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Original Article

Knowledge, Attitude, and Practice of Dentists towards Radiation Safety Procedures: A Questionnaire-Based Cross-Sectional

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Abstract: Dentists use radiographs to diagnose, treat, and monitor dental diseases and conditions. Therefore, they must know about radiation protection strategies and practice the safety standards to minimize radiation exposure and its hazardous effects.

The aim: This study aims to evaluate dentists' knowledge and attitudes regarding radiation protection standards in dental imaging and their compliance with safety protocols.

Methods: A questionnaire comprising two sections with 15 questions was conducted across three clinic types: educational, public, and private. A literature review was conducted to prepare this questionnaire. The dentists answered inquiries regarding their attitudes and knowledge toward radiation protection, as well as the protection of patients and dental staff. The questionnaire also contained questions regarding the management of radiographic waste. Descriptive statistics of Data analysis and graph creation were conducted using Microsoft Excel (Version 2010) software program.

Results: A response rate of 100%, 59% of the participants had less than 10 years of practice experience. Only 18.8% of dentists engaged in the radiation protection and safety course. A significant 80% indicated that they conduct dental radiography personally, while merely 17.4% of dentists use lead aprons. Notably, there is an absence of thyroid collars or personal protective equipment among the practitioners. No one used personal dosimeters during radiography. Our study revealed that 89.4% of dentists applied the same exposure parameters for children and adults.16.8% provide patients with lead aprons. Nearly 95% of dentists inquire about imaging during pregnancy.

Conclusion: The study shows that dentists possess significant theoretical knowledge about radiation protection standards, but they failed to apply this knowledge due to the lack of necessary safety tools, such as badges and thyroid collars, in their clinics, and the absence of a government-funded radiation monitoring program.

Keywords: Dentists, Radiation Protection, Safety, Dental Imaging.

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المعرفة والموقف والممارسة لدى أطباء الأسنان تجاه إجراءات السلامة الإشعاعية

دراسة مقطعية قائمة على الاستبيان

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المستخلص: يستخدم أطباء الأسنان الأشعة لتشخيص وعلاج ومراقبة أمراض وحالات الأسنان. لذلك، يجب عليهم معرفة استراتيجيات الحماية من الإشعاع وتطبيق معايير السلامة للحد من التعرض للإشعاع وآثاره الضارة.

الهدف: تهدف هذه الدراسة إلى تقييم معارف أطباء الأسنان ومواقفهم تجاه معايير الحماية من الإشعاع في تصوير الأسنان، ومدى التزامهم ببروتوكولات السلامة.

المنهجية: أُجري استبيان مكون من قسمين، يحتوي على 15 سؤالاً، عبر ثلاثة أنواع من العيادات: التعليمية، والعامة، والخاصة. وراجعت الدراسات السابقة لإعداد هذا الاستبيان. أجاب أطباء الأسنان على استفسارات حول مواقفهم ومعرفتهم تجاه الحماية من الإشعاع، بالإضافة إلى حماية المرضى وطاقم طب الأسنان. كما تضمن الاستبيان أسئلة تتعلق بإدارة نفايات التصوير الإشعاعي. أُجريت إحصاءات وصفية لتحليل البيانات وإنشاء الرسوم البيانية باستخدام برنامج مايكروسوفت إكسل (إصدار 2010).

النتائج: بلغت نسبة الاستجابة 100%، وكان لدى 59% من المشاركين خبرة ممارسة لا تقل عن 10 سنوات. وشارك 18.8% فقط من أطباء الأسنان في دورة الحماية من الإشعاع والسلامة. أشار 80% من أطباء الأسنان إلى أنهم يُجرون تصويرًا شعاعيًا للأسنان بأنفسهم، بينما يستخدم 17.4% فقط منهم مآزر الرصاص. والجدير بالذكر أن أطواق الغدة الدرقية أو معدات الوقاية الشخصية غير متوفرة لدى الممارسين. ولم يستخدم أحد أجهزة قياس الجرعات الشخصية أثناء التصوير الشعاعي. وكشفت دراستنا أن 89.4% من أطباء الأسنان يطبقون معايير التعرض نفسها للأطفال والبالغين، بينما يوفر 16.8% منهم مآزر الرصاص للمرضى. ويستفسر ما يقرب من 95% من أطباء الأسنان عن التصوير أثناء الحمل.

الخلاصة: تُظهر الدراسة أن أطباء الأسنان يمتلكون معرفة نظرية واسعة بمعايير الحماية من الإشعاع، إلا أنهم لم يطبقوا هذه المعرفة جيدًا نظرًا لنقص أدوات السلامة اللازمة، مثل الشارات وأطواق الغدة الدرقية، في عياداتهم، وغياب برنامج حكومي لرصد الإشعاع.

الكلمات المفتاحية: أطباء الأسنان، الحماية من الإشعاع، السلامة، تصوير الأسنان.

Introduction:

Dentists depend significantly on radiographic imaging techniques for diagnosing and managing dental conditions, more so than most other medical specialists[1,2]. A study by the European Commission indicates that dental X-ray procedures comprise roughly 32% of all plain radiography procedures in Europe. Approximately 352 dental imaging procedures are conducted annually for every 1,000 individuals [3]. The amount of radiation that patients are exposed to during dental procedures that make use of intraoral or extraoral radiography is significantly reduced by applying the radiological protection principles, which are based on three fundamental principles: justification, optimization, and dose limitation [4].

Stochastic effects are still possible with advanced imaging techniques, even though these techniques have advanced. It is guaranteed that stochastic effects will be manifested by the 'linear, non-threshold theory' regardless of the dose that is administered. Stochastic effects are directly proportional to the dose administered, implying that as the dose increases, the likelihood or magnitude of stochastic effects also increases proportionally. However, it is essential to clarify that, in radiobiology and related fields, stochastic effects—such as cancer induction or genetic mutations—are generally considered to have a probability that increases with dose but does not have a threshold; their severity is not dose-dependent in a linear fashion. Instead, the likelihood of occurrence rises with increasing dose, often modeled as a linear or linear-quadratic function [5,6].

Biological damage to DNA, whether caused directly or indirectly, can elevate the risk of developing cancer. The thyroid gland's specific anatomical position and high radiation sensitivity make it a vital organ to consider during dental radiography procedures. Given the widespread use and frequency of dental radiographic examinations over a person's lifetime, even a slight increase in the risk of thyroid cancer is significant. This underscores the importance of ethical considerations in dental practice, emphasizing the need to minimize radiation exposure to protect patient health while achieving diagnostic objectives [4, 5, 7].

Understanding radiation protection procedures and dentists' safety practices can minimize patient radiation exposure. During dental imaging, a lead apron and thyroid collars can significantly attenuate secondary radiation exposure [7, 8, 9]. Dentists must conform to radiation protection and safety standards to maintain high quality and safety in clinics.

Previous literature studies have shown that health professionals, including physicians, radiographers, and dentists, lack sufficient knowledge about the risks related to ionizing radiation and neglect the applied radiation protection equipment [1, 4, 6, 9,10]. Assessing dentists' knowledge, attitudes, and practices regarding dental imaging and implementing appropriate radiographic protection is imperative. This study assesses dentists' knowledge and attitudes regarding radiation protection standards in dental radiography and their compliance with safety protocols.

Material and methods:

This study developed an initial questionnaire based on existing scientific evidence regarding radiation hazards and the literature connecting radiation protection to health. Expert panels verified its content validity. Before data collection, each participant granted informed consent, and confidentiality and anonymity were maintained throughout the study. A questionnaire comprising two sections with 15 questions was conducted across three clinic types: educational, public, and private. A literature review was conducted to prepare this questionnaire.

All participants received an Arabic-language information sheet outlining the current study's objectives and the questionnaire. To ensure complete anonymity of responses, the information sheet indicated that no personal information capable of identifying the respondent was collected. The information sheet indicated that participation is entirely voluntary, and individuals who choose not to participate should return the provided documents without completing any information. Data analysis and graph creation were conducted using Microsoft Excel (Version 2010). Before analysis, all variables were examined for data entry accuracy and the presence of missing values.

Results:

This study involved the distribution of 85 questionnaires to dentists from three types of clinics: educational, public, and private, resulting in a response rate of 100% (Table 1). A questionnaire was developed to ensure complete anonymity, thus granting participants enhanced freedom. The participants were asked about years of professional experience, radiation protection measures for patients and dental staff, and their attitudes and behaviors regarding radiation safety. Participants were initially required to choose one option: yes or no. In the second part, participants completed multiple-choice questions to assess their knowledge. Descriptive statistics have been calculated using percentages.

This study showed that 59% of the participants had less than 10 years of dental practice experience. 27% of dentists were general dental practitioners (GDP), and 14% were specialists, as shown in Figure 1.

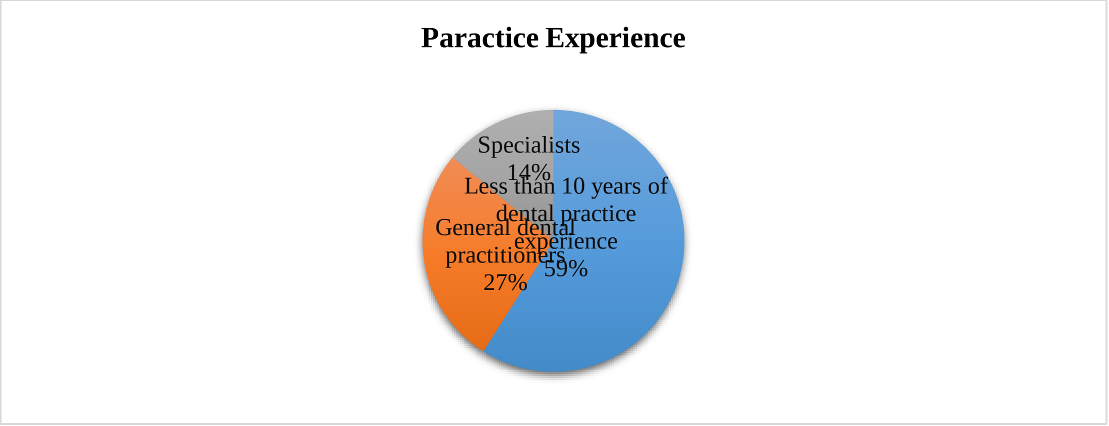

Figure 1 shows the practice experience for all dental practitioners, general dental practitioners, and specialists.

Protection of personnel

This survey reported that 18.8% of dentists who participated in the survey attended the radiation protection and safety course. 80% of dentists reported performing dental imaging procedures independently, while only 17.4% consistently wore lead aprons. Furthermore, only 2% of the dentists who participated in the survey wore personal protective equipment or had ever worn thyroid collars. According to the survey, none of the dentists in the study carry personal passive dosimeters to monitor radiation exposure during dental procedures, which could pose risks to their health. The results suggest that many participants either neglect or lack awareness regarding the significance of radiation monitoring as a protective measure.

Concerning imaging receptor holders, 65.2% of patients manually support imaging receptors during radiography procedures. 44.8% of participants manually hold imaging receptors or use film holders. This is due to the lack of film holders in dental clinics. (4%) Four percent of participants indicated ionizing radiation warning signboards in their workplace. Only 4% of participants could identify the radiation protection officer at their clinic.

Protection of Patient:

Exposure parameter Factors influencing decisions in medical imaging include Patient factors such as age, weight, and health status; image receptor properties, such as type and sensitivity; and exposure parameters: tube voltage (kV), tube current (mA), and exposure duration (s). Using the same parameters for adults and children: According to the study, 89.4% of practitioners use the same exposure parameters for adults and children, which may impact image quality and patient safety [13].

Only 16.7% of participants in this study always provide their patients with lead aprons. These results indicate that most patients lack protection during dental radiography procedures. 94.7% of dentists ask female patients whether they were pregnant before imaging.

Table 1: Participants' attitudes and practices in dental imaging:

Questionnaire (Translated to Arabic)	Answers	Number of participants N% %
Do you follow the radiation protection and radiation safety training course?	Yes	18.8%
	No	81.2%
Do you perform dental radiography procedures on your own?	Yes	80%
	No	20%
Do you wear a lead apron when doing dental radiography on your own	Yes	17.4%
	No	82.6%
Do you wear a thyroid collar when you are performing dental intraoral radiography?	Yes	2%
	No	98%
Do you use a personal passive dosimeter when performing dental intraoral radiography?	Yes	00%
	No	100%
Is there a barrier (shielding) between you and the X-ray source?	Yes	29.2%
	No	97.8%
Do you give the patient a leaded apron to wear before dental imaging?	Yes	16.7%
	No	83.3%
Do you use the same parameters (kV, mA, s) for dental imaging of adult and pediatric patients?	Yes	89.4%
	No	10.6%
Do you have ionizing radiation warning signboards in your workplace?	Yes	4%
	No	96%
Do you ask the patient to hold the radiographic film with his/her hand in dental radiography?	Yes	65.2%
	No	44.8%
Do you ask the female patients whether they are pregnant or not before imaging?	Yes	94.7%
	No	6.3%
Do you know who the «Radiation protection officer» is at your clinic?	Yes	4%
	No	96%

Distribution of Answers Given to Knowledge Questions

About 67.7% of participants accurately recognized the ionizing radiation protection principle as "as low as reasonably achievable" (ALARA), which corresponds to the guidelines set by the International Commission on Radiation Protection (ICRP). Additionally, 89.4% of participants determined that minimizing radiation exposure is essential in digital radiography. Furthermore, 45% of dentists recognized the annual occupational dose limit established by the ICRP.

In dental radiology, 82.6% of participants identified the thyroid gland as the most radiosensitive organ, the salivary glands were identified by 13.1%, the gonads by 2%, and the bone marrow by 3.3%

60.9% of the participants in this study gave accurate answers regarding the dosimeter's function. Table 2 summarises the results of the study on radiation protection knowledge among dentists.

Table 2: Distribution of participants' answers about radiation protection knowledge:

Questions	Answers	%
A dosimeter is used to study the amount of	Radiation exposure Tissue damage caused by ionizing radiation Stochastic effects Deterministic effects	60.9% 21.7% 3.4% 13%
According to ICRP, what is the annual occupational dose limit? (mSv)	50 100 150 200	45.8% 25.8% 28.4% 00%
From ICRP, which of the following is the principle of radiation protection	ALARA ABARA AFARA ASARA	67.7% 9.5% 8.5% 14.3%
What is the most crucial organ that must be protected during dental radiography?	Salivary gland Thyroid Gonads Bone marrow	13.1% 82.6% 2% 3.3%
Digital radiography requires less exposure than conventional radiography	Yes No	89.4% 10.6%
Do you know the best position during dental imaging	Yes No	65.4% 34.6%
Do you perform quality assurance for dental radiography in a clinic	Yes No	60.3% 39.7%

ABARA: As big as reasonably achievable,
AFARA: As fast as reasonably achievable,
ASARA: As slow as reasonably achievable
ALARA: As low as reasonably achievable,
ICRP: International Commission on Radiation Protection,

Discussion

Radiation protection is the practice and theory of safeguarding the environment and humans against the damaging effects of ionizing radiation. The International Atomic Energy Agency defines radiation protection as the principles, regulations, technologies, and practices designed to help protect individuals (personnel, the general public, and patients receiving radiation). Therefore, the objective of the radiation protection protocol should be to prevent deterministic effects and minimize the probability of stochastic effects by reducing exposure to ionizing radiation [10].

Dental imaging is a diagnostic procedure that, in dentistry, regularly employs ionizing radiation. Consequently, intraoral and maxillofacial imaging must be conducted selectively and responsibly, reducing radiation exposure while enhancing diagnostic performance. Nonetheless, ionizing radiation may cause biological damage to living tissues. It can directly harm the DNA of living cells and indirectly by generating free radicals. Repeated exposure to cytotoxic agents may lead to chronic cellular injury, compensatory cellular proliferation, hyperplasia, and tumorigenesis [4, 11]. Comprehending the potential risks and appropriately implementing precautions and preventive measures is crucial.

Dentists are responsible for ensuring the safety of their patients, staff, and themselves from radiation exposure during all dental radiographic procedures, diagnosis, and treatment of the adverse effects of ionizing radiation. To achieve these goals, they should be fully aware of the biological hazards of X-rays and the precautions required to prevent unnecessary radiation exposure. Though radiation exposure in dentistry is minimal, it is essential to follow the guidelines to minimize it [11, 12].

This study highlights dentists' knowledge, awareness, and practical and theoretical proficiency in radiological imaging and radiation protection protocols.

Many dentists possess dental imaging equipment in their clinics and perform radiological imaging individually. Moreover, dentists performing dental imaging must know legal and ethical considerations and have theoretical and practical expertise in imaging techniques.

Radiation protection and safety courses cover topics such as how much radiation dental patients are exposed to, how to optimize X-ray doses, and what resources are available to educate staff and patients about radiation risks and safety. Only 18.8% of the participants received radiation protection training, which is considered low compared with that of Maisuradze et al. [4].

The survey included 85 participants from renowned oral and dental health clinics in Tobruk. Eighty percent of participants reported conducting imaging independently, in addition to comprehensive patient physical exams. Ayşegül et al. found that 82.5% of dentists in private clinics and 23.3% in public hospitals perform dental imaging procedures independently. Overall, staffing costs for imaging processes are the leading cause [6].

89.4% of participants reported that digital radiography systems reduce patient radiation exposure compared to conventional radiography systems. Prior research demonstrates that direct or indirect digital systems in Intraoral radiography markedly decrease patient radiation exposure [13].

The selection of exposure parameters, such as tube voltage (kVp), tube current (mA), and exposure duration (s), is influenced by the patient's attributes and the specific characteristics of the image receptor used [14, 15, 6]. A thorough evaluation of all components and parameters before exposure is essential to enhance the efficiency of the radiation dose. The parameters for dental imaging procedures, specifically tube voltage, tube current, and exposure duration, must be consistently regulated within 65–70 kVp, 5–12 mA, and 2–18 seconds, respectively [16, 17]. Nonetheless, 89.4% indicated they used the same exposure parameters for adults and children. A study conducted in United States by Campbell et al. found that 95% of participants set lower exposure parameters for pediatric patients, while a minority used adult imaging parameters or didn't know how to adjust them [18]. Due to their higher radiation sensitivity than adults, 24 dental professional institutions and associated reports recommend minimal exposure parameters in pediatric imaging [2, 18].

In dental radiography, radiation quality assurance is accomplished through the use of specific protocols, which may include the use of thyroid collars on patients when it is deemed necessary. Monitoring staff radiation exposure and regular monitoring of radiographic equipment by regulatory authorities [6, 1]. The application of thyroid collars should be particularly encouraged for pediatric patients, women of reproductive age, and pregnant women. Although the National Council on Radiation Protection and Measurement [NCRP] does not require patients to wear lead aprons, it does advise using thyroid shields because of the possibility of stochastic radiation exposure. According to the study, 2% and 17.4% of participants wear thyroid collars and lead aprons for patient protection. When imaging the upper anterior teeth, Hoogeveen et al. found that using a thyroid shield reduces the radiation exposure to the thyroid [19]. Schueler demonstrated that a 0.5 mm-thick apron reduced scatter radiation by 90% [21]. Hyun et al., furthermore, tested how well a 0.5 mm thick lead apron blocked radiation and found that it did so for a little more than a third of the time [20]. Several studies suggest that repeated exposure to dental X-rays may increase the risk of thyroid cancer [7, 19, 20, 21].

Lee et al. found that over 50% of radiography patients catch imaging receptors with their hands [22]. 65% of patients held the imaging receptor independently; 45% of dentists did. The lack of film holders in dental clinics causes this. Halboub et al. found that holding the film in the patient's mouth during exposure was harmful [23].

Personal radiation monitoring devices, or dosimeters, protect workers from radiation. These devices measure radiation levels for safety protocols. Wearing dosimeters is limited to three months for operators. The dosimetry service provider gives staff the cumulative radiation dose from various sources. Although approximately 60% of participants correctly identified dosimeters, none of the dentists used theirs due to the lack of badges [4, 24].

Optimal radiation protection is attained by employing a barrier or vacating the examination room during dental radiographic procedures. For challenging procedures, the dentist must maintain an optimal position and distance. The dentist must maintain a distance of at least 2 meters from the patient and avoid direct exposure to the primary radiation beam [24]. This guideline employs the inverse square law to minimize operator X-ray exposure, as the patient's head predominantly absorbs radiation in this direction. The study revealed that 65.4% of participants knew appropriate positioning and distance guidelines, while 29.2% encountered a clinic barrier. Multiple studies indicate that dentists require no radiation protection equipment, such as lead aprons and thyroid collars, if positioned at least 2 meters from the radiation source [16].

The literature studies also recommend radiation protection for the thyroid gland as the most radiosensitive organ in dental imaging. Dentists in this survey identified the thyroid gland at 82.6% as the most radiosensitive tissue. This is aligned with previous literature, as Simmarasan et al found that 75.8% of dentists considered the thyroid gland the most important organ to protect during dental imaging [10].

Despite low radiation doses, studies show that dental imaging may cause low birth weight. In this study, 33.33% of dentists said dental imaging for pregnant patients is unsafe, while 94.7% said they always ask about pregnancy before imaging. Despite being pregnant, dental imaging must be done using minimal exposure parameters, and the patient must wear a lead apron and thyroid collar following the ALARA principle [24, 25]. This study found that 67.7% of dentists understood ALARA. 96.9% of participants reported no workplace radiation warning signs. Unlike our findings, Shah et al. found that 93% of participants reported seeing the radiation warning sign [1, 6].

Conclusion

The study demonstrates that dentists have a significant theoretical understanding of radiation protection. In contrast, in practical terms, we observe that most procedures were underutilized due to clinics lacking essential safety equipment, including badges and thyroid collars, and the absence of a government-funded radiation control program.

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Informed consent

Informed consent was obtained from all dentists who participated in the study.

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