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RADIATION CONTROL AND SAFETY IN DENTISTRY: HOW IT DIFFERS FROM THE MEDICAL RADIOLOGY SETTING

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ABSTRACT

Background: Radiation control and safety practices differ substantially between dentistry and medical radiology, despite both disciplines relying on the same underlying physics of ionising radiation and sharing common international frameworks. Objective: To review current evidence characterising the differences between dental and medical radiation protection, focusing on dose magnitude, optimisation philosophy, patient shielding practice, occupational monitoring, and regulatory governance, with particular reference to the South African setting.

Methodology: A narrative literature review was conducted using PubMed/MEDLINE, the Journal of the American Dental Association, and publications of the International Atomic Energy Agency, International Commission on Radiological Protection, National Council on Radiation Protection and Measurements, and the South African Health Products Regulatory Authority.

Major findings: Dental radiographic examinations (intraoral, panoramic, and cone-beam computed tomography) deliver effective doses that are one to three orders of magnitude lower than typical medical computed tomography and interventional fluoroscopic procedures. This dose differential has driven a divergence in protection philosophy: dentistry has progressively moved away from routine patient lead-apron and thyroid-collar shielding in favour of beam collimation and exposure optimisation, whereas medical radiology retains shielding, dedicated medical physics support, and structured occupational dosimetry, particularly for computed tomography and interventional personnel. Regulatory oversight in South Africa is unified under the Hazardous Substances Act, 1973, and administered by the South African Health Products Regulatory Authority, but licensing structures, quality-control obligations and access to qualified experts differ markedly between solo dental practice and hospital-based medical radiology departments.

Conclusion: Although dentistry and medicine share the As Low As Reasonably Achievable/As Low As Diagnostically Acceptable optimisation principle, the low-dose, high-frequency nature of dental imaging justifies protection strategies distinct from those of medical radiology. Continued education of dental practitioners on these evolving, discipline-specific standards remains a priority, particularly in resource-constrained settings.

Keywords: Radiation Protection; Dental Radiography; ALARA; Cone-Beam Computed Tomography; Occupational Exposure; South Africa

1 INTRODUCTION

Ionising radiation has been central to diagnostic imaging since Röntgen's discovery of X-rays in 1895, and both dentistry and medicine have built extensive clinical practice around its use. The two disciplines share a common regulatory ancestry: the foundational optimisation principle of radiation protection, As Low As Reasonably Achievable (ALARA), was formalised in the 1970s and applies across all diagnostic uses of ionising radiation, and the International Commission on Radiological Protection's (ICRP) system of dose limitation ¹ underlies national legislation in both fields. Despite this shared foundation, the clinical application of radiation protection in dentistry has increasingly diverged from that in medical radiology. Dental radiographic examinations are numerous, of low individual dose, and performed predominantly by the treating clinician or an auxiliary rather than a dedicated radiographer, whereas medical radiology encompasses a far wider dose range, from low-dose plain radiography to high-dose computed tomography (CT), fluoroscopically guided intervention and nuclear medicine, typically performed within departments supported by radiographers, radiologists and medical physicists ².

This divergence has become particularly evident since 2023–2024, when the American Academy of Oral and Maxillofacial Radiology (AAOMR) and, subsequently, the American Dental Association (ADA) Council on Scientific Affairs, recommended discontinuing routine patient lead-apron and thyroid-collar shielding for intraoral, panoramic, cephalometric and cone-beam computed tomography (CBCT) imaging ^{3,4}, a position that stands in contrast to medical radiology, where shielding, structured occupational dosimetry and formal medical physics oversight remain standard, particularly for CT and interventional fluoroscopy. For the general dental practitioner, understanding why dentistry has adopted a distinct protection strategy, rather than simply adopting medical radiology norms, is important both for evidence-based patient communication and for regulatory compliance.

The objective of this review is to characterise, and where possible quantify, the principal differences between radiation control and safety in dentistry and in medical radiology. The review addresses four domains: (i) the magnitude and distribution of radiation dose across dental and medical imaging modalities; (ii) the evolution of patient shielding and optimisation practice; (iii) occupational protection and personnel monitoring; and (iv) the regulatory and quality-assurance architecture governing each discipline, with specific reference to the South African regulatory environment in which the corresponding author practises.

2 MATERIALS AND METHODS

This is a narrative review rather than a systematic review or original data collection study; accordingly, no ethical approval, informed consent or patient-level data were required. A structured literature search was conducted using PubMed/MEDLINE, the Journal of the American Dental Association (JADA), Google Scholar, and the publicly available guidance documents of the International Atomic Energy Agency (IAEA), the ICRP, the National Council on Radiation Protection and Measurements (NCRP), the ADA, the AAOMR, and the South African Health Products Regulatory Authority (SAHPRA). Search terms included combinations of "dental radiography," "radiation protection," "ALARA," "ALADA," "cone-beam computed tomography," "occupational dose," "medical radiology," "lead apron," "thyroid collar," and "South Africa." Sources published between 2003 and 2026 were prioritised, with foundational documents (NCRP Report No. 145 and No. 177, and ICRP Publication 103) reviewed in full.

Sources were included where they provided quantitative dosimetric data, formal guideline or position-statement recommendations from a recognised professional or regulatory body, or peer-reviewed South African data on dental radiation protection practice or legislation. Non-peer-reviewed marketing material and sources without an identifiable authoring or regulatory body were excluded except where used to illustrate general public-facing dose comparisons. Given the narrative design, no formal risk-of-bias or quality-appraisal instrument was applied; emphasis was instead placed on triangulating dose and policy figures across multiple independent guideline sources.

3 RESULTS AND DISCUSSION

3.1 Dose magnitude: dental versus medical imaging

The single most consistent finding across the reviewed literature is that routine dental radiographic examinations deliver effective doses that are markedly lower than most medical radiological procedures. A digital intraoral periapical or bitewing radiograph delivers an effective dose in the region of 1–20 μSv (mean approximately 6 μSv), a full-mouth intraoral series up to approximately 400 μSv (mean approximately 171 μSv), and panoramic radiography a mean of approximately 20 μSv (range 4–61 μSv) ⁵. Dental CBCT is more variable and field-of-view dependent, with reported effective doses ranging from as little as 17 μSv for small fields of view to over 1,000 μSv for large maxillofacial fields, and mean values in the region of 50–150 μSv for small-to-medium volumes ^{6,7}. By comparison, a medical chest radiograph delivers approximately 100 μSv , a head CT approximately 1,500–2,000 μSv , and an abdominal or

abdominopelvic CT 8–10 mSv or more ^{7,8}; interventional fluoroscopic procedures and some nuclear medicine studies can deliver effective doses an order of magnitude higher still. Even the highest-dose routine dental examination, large-field CBCT, therefore remains, in most protocols, below the dose of a single chest radiograph and several orders of magnitude below that of an abdominal CT scan. This dose differential is the central physical justification for the divergent protection strategies discussed below; it does not, however, remove the obligation to justify and optimise every dental exposure, since the cumulative and paediatric-specific risk of even low-dose ionising radiation is not considered negligible by international bodies ¹.

3.2 Optimisation philosophy: ALARA and ALADA in both disciplines

Both dentistry and medical radiology operate under the same overarching optimisation principle, ALARA, introduced in 1977 and subsequently supplemented in imaging practice by the related concept of "As Low As Diagnostically Acceptable" (ALADA), which explicitly weighs image quality against diagnostic need rather than dose reduction alone ^{3,9}. In medical radiology, this principle is operationalised largely through diagnostic reference levels, protocol-specific dose modulation on CT scanners, and departmental audit by medical physicists. In dentistry, the same principle is applied predominantly at the level of individual clinical decision-making: justification of each exposure against a documented clinical indication, selection of the lowest-dose modality capable of answering the clinical question, rectangular collimation, digital receptors, and appropriate exposure-time and kilovoltage selection ^{3,10}. The 2019 NCRP Report No. 177, which superseded the 2003 Report No. 145, remains the principal technical reference underpinning contemporary dental optimisation guidance in the United States and, by extension, much internationally adapted dental curricula ^{2,11}.

3.3 Patient shielding: a point of genuine divergence

Perhaps the clearest example of dentistry diverging from long-standing medical radiology practice is patient shielding. Lead aprons and thyroid collars were, for decades, considered standard of care in both disciplines. In 2023 the AAOMR published an evidence-based position statement concluding that thyroid and gonadal shielding provide no measurable additional protection during intraoral, panoramic, cephalometric or CBCT imaging, because the great majority of the effective dose in these examinations arises from internally scattered radiation within the patient rather than from the primary beam striking unshielded tissue outside the field of view; the Academy further noted that shielding can obscure diagnostic anatomy, necessitate retakes (and therefore additional exposure), and pose an infection-control risk if not properly disinfected between patients ⁴. In February 2024 the ADA Council on Scientific Affairs, working with medical physicists from the US Food and Drug Administration, adopted an aligned position, recommending discontinuation of routine lead abdominal aprons and thyroid collars for all patients, including pregnant and paediatric patients, in favour of rectangular collimation, correct patient positioning and modern digital equipment ^{3,12}. This guidance has since been reaffirmed and extended in updated 2026 ADA-AAOMR patient-selection recommendations ¹².

Medical radiology has not undergone an equivalent wholesale change. Gonadal and gestational shielding practice in general radiography has itself been reassessed in recent years, but lead aprons, thyroid shields and protective eyewear remain standard occupational equipment for staff performing or assisting with fluoroscopy, interventional radiology and CT-guided procedures, where scatter fields and procedure durations are substantially greater than in dental radiography ¹. The result is a practical, and potentially confusing, divergence for patients who may receive shielding during a medical radiological visit but not during a dental one; dental practitioners should be equipped to explain this evidence-based distinction rather than defaulting to outdated shielding practice or to blanket extrapolation from medical settings. It is also notable that shielding requirements remain embedded in some subnational legislation, illustrating a lag between evidence, professional guidance and statute; for example, some United States jurisdictions still mandate gonadal apron use in dental radiography by regulation, notwithstanding the 2023–2024 professional guidance ¹³, underscoring that practitioners must reconcile evolving scientific consensus with the specific legal requirements of the jurisdiction in which they practise.

3.4 Occupational protection and personnel dosimetry

Occupational radiation protection also differs in emphasis. ICRP Publication 103 sets an occupational effective-dose limit of 20 mSv per year, averaged over defined five-year periods, with no single year exceeding 50 mSv, and, following ICRP Publication 118, an equivalent-dose limit for the lens of the eye of 20 mSv per year averaged over five years ^{1,14}. These limits apply identically, in principle, to dental and medical radiation workers. In practice, however, occupational doses in general dental practice are typically a small fraction of these limits, because operators can generally stand outside the primary beam and at a safe distance during exposure, and dental units operate at comparatively low tube current and short exposure times; NCRP Report No. 177 and associated dental radiation-protection literature accordingly note that many dental settings do not require routine personal dosimetry, provided structural shielding, operator positioning and equipment output are verified through periodic quality-control testing ^{2,11}. Medical radiology personnel, in particular those working in CT, fluoroscopy, interventional radiology and nuclear medicine, by contrast, are more likely to remain in or near the room during exposure, work with substantially higher-output equipment, and

accumulate doses that justify routine badge dosimetry, dedicated eye-lens monitoring, and departmental medical physics oversight ¹.

This difference should not, however, be read as an assumption that dental occupational protection can be neglected. South African survey data indicate that awareness of radiation protection principles and legislation among oral health care providers and students remains suboptimal, with respondents in one national survey answering only 58% of radiation-protection knowledge items correctly ¹⁵, and a separate cross-sectional study of rural Limpopo dental and radiography personnel identifying inconsistent dosimeter use and gaps in radiation-protection compliance following the closure of non-compliant radiography units ¹⁶. These findings suggest that the lower inherent occupational risk of dental radiography does not eliminate the need for structured training, quality assurance and, where indicated by facility risk assessment, personnel monitoring.

3.5 Regulatory and quality-assurance architecture, with reference to South Africa

In South Africa, the use of ionising radiation in both dentistry and medicine is regulated under a single statute, the Hazardous Substances Act, 1973 (Act No. 15 of 1973), which classifies X-ray-emitting equipment as a Group III hazardous substance and prohibits its importation, sale or use without a licence issued by the regulator ¹⁷. Since 2018 this function has been administered by the South African Health Products Regulatory Authority (SAHPRA) through its Radiation Control directorate, which succeeded the former Directorate: Radiation Control of the national Department of Health ¹⁸. Although the statutory framework is unified, its practical application differs between the two disciplines. In dentistry, the licence to use an X-ray device is typically issued to the individual dentist or dental therapist, who becomes the license holder personally responsible for compliance, equipment quality control, record-keeping and adherence to licence conditions at the practice level ¹⁹. SAHPRA's dedicated Guideline for Dental Radiography sets out requirements for radiation worker classification, unit-specific quality-control testing by an approved inspection body, and image-quality standards specific to intraoral, panoramic and CBCT equipment ¹⁹. In medical radiology, by contrast, licensing and compliance obligations typically sit within a hospital or imaging-department structure that includes a designated radiation safety officer and, for higher-output modalities such as CT and interventional fluoroscopy, access to a qualified medical physicist responsible for acceptance testing, dose optimisation protocols and departmental quality assurance ¹¹. The South African regulatory model, in this respect, mirrors the international pattern described in the NCRP and ICRP literature: dentistry operates a decentralised, practitioner-licensed model appropriate to its lower-risk, single-operator setting, while medical radiology operates a centralised, physics-supported model appropriate to its higher-dose, higher-complexity equipment base ².

3.6 Special populations and the pregnant or paediatric patient

Because dental radiographic doses are low and the exposed field is distant from the uterus, and because internal scatter rather than direct beam exposure dominates the small residual dose, current AAOMR and ADA guidance states that pregnancy is not, in itself, a reason to withhold clinically indicated dental radiography or to apply abdominal shielding, which offers no measurable fetal dose reduction in this context ^{4,3}. This differs from medical radiology practice, where pregnancy continues to materially influence modality selection, protocol modification and, for CT and fluoroscopic procedures involving the abdomen or pelvis, formal dose-estimation and multidisciplinary discussion, reflecting the substantially higher fetal doses possible with those modalities. Paediatric dental imaging is guided by the same justification and optimisation principles as adult imaging, informed additionally by campaigns such as Image Gently in Dentistry, which emphasise field-of-view limitation, exposure-parameter adjustment for smaller patients, and avoidance of CBCT where two-dimensional imaging is diagnostically sufficient ¹¹.

3.7 Cone-beam computed tomography as a convergence point

CBCT occupies an important transitional position in this comparison. Its dose range overlaps the upper end of dental imaging and the lower end of medical CT, and its expanding use in orthodontics, implant planning and endodontics has moved a subset of dental imaging doses closer to, though still generally below, medical CT doses ^{6,7}. This convergence is reflected in guidance requiring the same justification rigour applied to medical CT: field of view should be restricted to the smallest volume that answers the clinical question, exposure parameters should be adjusted rather than using a single default protocol, and CBCT should not substitute for two-dimensional imaging where the latter provides sufficient diagnostic information ^{3,12}. CBCT therefore illustrates that the dentistry–medicine divide is best understood as a dose-and-complexity continuum rather than a strict categorical boundary, reinforcing the case for optimisation practices scaled to the specific modality and protocol rather than to the discipline alone.

4 CONCLUSION

Dentistry and medical radiology share a common foundation in the physics of ionising radiation and in the ALARA/ALADA optimisation principle, and both are subject, in South Africa, to a single overarching statute administered by SAHPRA. Beyond this shared foundation, however, the two disciplines have developed materially

different radiation-safety strategies, driven principally by the substantially lower effective doses associated with routine dental imaging. This has justified the discontinuation of routine patient lead-apron and thyroid-collar shielding in dentistry, a reduced reliance on routine personnel dosimetry in low-risk dental settings, and a decentralised, practitioner-licensed regulatory model, in contrast to the shielding, medical-physics-supported, and centrally coordinated quality-assurance structures retained in medical radiology, particularly for CT, fluoroscopic and nuclear medicine practice. Cone-beam computed tomography sits at the convergence of these two paradigms and warrants medical-radiology-level justification discipline despite its dental origin. South African survey data indicate that practitioner awareness of these evolving, evidence-based distinctions is not yet optimal, supporting continued undergraduate and continuing-education emphasis on discipline-specific radiation protection rather than uncritical extrapolation from medical radiology norms.

STATEMENTS ON COMPLIANCE WITH ETHICAL STANDARDS

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Disclosure of conflict of interest

The author declares no financial, professional, institutional or personal conflict of interest relevant to the content of this manuscript.

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