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Patients Awareness and Anxiety of Radiation in Dental Imaging: A Literature Review

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Abstract

Radiographic imaging is a key element in the diagnostic and therapeutic planning of modern dentistry. However, these modalities use ionizing radiation that may carry biological risks, often causing concern and anxiety in the community. This review summarizes the literature worldwide regarding the patients' knowledge, attitude and anxiety levels toward radiation in dental imaging. The results show a pervasive and consistent deficit in patient literacy. Many patients do not know the difference between ionizing and non-ionizing modalities, underestimate equivalent doses from dental versus medical examinations, and have strong misconceptions about the safety of dental radiography during pregnancy and lactation. Routine dental X-ray procedures usually cause low-to-moderate baseline anxiety, but dramatic increases in emotional distress occur when protective equipment (e.g., lead aprons and thyroid collars) is not used or communication about clinical risk is inadequate. The most important predictor of compliance, more than perceived radiation risk, has been shown in empirical data to be trust in the clinician . These gaps need to be addressed through structured, system-level educational interventions, standardized visual aids, and a move to evidence-based risk communication relating dental exposures to natural background radiation.

Keywords: Dental radiography, Ionizing radiation, Patient awareness, Radiation anxiety, Risk perception, Radiation protection.

1. Introduction

Radiographic imaging procedures are among the most frequently performed diagnostic examinations on healthy persons worldwide [1-3]. In dental practice, modalities include low-dose intraoral digital examinations (periapical and bitewing films), panoramic radiography and advanced higher-dose cone-beam computed tomography [4, 5]. These methods provide dentists with important information for an accurate diagnosis, treatment planning and prognosis monitoring [5].

However, ionizing radiation interacts at atomic level and exposure to ionizing radiation can result in adverse biological effects [6]. Conventionally these biological hazards are divided into deterministic effects, which occur only when a certain threshold dose is reached and result in clinical functional impairment [1-3] and stochastic effects, which have no threshold dose and whose probability of occurrence (mainly carcinogenesis and hereditary damage) linearly increases with the accumulated dose [2]. To minimize these stochastic risks, radiation protection in medical and dental imaging is strictly based on the basic concepts of justification, limitation of dose and optimization [7]. Optimization in clinic is practiced under the guidelines of ALARA (As Low As Reasonably Achievable) and with the

rapid integration of cone-beam computed tomography ALADA (As Low As Diagnostically Acceptable) [8].

But even with these technical safety precautions, there remains a large gap in communication and understanding between clinical radiation safety guidelines and patients' real understanding of dental X-rays. Clinical apprehension, often characterized by misinformation and ambiguous risk perception, can compromise patient care through treatment avoidance or outright refusal of diagnostic procedures that are necessary [9]. The aim of this review is to review the empirical evidence from recent multi-center and cross-sectional studies, so as to assess dental radiology patients' knowledge about radiation, safety perceptions and levels of anxiety.

2. Discussion

A thematic analysis of the literature indicates a worldwide and enduring lack of public understanding of basic radiological concepts [10].

2.1 Public Awareness and Knowledge of Dental Radiation Modalities and Doses

The Ionizing vs. Non-Ionizing Modality Confusion: A large percentage of the general public cannot correctly identify the medical and dental diagnostic modalities that produce ionizing radiation. In cross-sectional studies, a significant percentage of patients consider that X-rays are used in non-ionizing modalities [11]. In particular, up to 60.7% of surveyed patients are not aware that Magnetic Resonance Imaging is radiation-free, and around 32.7% are not aware that Ultrasound is radiation-free [12]. In contrast, a large segment of the patient population is under the false impression that barium swallows and barium enemas, which are loaded with radiation, are completely free of radiation [13].

Dental vs. Medical Exposure Misconceptions: Patients always have a hard time understanding relative exposure levels and dose equivalencies [14]. For example, less than one third of adult dental patients know that the radiation dose of intraoral radiographs is less than that of medical radiographs of other parts of the body [15]. Only 8.6% of the patients know that there is no legal annual dose limit for clinically justified diagnostic examinations [16].

The Challenge of Cone-beam Computed Tomography and Panoramic Radiography: The general public is still not widely aware of advanced dental technologies like cone-beam computed tomography. More than 70.5% of patients do not realize that the 3D CBCT imaging involves a far greater radiation dose compared to conventional 2D panoramic radiography [17]. At the same time, very few patients are aware that the average effective dose of a single panoramic film is remarkably small, approaching only a fraction of the natural background radiation exposure per day [18].

Socio-demographic determinants: education and age are strong modulators of the knowledge of the patients. Multiple logistic and linear regression analyzes show that patients with younger age (18–25) and higher educational degrees (university or postgraduate levels) have statistically higher scores of radiation literacy [11, 19]. This cohort has a very high level of online literacy, which refers to their ability to find and understand health resources on the internet [20].

2.2 Anxiety, Risk Perception and the Psychological Function of the Protective Shield

Patients' emotional and psychological responses to dental imaging are not always commensurate with real biological risk.

Context-Specific Anxiety: In a clinical setting, baseline anxiety for routine dental radiographs is generally low-to-moderate, and most patients tolerate the procedure well. Anxiety, however, increases

considerably under certain conditions, especially when patients feel physically unprotected [21, 22].
The Shielding Paradox: Empirical data shows that the visible use of protective shielding equipment, such as lead aprons and thyroid collars, is the most important predictor of a patient's feeling of safety during dental radiography [21]. Conversely, the lack of protective shielding is a major trigger of feelings of vulnerability, insecurity and acute anxiety [23]. Modern regulatory bodies (e.g. ICRP) have recognized that lead aprons do not offer complete protection from exposure and are not always clinically justified due to the technical scatter properties, but the psychological reassurance they provide is still essential to the patient [24].
Trust vs. Risk Refusal: Patients are highly concerned in the abstract about cumulative doses of radiation, sensitivity of pediatric organs, and radiation carcinogenesis [25]. However, the true rate of refusal or delay of recommended dental radiographs is extremely low (between 11% and 23%) [26]. This divergence might suggest that patient compliance depends more on trust in the treating clinician than on perceived radiation hazards [26, 27].

2.3 Pregnancy and Lactation: The Tyranny of Extreme Misunderstandings
The clinical literature consistently reports that the largest cognitive gaps and misconceptions are centered around pregnancy and breastfeeding safety guidelines [28].
The Pregnancy Barrier: Evolving guidelines from professional bodies such as the American Dental Association reflect the absolute safety of dental radiography during pregnancy when warranted and when suitable protective shielding is employed [25]. Today, dental examinations provide a fetal dose of ~0.25 µGy, which is well below dose levels associated with teratogenic or carcinogenic hazards. Therefore, there is no scientific basis for delaying necessary diagnostic imaging [8, 25]. However, only around 11% of patients are aware that shielded dental X-rays are safe during pregnancy and over 80% believe that they should be avoided altogether [8, 25]. This extreme fear is often reinforced by ambiguous warning signs in clinics and a historically absent individualized counseling [8].
The Breastfeeding Myth: Public knowledge about dental radiography during lactation is also poor [16]. Only 21.9% of those surveyed knew that a mother who is breastfeeding could safely have a dental X-ray [16]. Most of the public incorrectly believes that ionizing radiation can biologically contaminate or otherwise alter breast milk, resulting in unnecessary delays in dental treatment of mothers [8].
2.4 Communication among Clinicians and Patients and Information Media There is a considerable discrepancy between clinicians' self-reported clinical disclosure practices and the patients' actual experience [29].
The Communication Gap: While most emergency and dental providers report routinely discussing the risks and benefits of radiation with their patients, over three-quarters of patients (74.7% to 85.6%) report that no such discussion ever occurred prior to their imaging [29].
Provider Hesitancy: Clinicians often do not initiate in-depth discussions regarding the risks and benefits of radiological examinations [24]. The main barriers reported by clinicians include time constraints in busy clinical settings, limited confidence in their own knowledge of radiation dose communication, and concerns that discussing radiation risks may unnecessarily increase patient anxiety or discourage patients from undergoing clinically necessary examinations [10].
Information Preferences: A high proportion of patients express a desire to receive information about radiation exposure and generally prefer such information to be communicated directly by healthcare professionals in clear, understandable language [29]. Social media has also been reported as a common

source of radiation-related information, accounting for up to 47.3% of responses in a recent dental patient survey. However, despite access to such information sources, overall patient knowledge regarding radiation risks and protection remains insufficient [11].

3. Conclusion

This review indicates that the biological hazards of dental radiography are very low, but the public knowledge about that is poor, and full with misconceptions. A major failure in current clinical communication is the continuing confusion about pregnancy and breastfeeding guidelines and the context-specific 'X-ray anxiety' of the lack of shielding.

The dental profession must move away from a passive approach of dose disclosure toward active, empathetic risk-communication in an effort to close this gap and develop informed consent. Clinicians should be educated about the use of simple analogies, such as comparing dental exposure to daily natural background radiation (e.g. a panoramic radiograph is equal to only a few days of natural background exposure). On a systems level, dental schools, professional associations and public health agencies should develop standardized, highly visual education tools (e.g. brochures and clinical posters) to debunk radiological myths. Finally, the monitoring of radiation exposure in Electronic Health Records or patient "radiation passports" will improve safety monitoring, reduce cumulative overexposure and build long-term patient trust.

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