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Patient shielding during dentomaxillofacial radiography

Recommendations from the American Academy of Oral and Maxillofacial Radiology

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ABSTRACT

Background. The American Academy of Oral and Maxillofacial Radiology established an ad hoc committee to draft evidence-based recommendations and clinical guidance for the application of patient contact shielding during dentomaxillofacial imaging.

Types of Studies Reviewed. The committee reviewed monographs and reports from radiation protection organizations and studies that reported radiation dose to gonads, breasts, and thyroid gland from dentomaxillofacial imaging.

Results. Considering the absence of radiation-induced heritable effects in humans and the negligible dose to the gonads and fetus from dentomaxillofacial imaging, the committee recommends discontinuing shielding of the gonads, pelvic structures, and fetuses during all dentomaxillofacial radiographic imaging procedures. On the basis of radiation doses from contemporaneous maxillofacial imaging, the committee considered that the risks from thyroid cancer are negligible and recommends that thyroid shielding not be used during intraoral, panoramic, cephalometric, and cone-beam computed tomographic imaging.

Practical Implications. This position statement informs and educates the reader on evolving radiation protection practices and provides simple, unequivocal guidance to dental personnel to implement these guidelines. State and local authorities should be contacted to update regulations to reflect these recommendations.

Key Words. Radiation effects; radiation shielding; radiation protection; thyroid collar; lead apron.

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Dentists use x-rays to obtain radiographs of the dentomaxillofacial region. Radiographs may be obtained to evaluate a symptom or to screen for occult disease in asymptomatic patients. Point-of-care imaging in dental offices includes intraoral, panoramic, cephalometric, and cone-beam computed tomographic (CBCT) imaging. In addition, dentists may prescribe multidetector computed tomography (CT), for example, to evaluate pathoses in the jaws and soft tissues. When prescribing imaging, dentists must consider the advantages and limitations of different imaging techniques and customize the radiographic examination to meet the diagnostic needs of each patient scenario. Although diagnostic objectives are situation-specific, the following principles that guide prescription of radiologic imaging are the same

- Imaging will likely provide answers to the diagnostic questions at hand.
- Imaging techniques will minimize patient radiation dose and provide the necessary diagnostic information.
- Benefits from imaging should vastly outweigh the estimated radiation-associated risks.

Appropriate application of these principles ensures the safety and efficacy of radiographic imaging. To assist dentists in this task, the American Academy of Oral and Maxillofacial Radiology

This article has an accompanying online continuing education activity available at: http://jada.ada.org/ce/home.

and other organizations have developed guidance documents that describe the selection of patients for radiologic examinations and implementation of radiation safety practices.[1-7]

RADIATION EFFECTS

Radiation-induced effects are categorized as stochastic effects and tissue reactions. Stochastic effects result from DNA sequence variations—misrepair of radiation-induced DNA damage. The paradigm considers that stochastic effects occur without a threshold, emphasizing the need to minimize dose to minimize radiation-associated risks. DNA sequence variations that occur in somatic cells may manifest as neoplasia, and there is strong evidence of radiation-induced neoplasia in humans exposed to ionizing radiation.[8] In contrast, DNA sequence variations that occur in germ cells may result in heritable effects that are manifested in the exposed patient's progeny. Unlike radiation-induced cancer, there is no evidence of radiation-induced heritable effects in humans.[9] Tissue reactions, previously termed deterministic effects, occur only when the dose exceeds a threshold. This threshold dose (that is, the minimum dose to induce a manifestable effect in 1% of the irradiated group) varies with effect and tissue of occurrence. Doses from dentomaxillofacial radiography are several thousand-fold below threshold doses for occurrence of tissue reactions. Therefore, there is no risk of tissue reactions from dentomaxillofacial radiography.

PATIENT DOSE REDUCTION

Radiation protection practices are targeted to minimize risks of cancer induction and heritable effects and to eliminate the risk of tissue reactions. With dose-reduction efforts in place, as summarized in the following section, radiation doses from dentomaxillofacial imaging carry negligible risk.

Selection criteria

The most effective approach to eliminating unnecessary radiation is appropriate radiographic prescription through the use of selection criteria. Published guidance assists dentists in the selection of patients for intraoral, panoramic, cephalometric, and CBCT imaging.[1-7] In a study of radiographic prescription patterns, researchers found that most providers followed radiographic prescription guidelines,[10] emphasizing the feasibility of this simple, effective practice.

Collimation

Limiting the radiation field to the region of interest eliminates unnecessary radiation exposure. For intraoral radiography, rectangular collimation limits the beam to the size of the image receptor and reduces patient dose by 60%.[11,12] With CBCT imaging, using the smallest field of view that encompasses the anatomy of interest allows patient dose reduction.

Image receptors and exposure optimization

The use of digital receptors for intraoral, panoramic, and cephalometric radiography reduces radiation exposure. Results of a survey of US dental practices estimated that for intraoral radiography, dental offices use direct digital sensors (68%), photostimulable storage phosphor digital technology (18%), and silver halide film-based imaging (14%).[13] Most intraoral imaging is performed using direct digital sensors, which offer the highest dose reduction. Likewise, almost 80% of panoramic radiographic units in dental offices use digital receptors.[13]

Dental offices should optimize radiation exposure protocols to ensure adequate diagnostic quality with the least amount of radiation. The American National Standard Institute/American Dental Association Standard 1094 provides guidance to establish optimal exposure settings for intraoral imaging considering patient age and size.[14] Some CT units allow automatic exposure control to customize the radiation exposure for each patient.

Shielding

This approach is targeted to reduce exposure of sensitive tissues to external radiation. Gonadal shielding is a long-standing practice during radiographic imaging in general and is mandated by law in many US states. The rationale for gonadal shielding is to reduce the risk of radiation-caused hereditary effects. However, the scientific rationale of this practice has been challenged, and organizations have recommended that routine gonadal shielding during radiography be

ABBREVIATION KEY

ALARA: As low as reasonably achievable.
ATA: American Thyroid Association.
CBCT: Cone-beam computed tomography.
CT: Computed tomography.
FMX: Full-mouth radiographic examination.
NA: Not applicable.
NCRP: National Council on Radiation Protection and Measurements.

Table 1. Effects of prenatal radiation exposure.

EFFECT	THRESHOLD DOSE, mGy*	SENSITIVE GESTATION PERIOD*	RISK FROM ORAL AND MAXILLOFACIAL IMAGING†
Prenatal Death	100	< 10 d	None; fetal dose approximately 10,000-fold lower than threshold
Microcephaly	100	2-15 wk	None; fetal dose approximately 10,000-fold lower than threshold
Growth Retardation	100	2-15 wk	None; fetal dose approximately 10,000-fold lower than threshold
Intellectual Disability	300	8-15 wk	None; fetal dose approximately 30,000-fold lower than threshold
Radiation-Induced Cancer	None‡	Throughout pregnancy‡	Negligible, approximately 1 in 1.7 million§

* Data from the International Commission on Radiological Protection.[26] † Fetal dose from dentomaxillofacial imaging, including cone-beam computed tomography, estimated at 0.01 mGy.[22] ‡ Radiation-induced cancer is considered a stochastic risk[26]; however, cancer induction in utero is not observed with doses less than 10 mGy.[26] § Cancer risk calculated on the basis of linear no-threshold model[27] and an excess absolute risk of 6% per Gy.[28]

discontinued.[15,16] This position statement summarizes scientific evidence for these changing practices and provides guidance to implement new practices in the dental office. Thyroid shielding seeks to reduce the risk of radiation-induced thyroid cancer—a risk corroborated by classic and contemporary evidence.[17] This position statement summarizes scientific evidence for radiation-induced thyroid neoplasia and provides recommendations and guidance to implement new practices in the dental office.

GONADAL SHIELDING DURING DENTOMAXILLOFACIAL RADIOGRAPHY

Practice of using gonadal shielding in dentomaxillofacial radiography

Gonadal shielding during dental imaging is controversial and was implemented to optimize patient protection during radiography imaging procedures. In 1950, the International Commission on Radiological Protection "strongly recommended that every effort be made to reduce exposures to all types of ionizing radiations to the lowest possible level."[18] In 1966, the International Commission on Radiological Protection introduced the concept of as low as is readily achievable,[19] which was subsequently shortened to the acronym ALARA (which now stands for as low as reasonably achievable).[20] The ALARA principle reinforced the concept of using time, distance, and shielding to reduce patient radiation dose.[20] Technical enhancements to all dental radiographic modalities have substantially decreased patient dose over the years. Nevertheless, the use of gonadal aprons is common practice, and patients expect and often request shielding when dental radiographs are obtained. This long-standing practice reflects public perception of radiation risk and the ease of use of aprons. Many practices offer gonadal shields to alleviate patients' apprehension, and many state regulations require the use of gonadal shielding during dental radiography. However, the decrease in gonad radiation dose from shielding is negligible, and the scientific rationale for its continued use has been questioned.

Absence of heritable effects in humans

Stochastic effects of radiation result from sequence variations. When these sequence variations occur in germ cells, they could potentially manifest as disease in the exposed person's offspring. Although reported in animal studies, there is no evidence of radiation-induced heritable disease in humans.[9,21] Thus, the risk of radiation-induced heritable effects is practically nonexistent with diagnostic imaging, and data do not support routine use of gonadal shielding.

Lead aprons do not protect against internal scatter radiation and radiation doses to the gonads and fetus due to scattered radiation from dental diagnostic imaging have been reduced to negligible levels.[22] With dentomaxillofacial imaging, lead shielding provides no decrease in radiation absorbed by reproductive organs outside of the primary field.[23,24] Overall, scientific evidence does not identify a need to protect against radiation-induced heritable effects, and, thus, gonadal shielding during dentomaxillofacial imaging is deemed unnecessary.

Table 2. Median breast-absorbed doses from dental maxillofacial imaging.*

PROCEDURE	BREAST-ABSORBED RADIATION DOSES,† mGy	
	Unshielded	Shielded
Intraoral Radiography	< 0.1	< 0.1
Panoramic Radiography	< 0.1	< 0.1
Cephalometric Radiography	< 0.1	< 0.1
Cone-Beam CT‡	< 0.1	< 0.1
Mammography, Range	1.4-3.1	NA¶
Head CT	0.3	NA
Chest CT, Lung Cancer Screening, Mean (SD)	15 (0.5)	NA

* Published studies used to compile these data are provided in eTable 1 (available online at the end of this article). † Doses less than 0.1 mGy are reported as a single category. This dose is 500- through 1,000-fold smaller than the lowest doses with demonstrable carcinogenic effects in humans. The committee considered that risk reduction is insignificant when other dose reduction practices, such as fast receptors and rectangular collimation, are implemented. ‡ CT: Computed tomography. ¶ NA: Not applicable.

Radiation exposure of the embryo and fetus: imaging the pregnant patient

Researchers have reported tissue reactions and stochastic cancer induction from in utero irradiation of the human embryo and fetus. Table 1 lists the tissue reactions associated with radiation exposure of the human embryo or fetus and the period of sensitivity during the gestational period. The threshold doses for causation of these tissue reactions are several thousand-fold higher than the estimated fetal doses from dentomaxillofacial imaging.[22] Thus, diagnostic imaging of a pregnant patient poses no risk of occurrence of prenatal death, growth retardation, microcephaly, and intellectual disability. This is consistent with the American College of Radiology's practice parameter for imaging pregnant patients; when the radiologic examination will not directly expose the fetus or gravid uterus, verification of pregnancy status is not needed and is not part of the preparatory questionnaire.[25]

Shielding breast tissue

Although originally intended to shield the gonads, lead aprons also shield the breasts, a sensitive tissue for radiation-induced cancer in women. We reviewed reported breast radiation doses from intraoral, panoramic, and CBCT imaging to derive median breast radiation doses from contemporary dentomaxillofacial radiologic imaging. Table 2 summarizes breast-absorbed doses according to imaging procedure. Published studies used to derive these summary data are listed in eTable 1 (available online at the end of this article).

Breast doses from intraoral, panoramic, and cephalometric radiography and CBCT imaging are less than 0.1 mGy. The median breast-absorbed dose from CBCT imaging is approximately 0.034 mGy, approximately 10-fold lower than the breast dose from multidetector CT imaging of the head.[22] Overall, breast radiation dose and the subsequent risk of breast cancer are negligible, and the added benefit from shielding is insignificant. Thus, there is no evidence to require the use of breast shielding during dentomaxillofacial radiography. This includes the use of cape aprons that have been marketed for use during panoramic imaging.

Practical issues related to gonadal shielding during dentomaxillofacial imaging

Effectiveness in Reducing Gonadal Radiation Exposure

Two sources of radiation exposure to organs outside the anatomic region imaged are internal scattered radiation originating from the anatomic region imaged and traversing internally through the body and external scattered radiation originating from off-focus radiation.

Lead shielding can only decrease external scattered radiation. When using a lead apron for pediatric chest CT, the mean percentage dose reduction outside the region scanned is approximately 19.1%, 10.1%, and 4.3% at 1, 5, and 10 cm from the edge of the scan, respectively.[29] Likewise, lead shielding did not substantially decrease organ-absorbed doses from panoramic radiography and CBCT imaging, especially in organs outside the primary beam.[23,24]

Potential Artifacts

The lead apron may be inadvertently placed too close to the mandible during intraoral imaging or too high on the neck during panoramic imaging, thus blocking the primary beam, obscuring anatomy, decreasing diagnostic value, and potentially requiring retakes.

Infection Control

The lead apron may get contaminated with saliva, particularly during intraoral imaging. Failure to properly disinfect the lead apron may result in patient cross-contamination.

Selected published statements and guidance documents

National Council on Radiation Protection and Measurements

The National Council on Radiation Protection and Measurements (NCRP) Statement No. 13[15] concludes that, in most circumstances, the use of gonadal shielding does not contribute substantially to reducing risks from exposure and may have the unintended consequences of increased exposure and loss of valuable diagnostic information.[16] The NCRP recommends that gonadal shielding not be used routinely during abdominal and pelvic radiography, and that federal, state, and local regulations and guidance be revised to remove any actual or implied requirement for routine gonadal shielding. The NCRP recognizes that gonadal shielding use may remain appropriate in some limited circumstances. NCRP Report No. 177 specifically identified that technological and procedural improvements incorporated into its recommendations have practically eliminated the requirement for the gonadal shield.[7]

American Association of Physicists in Medicine

Patient gonadal and fetal shielding during radiography-based diagnostic imaging should be discontinued as routine practice.[15] Use of these shields during radiography-based diagnostic imaging may obscure anatomic information or interfere with the automatic exposure control of the imaging system.[15]

The British Institute of Radiology

The key recommendation in The British Institute of Radiology's report,[30] "Guidance on Using Shielding on Patients for Diagnostic Radiology Applications," is that all optimization approaches should be considered and applied in the first instance, and that the use of patient shielding during CT is not generally advised. The prime reasons against the use of patient protection are the effects on image quality and interference with automatic exposure control settings for in-beam protection and, for out-of-beam, the potential for artifacts from misplaced protection. Considerations for reassurance of the patient or caregiver suggest that the use of patient protection may either reassure or frighten and, therefore, strong, informed guidance from the radiology professionals is required, while bearing in mind the perspective of each patient.

The European consensus on patient contact shielding does not recommend the use of gonadal shielding or breast shielding during radiologic imaging.[31]

RECOMMENDATIONS

Patient gonadal and fetal shielding during diagnostic intraoral, panoramic, cephalometric, and CBCT imaging should be discontinued as routine practice. Federal, state, and local dental regulations and guidance should be revised to remove any actual or implied requirement for routine gonadal shielding for intraoral, panoramic, cephalometric, and CBCT imaging.

Special considerations

In light of these new recommendations that counter long-standing and well-accepted practices, special considerations must be given to populations such as pregnant, apprehensive, and pediatric patients.

Pregnant Patients

Table 1 lists the effects from radiation exposure on the fetus and embryo. Loss of pregnancy, growth retardation, and congenital malformations only occur at doses higher than 100 mGy.[26] With technology, diagnostic-level doses in dentistry are tens of thousands-fold below these thresholds.

As a comparison, when the fetus is positioned directly within the primary beam during a CT examination, the dose rarely exceeds from 15 through 20 mGy and is even lower for planar radiography. In all modalities of dentomaxillofacial imaging, including CBCT, the fetus is well outside the field of imaging and radiation dose is less than 0.01 mGy,[22] contributed by means of internal scatter radiation that is not attenuated by external shielding.[22-24] There is no evidence to indicate that a single imaging examination poses any risk to a fetus.[31]

Pregnant patients may question this lack of fetal shielding. The oral health care team must effectively communicate the absence of substantial risks and the lack of any benefit from such shielding. Eventually, it remains the responsibility of the health care provider to address the patient's concerns and increase their confidence in the evidence-based care provided.

Pediatric Patients (Parent Considerations)

Oral health care providers who treat pediatric patients may lack specific knowledge about radiation risk in this group of patients. It is essential that these providers be familiar with the background information related to pediatric populations to be able to communicate effectively with them and their parents or caregivers. This includes the understanding that off-focus, external scattered radiation is considerably limited by beam collimation and that the primary source of radiation to the child is internal scattered radiation within the body. The lead apron does not reduce dose from internal scattered radiation.[22-24] Furthermore, lead aprons can be heavy and uncomfortable for the pediatric patient, leading to motion during imaging. Many national and international organizations, including the Society for Pediatric Radiology and the Image Gently Alliance, support discontinuing routine shielding.

In summary, for organs positioned outside the imaged field, most radiation exposure results from internal scattered radiation and shielding provides negligible protection to the patient. For dentomaxillofacial imaging, this applies to exposure of the gonads, fetuses, and breasts and is applicable to all patients, including pregnant and pediatric patients. Of prime importance in all patients is adherence to the ALARA principles. This includes appropriate patient selection and procedure optimization, including collimation and periodic quality assurance. These dose-reduction procedures adequately decrease radiation risks. It is important for the clinician to emphasize the benefit and safety of dentomaxillofacial imaging procedures and the need for imaging to facilitate diagnosis and timely treatment. Particularly in the case of pregnancy, failure to provide proper patient care for dental disease is much more harmful to the fetus than any risk that might be associated with radiation exposure.

THYROID SHIELDING DURING DENTOMAXILLOFACIAL RADIOGRAPHY

Practice of using thyroid shielding in dentomaxillofacial radiography

Thyroid shielding is a long-standing dental radiation safety recommendation. Via our article, we sought to provide oral health care teams with contemporary understanding on why this may be unnecessary during dentomaxillofacial radiography. Recommendations for thyroid shielding are provided in NCRP Report No. 177[7] and from the American Thyroid Association (ATA).[32] The recommendations are based on risks of radiation-induced thyroid cancer at doses of approximately 50 mGy and higher[33] and on the linear no-threshold model—the accepted approach to model radiation risks from low doses.[34] In dentistry, appropriate selection of patients for imaging[6] and rectangular collimation[11] offers the best protection to the thyroid when combined with guiding principles of radiation safety.

Evidence for radiation-induced thyroid cancer

In numerous studies, researchers have identified radiation exposure as a strong risk factor for inducing benign and malignant tumors of the thyroid gland. These researchers have included survivors of the atomic bomb explosion, cohorts irradiated for medical purposes, and populations exposed to radioactive iodine, including populations affected via the fallout of the nuclear accident at Chernobyl, Ukraine. Overall, data from the diverse population sources consistently support radiation as a substantial thyroid carcinogen. These data are summarized in detail in NCRP Report No. 159.[17] A consistent trend in all studies is the higher sensitivity to thyroid cancer induction in children and adolescents; relative to adults, the risk is 3-fold higher when exposed from ages

Table 3. Median thyroid-absorbed doses from dental maxillofacial imaging.*

PROCEDURE	THYROID-ABSORBED RADIATION DOSES,† mGy	
	Unshielded	Shielded
Intraoral Radiography, FMX,‡ Round Collimation, F-Speed Radiograph or Photostimulable Storage Phosphor	0.8	0.5
Intraoral Radiography, FMX, Rectangular Collimation, F-Speed Radiograph or Photostimulable Storage Phosphor	0.4	0.3
Intraoral Radiography, FMX, Rectangular Collimation, Complementary Metal-Oxide Semiconductor Sensors§	0.2	0.1
Intraoral Radiography, Bite-Wing Radiographs	0	NA¶
Panoramic Radiography	< 0.1	< 0.1
Cephalometric Radiography	< 0.1	< 0.1
Cone-Beam CT#	0.3	0.1**
Head and Craniofacial CT, Range	0.6-8.7	NA
Mammography, Range	0.4-0.8	NA
Chest CT, Mean (SD)	18 (8)	NA

* Published studies used to compile these data are provided in eTable 2 (available online at the end of this article). † Doses less than 0.1 mGy are reported as a single category. This dose is 500- through 1,000-fold less than the lowest doses with demonstrable carcinogenic effects in humans. ‡ FMX: Full-mouth radiographic examination. § Dose reduction with use of direct digital sensors is estimated at 50% on the basis of the published literature. ¶ NA: Not applicable. # CT: Computed tomography. ** Dose reduction with thyroid shield is estimated on the basis of the dose reduction factor computed from published reports as listed in eTable 2 (available online at the end of this article).

10 through 19 years and is 10-fold higher when age at exposure is younger than 10 years.[17,35,36] Thus, efforts to reduce thyroid radiation dose are especially important for children and adolescents younger than 19 years. However, the risk when exposed after age 30 years is small to none.[9] There is some, but inconsistent, evidence that female patients appear to be at greater risk, but this is complicated, given their greater risk of developing spontaneous thyroid cancer.

Thyroid dose from dentomaxillofacial imaging

It is estimated that more than 380 million intraoral radiographic examinations are performed annually in the United States.[13] Approximately 20% of these examinations are performed in pediatric patients, the sensitive subpopulation for thyroid cancer induction.[13] More than 86% of dental offices use digital imaging, which allows for considerable dose reduction in intraoral imaging. Data from the Nationwide Evaluation of X-ray Trends highlight an almost 40% reduction in dose used to obtain intraoral radiographs since the group's previous survey.[13] This trend emphasizes continued evolution of dental imaging with better safety.

The thyroid gland is exposed via the primary beam and internal scatter. The anticipated doses to the thyroid gland are minimal relative to other imaging procedures (Table 3) (published reports used to compile the data in Table 3 are provided in eTable 2, available online at the end of this article). Thyroid dose estimates are based on use of F-speed radiograph or storage phosphor plates. Digital imaging with complementary metal-oxide semiconductor sensors further reduces the dose by 50% (Table 3). Furthermore, rectangular collimation decreases thyroid dose approximately 50%, and is more effective at reducing thyroid dose than thyroid shielding.[11] The extent of the intraoral radiographic examination strongly influences thyroid dose; doses with bite-wing radiographs and periapical radiographs are below detection levels.[37] In children, bite-wing and selected periapical radiographs are obtained more frequently than full-mouth examinations.[13] Thus, the committee considered that the overall population radiation exposure with intraoral radiography has negligible effects on thyroid carcinogenesis.

Panoramic imaging uses a collimated narrow radiography beam and produces little scatter. Similar to intraoral imaging, more than 80% of panoramic units use digital imaging receptors. Thyroid gland–absorbed doses are less than 0.1 mGy.[37-43] Thyroid shields could cause artifacts that degrade image quality and negatively affect diagnostic evaluation.

Cephalometric imaging uses standardized projection geometry. Some digital cephalometric units use a narrow, collimated beam that scans across the patient's craniofacial structures—this will decrease scatter radiation and subsequent dose. Other digital units image the entire field with a single exposure. Nevertheless, the thyroid radiation dose from cephalometric imaging is less than 0.1 mGy.[37,44-46] Although shields may be placed to reduce thyroid gland dose, their placement could cause artifacts that degrade image quality and negatively affect diagnostic evaluation. Considering the already low dose to the thyroid gland, added benefits from shielding are questionable.

Radiation doses from CBCT imaging vary depending on the exposure settings, the size of the imaged field, and the device model and manufacturer. CBCT scans of the maxilla deliver less dose to the thyroid than mandibular CBCT scans. Thyroid doses from CBCT imaging[38,44,45,47-58] are within the range of those from intraoral imaging[12,41,59] and are considerably lower than doses from head and neck multidetector CT examinations (Table 3).

Practical issues related to thyroid collar use during dentomaxillofacial imaging

Blocking the Useful Primary Beam

With panoramic and some CBCT devices, the primary radiography beam is projected with a negative angulation. When obtaining a panoramic radiograph, the image of a thyroid shield may be projected onto and obscure anatomy of the mandible and often the anterior maxilla. Thyroid-absorbed dose from panoramic imaging is less than 0.1 mGy (Table 3). It is challenging to place a thyroid shield to yield effective radiation dose reduction without creating artifacts. With CBCT imaging, the artifacts are pronounced and spread over a large area of the scan. Such artifacts may manifest even when the thyroid shield is placed outside the field of view. This is often the case with mandibular scans.

Infection Control

The thyroid shield is likely to become contaminated with saliva, particularly during intraoral imaging. Failure to properly disinfect the thyroid shield may result in patient cross-contamination.

Selected published statements and guidance documents

NCPR Report No. 177 is the most contemporary document that provides guidance for radiation safety and protection in dentistry and oral and maxillofacial imaging.[7] Recommendation No. 19 of this report states: "Thyroid shielding shall be provided for patients when it will not interfere with the examination."[7]

In 2012, the American Dental Association's Council on Scientific Affairs published guidance for patient selection and dose limitation.[6] Thyroid shielding was discussed as

> The thyroid gland is more susceptible to radiation exposure during dental radiographic exams given its anatomic position, particularly in children. Protective thyroid collars and collimation substantially reduce radiation exposure to the thyroid during dental radiographic procedures. Because every precaution should be taken to minimize radiation exposure, protective thyroid collars should be used whenever possible.[6]

In 2013, the ATA published a policy statement on thyroid shielding during diagnostic imaging.[32] These quotations are specific references to dental diagnostic imaging

- "With regards to dental x-rays, the ATA recommends the reduction of thyroidal radiation exposure as much as possible without compromising the clinical goals of dental examinations."[32]
- "The ATA also recommends that efforts be made to encourage and monitor compliance with the American Dental Association (ADA) and NCRP guidelines and to reduce, as much as possible, the areas of ambiguity in them."[32]

The European consensus on patient contact shielding was published in 2022.[31] For intraoral, cephalometric, and CBCT imaging, the committee recommendation was thyroid contact shielding may be used.[31] This category indicates "general agreement favours usefulness of patient contact shielding in some circumstances."[31] The European consensus group did not recommend thyroid shielding for mammography and CT, both procedures when the thyroid-absorbed doses are equal to or exceed those from dentomaxillofacial imaging.[60,61]

RECOMMENDATIONS

Patient thyroid shielding during diagnostic intraoral, panoramic, cephalometric, and CBCT imaging should be discontinued as routine practice. As necessary, federal, state, and local regulations and guidance should be revised to remove any actual or implied requirement for routine thyroid shielding for intraoral, panoramic, cephalometric, and CBCT images. ■

SUPPLEMENTAL DATA

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1. American Academy of Oral and Maxillofacial Radiology. Clinical recommendations regarding use of cone beam computed tomography in orthodontics: position statement by the American Academy of Oral and Maxillofacial Radiology. *Oral Surg Oral Med Oral Pathol Oral Radiol*. 2013;116(2):238-257.

2. Special Committee to Revise the Joint AAE/AAOMR Position Statement on Use of CBCT in Endodontics. AAE and AAOMR Joint Position Statement: use of cone beam computed tomography in endodontics 2015 update. *Oral Surg Oral Med Oral Pathol Oral Radiol*. 2015;120(4):508-512.

3. Horner K, Islam M, Flygare L, Tsiklakis K, Whaites E. Basic principles for use of dental cone beam computed tomography: consensus guidelines of the European Academy of Dental and Maxillofacial Radiology. *Dentomaxillofac Radiol*. 2009;38(4):187-195.

4. Tyndall DA, Price JB, Tetradis S, et al.; American Academy of Oral and Maxillofacial Radiology. Position statement of the American Academy of Oral and Maxillofacial Radiology on selection criteria for the use of radiology in dental implantology with emphasis on cone beam computed tomography. *Oral Surg Oral Med Oral Pathol Oral Radiol*. 2012;113(6):817-826.

5. ADA Council on Scientific Affairs. An update on radiographic practices: information and recommendations. *JADA*. 2001;132(2):234-238.

6. Dental radiographic examinations: recommendations for patient selection and limiting radiation exposure. American Dental Association, US Department of Health and Human Services. Accessed June 17, 2022. https://www.ada.org/-/media/project/ada-organization/ada/ada-org/files/resources/research/oral-health-topics/dental_radiographic_examinations_2012.pdf?rev=b074dde4cb0b4cc5a2343feb3f89b66d&hash=AF0BCF8A12C4937B2921177FE650CC54

7. National Council on Radiation Protection and Measurements. *Radiation Protection in Dentistry and Oral & Maxillofacial Imaging: Recommendations of the National Council on Radiation Protection and Measurements. NCRP Report No. 177*. National Council on Radiation Protection and Measurements; 2019.

8. *Health Risks From Exposure to Low Levels of Ionizing Radiation: BEIR VII Phase 2*. National Research Council. The National Academies Press; 2006. Accessed July 20, 2023. https://nap.nationalacademies.org/catalog/11340/health-risks-from-exposure-to-low-levels-of-ionizing-radiation

9. National Research Council Committee to Assess Health Risks from Exposure to Low Level of Ionizing Radiation. Health Risks From Exposure to Low Levels of Ionizing Radiation: *BEIR VII Phase 2*. National Academies Press; 2006.

10. Menaker NH, Yepes JF, Vinson LA, et al. Prescription of bite-wing and panoramic radiographs in pediatric dental patients: an assessment of current trends and provider compliance. *JADA*. 2022;153(1):23-30.

11. Johnson KB, Ludlow JB, Mauriello SM, Platin E. Reducing the risk of intraoral radiographic imaging with collimation and thyroid shielding. *Gen Dent*. 2014;62(4):34-40.

12. Johnson KB, Ludlow JB. Intraoral radiographs: a comparison of dose and risk reduction with collimation and thyroid shielding. *JADA*. 2020;151(10):726-734.

13. Hilohi MC, Eicholtz G, Eckerd J, Spelic DC. *Nationwide Evaluation of X-Ray Trends (NEXT): Tabulation and Graphical Summary of the 2014-2015 Dental Survey*. Conference of Radiation Control Program Directors; 2019.

14. American National Standard/American Dental Association Standard 1094. *Quality Assurance for Digital Intra-Oral Radiographic Systems*. American Dental Association; 2020.

15. AAPM position statement on the use of patient gonadal and fetal shielding. American Association of Physicists in Medicine. Accessed November 16, 2020. https://www.aapm.org/org/policies/details.asp?id=468&type=PP

16. NCRP recommendations for ending routine gonadal shielding during abdominal and pelvic radiography. National Council of Radiation Protection and Measurements. Accessed July 18, 2023. https://ncrponline.org/wp-content/themes/ncrp/PDFs/Statement13.pdf

17. National Council on Radiation Protection and Measurements. *Scientific Committee 1-8 on Risk to the Thyroid from Ionizing Radiation*. National Council on Radiation Protection and Measurements; 2009.

18. International recommendations on radiological protection. *Br J Radiol*. 1951;24(277):46-53.

19. Recommendations of the International Commission on Radiological Protection. *ICRP Publication* 9. Pergamon Press; 1966.

20. Recommendations of the ICRP. ICRP Publication 26. *Ann ICRP*. 1977;1(3).

21. The 2007 Recommendations of the International Commission on Radiological Protection. ICRP Publication 103. *Ann ICRP*. 2007;37(2-4):1-332.

22. Kelaranta A, Ekholm M, Toroi P, Kortesniemi M. Radiation exposure to foetus and breasts from dental x-ray examinations: effect of lead shields. *Dentomaxillofac Radiol*. 2016;45(1):20150095.

23. Rottke D, Andersson J, Ejima KI, Sawada K, Schulze D. Influence of lead apron shielding on absorbed doses from cone-beam computed tomography. *Radiat Prot Dosimetry*. 2017;175(1):110-117.

24. Rottke D, Grossekettler L, Sawada K, Poxleitner P, Schulze D. Influence of lead apron shielding on absorbed doses from panoramic radiography. *Dentomaxillofac Radiol*. 2013;42(10):20130302.

25. ACR-SPR practice parameter for imaging pregnant or potentially pregnant adolescents and women with ionizing radiation. American College of Radiology. 2018. Accessed December 21, 2022. https://www.acr.org/-/media/ACR/Files/Practice-Parameters/pregnant-pts.pdf

26. Streffer C, Shore R, Konermann G, et al. Biological effects after prenatal irradiation (embryo and fetus). A report of the International Commission on Radiological Protection. *Ann ICRP*. 2003;33(1-2):5-206.

27. National Council on Radiation Protection and Measurements. *Implications of Recent Epidemiologic Studies for the Linear Nonthreshold Model and Radiation Protection*. National Council on Radiation Protection and Measurements; 2018.

28. Doll R, Wakeford R. Risk of childhood cancer from fetal irradiation. *Br J Radiol*. 1997;70:130-139.

29. Yu L, Bruesewitz MR, Vrieze TJ, McCollough CH. Lead shielding in pediatric chest CT: effect of apron placement outside the scan volume on radiation dose reduction. *AJR Am J Roentgenol*. 2019;212(1):151-156.

30. Guidance on using shielding on patients for diagnostic radiology applications. The British Insititue of Radiology. Accessed September 20, 2022. https://www.bir.org.uk/media/414334/final_patient_shielding_guidance.pdf
31. Hiles P, Gilligan P, Damilakis J, et al. European consensus on patient contact shielding. *Radiography (Lond)*. 2022;28(2):353-359.
32. Policy statement on thyroid shielding during diagnostic medical and dental radiology. American Thyroid Association. 2013. Accessed December 16, 2023. https://www.thyroid.org/wp-content/uploads/statements/ABS1223_policy_statement.pdf
33. Schneider AB, Kaplan MM, Mihailescu DV. Thyroid collars in dental radiology: 2021 update. *Thyroid*. 2021;31(9):1291-1296.
34. Boice JD. The linear nonthreshold (LNT) model as used in radiation protection: an NCRP update. *Int J Radiat Biol*. 2017;93(10):1079-1092.
35. Ron E, Modan B, Preston D, Alfandary E, Stovall M, Boice JD Jr. Thyroid neoplasia following low-dose radiation in childhood. *Radiat Res*. 1989;120(3):516-531.
36. Thompson DE, Mabuchi K, Ron E, et al. Cancer incidence in atomic bomb survivors, part II: solid tumors, 1958-1987. *Radiat Res*. 1994;137(2 suppl):S17-S67.
37. Ludlow JB, Davies-Ludlow LE, White SC. Patient risk related to common dental radiographic examinations: the impact of 2007 International Commission on Radiological Protection recommendations regarding dose calculation. *JADA*. 2008;139(9):1237-1243.
38. Li Y, Huang B, Cao J, et al. Estimating radiation dose to major organs in dental x-ray examinations: a phantom study. *Radiat Prot Dosimetry*. 2020;192(3):328-334.
39. Han GS, Cheng JG, Li G, Ma XC. Shielding effect of thyroid collar for digital panoramic radiography. *Dentomaxillofac Radiol*. 2013;42(9):20130265.
40. Granlund C, Thilander-Klang A, Ylhan B, Lofthag-Hansen S, Ekestubbe A. Absorbed organ and effective doses from digital intra-oral and panoramic radiography applying the ICRP 103 recommendations for effective dose estimations. *Br J Radiol*. 2016;89(1066):20151052.
41. Benchimol D, Koivisto J, Kadesjo N, Shi XQ. Effective dose reduction using collimation function in digital panoramic radiography and possible clinical implications in dentistry. *Dentomaxillofac Radiol*. 2018;47(7):20180007.
42. Lee C, Park B, Lee SS, et al. Efficacy of the Monte Carlo method and dose reduction strategies in paediatric panoramic radiography. *Sci Rep*. 2019;9(1):9691.
43. Ludlow JB, Davies-Ludlow LE, Brooks SL. Dosimetry of two extraoral direct digital imaging devices: NewTom cone beam CT and Orthophos Plus DS panoramic unit. *Dentomaxillofac Radiol*. 2003;32(4):229-234.
44. Grunheid T, Kolbeck Schieck JR, Pliska BT, Ahmad M, Larson BE. Dosimetry of a cone-beam computed tomography machine compared with a digital x-ray machine in orthodontic imaging. *Am J Orthod Dentofacial Orthop*. 2012;141(4):436-443.
45. Qu X, Li G, Zhang Z, Ma X. Thyroid shields for radiation dose reduction during cone beam computed tomography scanning for different oral and maxillofacial regions. *Eur J Radiol*. 2012;81(3):e376-e380.
46. Hoogeveen RC, Rottke D, van der Stelt PF, Berkhout WE. Dose reduction in orthodontic lateral cephalography: dosimetric evaluation of a novel cephalographic thyroid protector (CTP) and anatomical cranial collimation (ACC). *Dentomaxillofac Radiol*. 2015;44(4):20140260.
47. Tsiklakis K, Donta C, Gavala S, Karayianni K, Kamenopoulou V, Hourdakis CJ. Dose reduction in maxillofacial imaging using low dose cone beam CT. *Eur J Radiol*. 2005;56(3):413-417.
48. Ludlow JB, Ivanovic M. Comparative dosimetry of dental CBCT devices and 64-slice CT for oral and maxillofacial radiology. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod*. 2008;106(1):106-114.
49. Ludlow JB. A manufacturer's role in reducing the dose of cone beam computed tomography examinations: effect of beam filtration. *Dentomaxillofac Radiol*. 2011;40(2):115-122.
50. Pauwels R, Beinsberger J, Collaert B, et al.; The SEDENTEXCT Project Consortium. Effective dose range for dental cone beam computed tomography scanners. *Eur J Radiol*. 2012;81(2):267-271.
51. Al-Okshi A, Nilsson M, Petersson A, Wiese M, Lindh C. Using GafChromic film to estimate the effective dose from dental cone beam CT and panoramic radiography. *Dentomaxillofac Radiol*. 2013;42(7):20120343.
52. Goren AD, Prins RD, Dauer LT, et al. Effect of leaded glasses and thyroid shielding on cone beam CT radiation dose in an adult female phantom. *Dentomaxillofac Radiol*. 2013;42(6):20120260.
53. Ludlow JB, Walker C. Assessment of phantom dosimetry and image quality of i-CAT FLX cone-beam computed tomography. *Am J Orthod Dentofacial Orthop*. 2013;144(6):802-817.
54. Morant JJ, Salvado M, Hernandez-Giron I, Casanovas R, Ortega R, Calzado A. Dosimetry of a cone beam CT device for oral and maxillofacial radiology using Monte Carlo techniques and ICRP adult reference computational phantoms. *Dentomaxillofac Radiol*. 2013;42(3):92555893.
55. Kim DS, Rashsuren O, Kim EK. Conversion coefficients for the estimation of effective dose in cone-beam CT. *Imaging Sci Dent*. 2014;44(1):21-29.
56. Hidalgo A, Davies J, Horner K, Theodorakou C. Effectiveness of thyroid gland shielding in dental CBCT using a paediatric anthropomorphic phantom. *Dentomaxillofac Radiol*. 2015;44(3):20140285.
57. Ludlow JB, Timothy R, Walker C, et al. Effective dose of dental CBCT-a meta analysis of published data and additional data for nine CBCT units. *Dentomaxillofac Radiol*. 2015;44(1):20140197.
58. Lukat TD, Perschbacher SE, Pharoah MJ, Lam EW. The effects of voxel size on cone beam computed tomography images of the temporomandibular joints. *Oral Surg Oral Med Oral Pathol Oral Radiol*. 2015;119(2):229-237.
59. Perez Fuentes JA, Roldan Sanchez VS, Gordillo Ledesma AK, Mena AF, Brito S, Soteldo C. Mean glandular dose in the mammary gland and dose of radiation in the thyroid gland and lens in women with and without breast implants during different modalities of mammography. *Radiologia (Engl Ed)*. 2022;64(suppl 1):11-19.
60. Franck C, Smeets P, Lapeire L, Achten E, Bacher K. Estimating the patient-specific dose to the thyroid and breasts and overall risk in chest CT when using organ-based tube current modulation. *Radiology*. 2018;288(1):164-169.
61. Mazonakis M, Tzedakis A, Damilakis J, Gourtsoyiannis N. Thyroid dose from common head and neck CT examinations in children: is there an excess risk for thyroid cancer induction? *Eur Radiol*. 2007;17(5):1352-1357.
62. Ludlow JB. Dose and risk in dental diagnostic imaging: with emphasis on dosimetry of CBCT. *Imaging Sci Dent*. 2009;39(4):175-184.
63. Okano T, Harata Y, Sugihara Y, et al. Absorbed and effective doses from cone beam volumetric imaging for implant planning. *Dentomaxillofac Radiol*. 2009;38(2):79-85.
64. Okano T, Matsuo A, Gotoh K, et al. Comparison of absorbed and effective dose from two dental cone beam computed tomography scanners. Article in Japanese. *Nihon Hoshasen Gijutsu Gakkai Zasshi*. 2012;68(3):216-225.
65. Schulze RKW, Cremers C, Karle H, de Las Heras Gala H. Skin entrance dose with and without lead apron in digital panoramic radiography for selected sensitive body regions. *Clin Oral Investig*. 2017;21(4):1327-1333.

eTable 1. List of published studies of breast-absorbed dose from dentomaxillofacial imaging.

STUDY	MODALITY	BREAST DOSE,* mGy	
		Unshielded	Shielded
Ludlow, 2009[62]	Bite-wing	0.001	0
Ludlow, 2009[62]	Full-mouth intraoral radiographs, rectangular collimation	0.000	0
Ludlow, 2009[62]	Full-mouth intraoral radiographs, round collimation	0.002	0.001
Ludlow, 2009[62]	Panoramic	0.002	0
Ludlow, 2009[62]	Cephalometric, lateral	0.001	0
Ludlow, 2009[62]	Cephalometric, anteroposterior	0.001	0
Okano and Colleagues, 2009[63]	CBCT†	0.01-0.03	NA‡
Okano and Colleagues, 2012[64]	CBCT	0.013-0.034	NA
Rottke and Colleagues, 2013[24]	CBCT	0.002-0.084	0.037-0.093
Kelaranta and Colleagues, 2016[22]	Periapical, mandibular incisor	0.001	0.000
Kelaranta and Colleagues, 2016[22]	Periapical, maxillary premolar	0.001	0.001
Kelaranta and Colleagues, 2016[22]	Occlusal, maxilla	0.002	0.001
Kelaranta and Colleagues, 2016[22]	Panoramic	0.004	0.001
Kelaranta and Colleagues, 2016[22]	Cephalometric, lateral	0.004	0
Kelaranta and Colleagues, 2016[22]	CBCT	0.0-0.076	0.00-0.011
Rottke and Colleagues, 2017[23]	CBCT	0.221-0.278	0.203
Rottke and Colleagues, 2017[23]	CBCT	0.278	0.261
Rottke and Colleagues, 2017[23]	CBCT	0.263	0.263
Schulze and Colleagues, 2017[65]	Panoramic	0.004	0
Franck and Colleagues, 2018,[60] **Mean (SD)**	Chest computed tomography	15 (0.5)	NA
Li and Colleagues, 2020[38]	Intraoral radiograph	0.002	NA
Li and Colleagues, 2020[38]	Panoramic	0.006-0.009	NA
Li and Colleagues, 2020[38]	CBCT	0.025	NA
Perez Fuentes and Colleagues, 2022[59]	Mammography	1.360-3.080	NA

* Individual data were compiled and used to calculate median doses. Doses are rounded to the nearest microgray (0.001 mGy) and doses less than 0.001 mGy are reported as 0. † CBCT: Cone-beam computed tomography. ‡ NA: Not applicable.

eTable 2. List of published studies of thyroid-absorbed dose from dentomaxillofacial imaging.

STUDY	MODALITY	THYROID DOSE,* mGy	
		Unshielded	Shielded
Tsiklakis and Colleagues,[47] 2005	CBCT†	0.320	0.180
Ludlow and Colleagues,[37] 2008	Intraoral, full-mouth examination, PSP,‡ rectangular collimation	0.117	NA§
Ludlow and Colleagues,[37] 2008	Intraoral, bite-wings, rectangular collimation	0	NA
Ludlow and Colleagues,[37] 2008	Intraoral, full-mouth examination, PSP, round collimation	0.550	NA
Ludlow and Ivanovic,[48] 2008	Cephalometric	0.030-0.045	NA
Ludlow and Ivanovic,[48] 2008	CBCT	0.333-1.733	NA
Ludlow,[49] 2011	CBCT	0.835	NA
Grunheid and Colleagues,[44] 2012	Cephalometric	0.030	NA
Grunheid and Colleagues,[44] 2012	CBCT	0.150-0.367	NA
Pauwels and Colleagues,[50] 2012	CBCT	0.474	NA
Qu and Colleagues,[45] 2012	CBCT	1.895	0.625-0.768
Qu and Colleagues,[45] 2012	CBCT	2.700	0.695-0.740
Al-Okshi and Colleagues,[51] 2013	CBCT	0.050	NA
Goren and Colleagues,[52] 2013	CBCT	0.470-1.780	0.280-1.200
Han and Colleagues,[39] 2013	Panoramic	0.028-0.068	0.025-0.056
Ludlow and Walker,[53] 2013	CBCT	0.183-0.301	NA
Morant and Colleagues,[54] 2013	CBCT	0.050	NA
Kim and Colleagues,[55] 2014	CBCT	0.533	NA
Hildalgo and Colleagues,[56] 2015	CBCT	1.620	0.940-1.050
Hoogeveen and Colleagues,[46] 2015	Cephalometric	0.004	0.004-0.005
Ludlow and Colleagues,[57] 2015	CBCT	0.345	NA
Ludlow and Colleagues,[57] 2015	CBCT	0.162-1.374	NA
Lukat and Colleagues,[58] 2015	CBCT	0.023	NA
Granlund and Colleagues,[40] 2016	Cephalometric	0.040-0.048	NA
Benchimol and Colleagues,[41] 2018	Panoramic	0.040	NA
Lee and Colleagues,[42] 2019	Panoramic	0.024-0.036	NA
Johnson and Colleagues,[12] 2020	Intraoral, full-mouth examination, PSP, rectangular collimation	1.086	0.448
Johnson and Colleagues,[12] 2020	Intraoral, full-mouth examination, PSP, rectangular collimation	0.366-1.027	0.266-0.428
Li and Colleagues,[38] 2020	Panoramic	0.054-0.064	NA
Li and Colleagues,[38] 2020	CBCT	0.453-0.476	NA

* Individual data were compiled and used to calculate median doses. Doses are rounded to the nearest microgray (0.001 mGy) and doses less than 0.001 mGy are reported as 0. † CBCT: Cone-beam computed tomography. ‡ PSP: Photostimulable storage phosphor. § NA: Not applicable.