Cone: The long open-ended lead-lined cone provides the least diverging X-ray beam and also limits scatter radiation to the patient and the operator. Pointed cones result in significant amounts of scatter radiation to a wide-spread area across the face during exposure as well as increased scatter radiation throughout the operatory.

When dental X-rays pass through the mouth during a dental exam, more X-rays are absorbed by the denser parts (such as teeth and bone) than by soft tissues (such as cheeks and gums) before striking the film. Even though dental X-ray doses are not high enough to cause long term damaging effects alone, the cumulative nature of radiation effects from all sources of radiation dictates that we adhere to the ALARA concept, "As Low as Reasonably Achievable" to limit patient radiation exposure. The technology has advanced considerably, and X-ray imaging has become much safer. Despite these advances, it is important for operators of radiation equipment to be professionally responsible to apply Radiation Safety procedures in practice on a daily basis. Understanding of potential hazards associated with radiation exposure is essential for dental assistants to keep patients and operators safe during radiographic examinations.

How Tissue Damage Occurs (Mechanics)

Ionization of the molecules of living tissues is the basic mechanism of tissue damage resulting from exposure to X-rays. COMMON TABLE SALT – is ionized when it is dissolved in water as the sodium and chloride atoms separate into Na+ and C1 – ions. When X-rays are absorbed by the tissues, the molecules of the tissues are IONIZED (atoms separate) and damage may result.

Radiation exposure can produce either a Genetic Effect or a Somatic Effect.

Genetic Effect – The effect of radiation exposure to the reproductive cells causing alterations in genetic code can possibly lead to mutations in the offspring. Ex: Mutations
Somatic Effect – The effects of radiation that are expressed in the exposed person rather that the offspring. Ex: radiation burns on the skin, cataracts

There are different effects that radiation can have on cells ranging from changing the cells function to cell death. In other words, all cells of the body are not equally susceptible to radiation. The same dose of radiation will have different degrees of effect on different cells in the same organism. Cells that are more sensitive to X-rays, that is, more likely to be affected by radiation, are immature, rapidly growing cells. Cells are more susceptible to radiation during cell division, which explains why rapidly dividing immature cells are more sensitive. Cells that are more sensitive to X-rays are immature, rapidly growing cells. These cells include reproductive cells, blood marrow (blood forming tissue cells) and cells in a developing embryo. Cells that tend to be least sensitive to radiation are the mature, functioning cells that rarely undergo cell division. Examples include: nerve, muscle, brain cells.

The most sensitive of all human tissue is the embryo, especially during the first three months of development. Pregnant

woman are highly sensitive to radiation and all safety procedures should be strictly performed ONLY if it is deemed necessary by the dentist. All women of childbearing age should be treated cautiously with proper shielding.

Tissues and Organs

Their sensitivity to radiation is determined by the susceptibility of the cells the tissue contains. The effect of low doses of X-rays on adult tissues and organs is considered to be similar to premature aging. Repeated exposures of low doses of radiation, such as those used in dentistry, may affect the functional efficiency of an organ, resulting in not only a decrease in performance of tissue functions but also a decrease in defense against infections and the ability to repair itself following injury.

Fortunately, most of the damage caused by low levels of radiation is repaired with the cells, tissues, and organs of the body. Damaging effects of a single exposure to X-rays may repair completely. Chronic and repeated exposure to radiation, however, may lead to a minor percentage of unrepaired effects that accumulate in the exposed tissues. The accumulation of radiation effects tends to accelerate the normal aging process in the organs and tissues. Repeated doses result in a more immediate expression of the effect including: reddening of the skin (never in dentistry). As the dose is reduced, the longer is the period before an effect is expressed. The time between exposure to expression of the biological effect is called the latent period.

Two sites adjacent to the oral cavity that are especially sensitive to radiation are the thyroid gland and the lens of the eye. On account of their location, they may be exposed to the primary (high energy X-ray) beam of X-rays during the exposure of dental radiographs. Thyroid cancer and cataracts of the eye are known to be caused by X-rays – the X-rays dose required to result in this effect is much higher than that used in dentistry. PLEASE ASK PATIENTS TO CLOSE EYES WHILE BEING EXPOSED. Even though dental X-rays dosage is not high enough to cause one of these effects alone, the cumulative nature of radiation effects from all sources of radiation dictates that we use the least amount of radiation possible. The use of the intraoral paralleling technique (XCP) is preferred over the bisecting angle because the vertical angulation is less steep, thereby reducing primary beam exposure to the thyroid and lens of the eye. A thyroid shield is also available to protect the thyroid gland.

Pregnant Women and Dental X-rays

The aim is always to minimize the unborn child's radiation exposure. An unborn child is considered to be more sensitive than an adult or child to the potential adverse effects of radiation. A dental X-ray dose to an unborn child would be low since the patient's pelvic region is not exposed to the primary X-ray beam. However, the dentist would need to decide how essential the procedure is to the mother's health and if necessary, take special action such as shielding to keep the dose to the unborn child as low as possible.

Patient Protection

1. The most effective way to reduce dose in dental radiography is to avoid unnecessary X-rays examinations by justifications. Routine dental X-ray examination for all patients is not justified. The American Dental Association (ADA) and the Food and Drug Administration (FDA) have outlined "DENTAL RADIOGRAPHIC EXAMINATION: RECOMMENDATIONS FOR PATIENT SELECTION AND LIMITING RADIATION EXPOSURE". These guidelines were developed in adjunct to the dentist's professional judgment of how to best use diagnostic imaging for each patient. prescribed by the Dentist.

2. X-rays should be performed *As Low As Reasonably Achievable (ALARA)* and consistently with producing quality images to eliminate the need to retake films. "Doing it Right the First Time." Choose the number and size of film conservatively. Only the number of films that are absolutely necessary to view the teeth of interest should be used.

3. Proper patient positioning or film positioning. All individuals shall be positioned such that no part of the body will be struck by the useful beam, unless protected by not less than 0.5 mm lead (equivalent) material.

4. Proficient training in exposure, processing skills and techniques by the dentist and a South Carolina certified Radiation Safety Course are required prior to pushing the exposure button to take an X-ray.

5. Be clear in explaining the process to the patient. Have the patient close their eyes during the radiographic procedure. This will increase protection to the eyes which may be exposed to the primary and secondary X-ray beam.

6. Proper Equipment Training and all Administrative Requirements by DHEC.

7. Proper use of film processing procedures by DHEC. This includes using 15-watt safelights in darkroom and place four feet away from workspace. Safelights can contribute to film fogging if they are too close to the work area, if the filter is cracked, or if the bulb wattage is too high.

8. Protective equipment and apparel such as lead aprons and possibly thyroid shielding, or panoramic shields should be used. Lead aprons shall be checked and documented at least annually for tears, cracks and holes that could compromise the radiation protection it provides. Protective aprons and thyroid shields should be hung or laid flat and never folded, manufacturer's instructions should be followed. The X-ray operator, other staff and ancillary persons shall be protected from the direct scatter radiation by protective barriers of not less than 0.25 mm lead equivalent material.

9. Radiation Area signage is required for cephalometric or dental CT units.

10. The X-ray control must have a label on it which states" WARNING: This X-ray unit may be dangerous to patient and operator unless safe exposure factors and operating instructions are observed." This label must be legible and in clear view.

11. It is essential to have pregnancy warning signs. Information on possible pregnancy should be obtained from the patient. A female of childbearing age should be considered/treated as pregnant unless known otherwise.

12. The Technique Charts must be posted at each control panel for units without built-in settings. Chart must state the speed of film used or use of a digital receptor, patient size (small, medium, large) and Technique Factors (kVp, mA and time). Technique charts are tables that indicate appropriate settings on the x-ray unit for a specific anatomical area and will ensure the least amount of radiation exposure to produce a consistently good-quality radiograph.

13. Equipment such as filters and a collimator should be used properly in accordance with the vendor's quality assurance plan.

14. A long-open-ended, lead-lined cone that provides the least diverging X-ray beam and also limits scatter radiation to the patient and operator should be used.

15. Film Holding Devices for positioning of the paralleling technique.

16. High Speed Film- Ultra speed film (D speed) or higher/faster (F speed) is recommended for intraoral radiographs. Increased film speed- decreased exposure time equals less radiation to the patient. Film will be damaged if exposed to scatter radiation. Film should be stored in a lead lined film storage bin.

17. Electronic Timers (mechanical timers are prohibited) should be used.

Operator Protection

All persons in the area in which radiographs are performed are subject to radiation exposure. Any person, operator, or other office staff member who is positioned in the line with the X-ray cone may be exposed to relatively high doses of radiation because the primary beam produces scatter radiation when it reaches the patient and travels some distance until absorbed by the air or some object. Scatter radiation is the secondary beam produces, this is present throughout the operatory during the exposure. The procedure affording maximum operator protection is to position the operator behind a protective barrier containing lead.

Employees Performing dental radiography will not under normal conditions receive a significant radiation dose provided normal radiation protection measures are followed, such as distance and shielding. The mean dose reported by dental workers is to be 0.2 mSv. The following should be considered to protect operators:

1. Documented training specific to equipment and including operating procedures for that equipment.

2. All personnel operating X-ray equipment have been certified to take X-rays in accordance with the South Carolina Dental Practice Act.

3. Provide personnel with a monitoring device or film badge. This is one way to tell if an employee is receiving below the maximum permissible doses. These are plastic holders which contain radiographic film. They are clipped to each individual employee's clothes during the working day and measure the amount of radiation being received by just being around the radiation in the office. Personnel Monitoring devices are required:
    - When an employee is likely to receive greater than 10% of their occupational dose limit for one year.
    - When an individual operates a Dental CT.
    - When declared pregnant workers request an additional badge for monitoring doses underneath lead aprons.
    - For personnel who have been operating a Nomad unit for 6 months or less.
    - When DHEC deems it necessary.

4. Keep the time of exposure to radiation as short as possible. Mentally consider the recommended radiation safety precaution with every radiographic exposure.

5. Do not stay in the radiography room, use long exposure cords on units to stand at least six feet away from the patient and between 90'-135' to the direction of the useful beam or behind a barrier. Never stand in direct path of the useful beam. Do not peek around corner of the barrier during exposures.

6. Do not use faulty equipment. If you suspect problems (unusual noises, drifting tube head, etc.) immediately report these to your Radiation Safety officer before using the unit again.

7. A patient or film/ image receptor should not be 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 parent or guardian must be involved. This should be done using appropriate XCP film holders (or the long" cone" paralleling technique recommended by the ADA), so that fingers are not in the primary beam.

8. The tube housing and the PID (Position indicating device) shall not be hand-held during an exposure. When feasible, position the body so that the nearest portion of the body is at least 2 meters from both the tube head and the nearest edge of the image receptor.

9. Proper attention to details of processing under a good safelight and clean work environment are also key to quality radiographs.

10. A pregnant employee taking radiographs should inform her employer. Generally, the working conditions, after declaration of pregnancy, should be such that it is unlikely that the fetus dose exceed 1 mSv during the remainder of the pregnancy. In order for a pregnant worker to take advantage of the lower exposure limit and dose monitoring provisions, the woman must voluntarily declare her pregnancy in writing to the dentist. A pregnant employee may ask her employer for a job that does not involve any exposure at all to occupational radiation, but the employer is not obligated to provide the pregnant employee a job involving no radiation exposure.

11. Prior Occupational Exposure: All personnel must disclose any previous occupational dose prior to employment. Each employer has the responsibility to determine the occupational radiation dose received within the current year for any new individual who enters the facility's restricted or controlled area. All persons who are associated with the operation of an X-ray system are subject to occupational exposure limits and the requirements for the determination of the doses which are stated in (Occupational Dose Limits for Adult annual limit: the total effective dose equivalent being equal to 5 rems (0.5Sv). Any individual exceeding his/her annual occupational exposure limit shall not be exposed to additional occupational radiation for the remainder of the calendar year. Dose to an Embryo/ Fetus: The employer shall ensure that the dose to an embryo/fetus during the entire pregnancy, due to occupational exposure of a declared pregnant woman, does not exceed 05 rem (5 mSv) during the remainder of the pregnancy.

12. Occupational Exposure at Multiple Facilities: The annual exposure limit applies to all occupational doses that an individual receives during the year. If an employee is likely to receive a dose in excess of 50% of the annual allowable dose, the exposure that an employee receives at any facility must be recorded by each facility at which the employee works. Each facility must ensure that the total dose received by the employee at both locations does not exceed the occupational limits.

13. A "Notice to Employees" must be posted in an area where it can be reviewed by all employees.

Misadministration

Misadministration means:

- Radiation to the wrong patient, wrong treatment site, or wrong mode of treatment.
- Performance of a diagnostic or therapeutic procedure other than that ordered by the prescribing dentist.

Each employer shall retain a record of each therapy misadministration for 10 years and 3 years for each diagnostic misadministration. The record must contain the names of all individuals involved in the event (including the prescribing dentist, allied health personnel, the patient, and the patient's referring physician); the patient's identification number if one has been assigned; a brief description of the event misadministration; the effect on the patient; what improvements are needed to prevent recurrence; and the actions taken to prevent recurrence.

References:

International Atomic Energy Agency
https://www.iaea.org/
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