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Radio Protection Measures in Endodontics: Survey among Dentists in Casablanca

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Abstract

Introduction: Imaging is an essential tool for good endodontic practice. It participates in the diagnosis and control of the different phases of treatment. However, it should not be forgotten that it is indeed an examination involving ionizing radiation, which can have harmful effects on the patient's health as well as the practitioner's and his paramedical staff if the exposure times are long or repeated. The aim of the present study is to evaluate the knowledge and practices of radiation protection in endodontics among dentists in private practice in Casablanca. **Material and Methods:** A descriptive cross-sectional study was conducted over a period of 3 months from October 12, 2022, to January 10, 2023, among private practice dentists of Casablanca. A questionnaire with 33 questions was distributed. Statistical analysis of the results was conducted using SPSS software in the epidemiology laboratory at the Faculty of Dentistry in Casablanca. **Results:** Of the 320 dentists selected by simple random sampling, 233 dentists agreed to participate in this study, representing a response rate of 72.8%. All the interrogated dentists stated that they were equipped with an intraoral radiographic device, which was located inside the treatment room for 98.3% and 84.1% of dentists used a digital sensor, 60.1% of the practitioners held the X-ray receiver inside the patient's mouth themselves, 42.9% of the dentists were within 2 m of the patient and the X-ray tube without any protective barrier, 70.4% of the dentists interrogated were not aware of the As low as reasonably achievable (ALARA) principle. **Conclusion**: The present survey highlighted that the knowledge and practices of dentists regarding radiation protection during endodontic procedures were unsatisfactory, as has been

found in many other countries. It is, therefore, necessary to raise the awareness of the practitioners on the importance of respecting the rules of radioprotection for better use of radiographic examinations.

Subject Areas

Dentistry, Radiology & Medical Imaging

Keywords

Digital Radiograph, Radiographic Film, Dental Radiography, Radiography, Dentistry, Radiation Protection, Endodontics

1. Introduction

In December 1895, Wilhelm Conrad Röntgen, a German physicist, unveiled a groundbreaking discovery: X-rays. Through seven weeks of rigorous study, he delved into the properties of this enigmatic radiation capable of penetrating thick screens. Dubbed "X-rays" to signify their mysterious nature, Röntgen's revelation ignited a frenzy of scientific inquiry [1].

Promptly, physicians and physicists started using X-rays in patient care, marking the inception of medical radiology in January 1896. Dentists swiftly followed suit, as Dr. Otto Walkhoff captured the inaugural intra-oral dental X-ray just weeks after the announcement, with an exposure time of 25 minutes. Subsequently, dental imaging has evolved into a cornerstone of dental practice, furnishing precise diagnostics, treatment guidance, and therapy monitoring. Nevertheless, the indispensable role of radiography in dentistry is tempered by the awareness of its ionizing radiation's potential adverse effects [2].

Categorized into direct and indirect actions, the biological ramifications of ionizing radiation are twofold: deterministic tissue reactions (skin burns, cataracts, or cellular death after an acute radiation exposure ≥ 100 mGy) and stochastic (random) effects [3]. In endodontics, the indispensability of radiographic imaging across preoperative, intraoperative, and postoperative phases underscores its pivotal role. Adherence to radiation protection guidelines is imperative to mitigate risks for both patients and healthcare professionals, grounded in principles emphasizing justification, optimization, and dose limitation [3] [4].

The aim of this study is to highlight the knowledge and practices in terms of radiation protection implemented by dentists in private practice in Casablanca during endodontic treatment in order to protect the medical and nursing staff.

2. Materials and Methods

The present study was conducted to evaluate the knowledge and practices of ra-

diation protection in endodontics among dentists in private practice in Casablanca. A descriptive cross-sectional study was conducted over a 3-month period from 12 October 2022 to 10 January 2023 on a sample of 320 participants selected by simple random sampling.

The inclusion criterias were private practice practitioners of Casablanca and carrying out endodontic treatments. Specialists who do not provide endodontic care (specialists in exclusive orthodontics and specialists in exclusive periodontology and oral surgery) were excluded.

To gather the necessary data, a four-page questionnaire was drawn up in French with 33 questions divided into 5 sections:

1st section: Demographic and professional identification of the dental practitioner.

2nd section: Radiological premises and equipment (8 questions).

3rd section: Radiographs during endodontic treatment (4 questions).

4th section: Knowledge and practices in radioprotection (12 questions).

5th section: knowledge of the risks of ionising radiation (5 questions).

The data were analysed statistically using SPSS software. This analysis was descriptive for all the qualitative variables, which were expressed in terms of numbers and percentages.

3. Results

Socio-Demographic and Professional Characteristics:

233 dentists agreed to participate in this study, giving a response rate of 72.8%. 140 (60.1%) dentists were female and 93 (39.9%) were male. 77 (33%) dentists were between 30 and 40 years of age. 117 (50.2%) dentists had been practising for more than 10 years. 211 (90.6%) dentists were general practitioners.

Radiological Premises and Equipment:

All the surveyed dentists had an intra-oral X-ray machine, they were interrogated about the location of their device, knowledge about the technical particularities of their equipment as mentioned in Table 1 & Table 2.

Specific Features of X-Rays Taken During Endodontic Therapy:

Endodontic therapy requires frequent radiographs. Practitioners were surveyed regarding their approach to take preoperative, intraoperative, and postoperative radiographs during endodontic procedures. The findings are outlined in Table 3 & Table 4.

Radiation Protection Practices: (Table 5)

Regarding the adherence to radiation protection protocols among dentists surveyed: 84.5% did not stand behind a protective wall, while 33% positioned themselves more than 2 meters away from the X-ray machine, and 30.5% were closer than 2 meters. Nearly half (47.2%) used the lowest possible exposure parameters, and only 27% wore lead aprons. Furthermore, 95.7% did not have dosimetric monitoring for themselves, and 97.4% lacked it for their assistants. A

Table 1. X-ray equipment used: (N = 233).

		N	%
Presence of an intra-oral X-ray machine in the practice	Yes	233	100
	No	0	0
Location of X-ray equipment	Inside the treatment room	229	98.3
	In a separate x-ray room	4	1.7
Current voltage of intra-oral X-ray machine	Less than 65 KV	56	24
	Between 65-70 KV	68	29.2
	More than 70 KV	4	1.7
	Don't know	105	45.1
Current intensity of the intra-oral X-ray machine	Less than 10 Ma	83	35.6
	Between 10-12 Ma	23	9.9
	More than 12 Ma	7	3
	Don't know	120	51.5
Type of spacer cone	A long cone	130	55.8
	A short cone	96	41.2
	A pointed cone	7	3
Use of a collimator	Yes	68	29.2
	No	165	70.8
Type of collimator used	Rounded	50	21.5
	Rectangular	18	7.7
Type of X-ray receiver used	Radiovisiography (RVG)	192	82.4
	Analog film	37	15.9
	Phosphor plates	4	1.7
Periodic quality control of the X-ray equipment	Yes	45	19.3
	No	188	80.7
Frequency of quality control	1 time/year	22	9.4
	1 time/6 months	7	3
	1 time/2 years	6	2.5
	1 time/3 months	5	2.1
	1 time/month	3	1.3
	1 time/4 years	1	0.4
	1 time/5 years	1	0.4

Table 2. Premises housing the intra-oral X-ray machine.

		N	%
Protection of the room housing the intra-oral radiography unit	No special protection	187	80.3
	Adequate thickness of gypsum	22	9.4
	Leaded walls	14	6
	Lead partitions	12	5.2

Table 3. Radiographs taken during endodontic therapy: (N = 233).

		Yes	No
		N (%)	N (%)
Preoperative radiographs		216 (92.7%)	17 (7.3%)
Intraoperative radiographs	Working length radiograph	172 (73.8%)	61 (26.2%)
	Master Cone-fit radiograph	182 (78.1%)	51 (21.9%)
Post-operative radiographs		195 (83.7%)	38 (16.3%)

Table 4. Intraoperative eccentric radiographs: (N = 233).

For single-rooted teeth		**(N)**	**(%)**
Frequency of eccentric radiographs taken	Always	21	9
	Occasionally	82	35.2
	Rarely	90	38.6
	Never	40	17.2
Number of X-rays taken	0	40	17.2
	1	66	28.3
	2	87	37.3
	3	37	15.9
	4	3	1.3
For multi-rooted teeth.		**(N)**	**(%)**
Frequency of eccentric radiographs taken	Always	86	36.9
	Occasionally	114	48.9
	Rarely	28	12
	Never	5	2.1
Number of X-rays taken	0	5	2.1
	1	26	11.2
	2	87	37.3
	3	65	27.9
	4	29	12.4
	>4	21	9.1

Table 5. Practices related to taking intra-oral radiographs.

			(N)	**(%)**
Adjustment of exposure time according to	Tooth location	Yes	125	53.6
		No	70	30
		Sometimes	38	16.3

Continued

Adjustment of exposure time according to	Patient's age	Yes	96	41.2
		No	116	49.8
		Sometimes	21	9
Adjustment of exposure time according to	Patient's build	Yes	41	17.6
		No	153	65.7
		Sometimes	39	16.7
Technique used to take radiographs during endodontic treatment		Parallel plane technique	96	41.2
		Bisector technique	40	17.2
		Both	97	41.6
Positioning the receiver when taking an intra-oral radiograph using		The practitioner's finger	140	60.1
		The patient's finger	109	46.8
		An angulator	50	21.5
		Assistant's finger	9	3.9

significant portion, 70.4%, were unfamiliar with the ALARA principle, and 73.8% were unaware of recommendations from the National Council on Radiation Protection and Measurements (NCRP) and the International Commission on Radiological Protection (ICRP). Lastly, 76.8% had not received training in radiation protection (Table 5).

Practices Related to the Taking of Intra-Oral Radiographs:

Regarding the dentists' practices while taking intra-oral radiographs: 53.6% adjusted exposure time based on tooth location, 41.2% based on patient age, and 17.6% based on patient build. In terms of techniques, 41.2% used the parallel plane technique, 17.2% used the bisector technique, and 41.6% employed both. When positioning the radiographic sensor, 60.1% used their finger, 46.8% used the patient's finger, and 21.5% used an angulator, as depicted in Table 6. Additionally, 61.8% chose position F to minimize radiation exposure according to Figure 1.

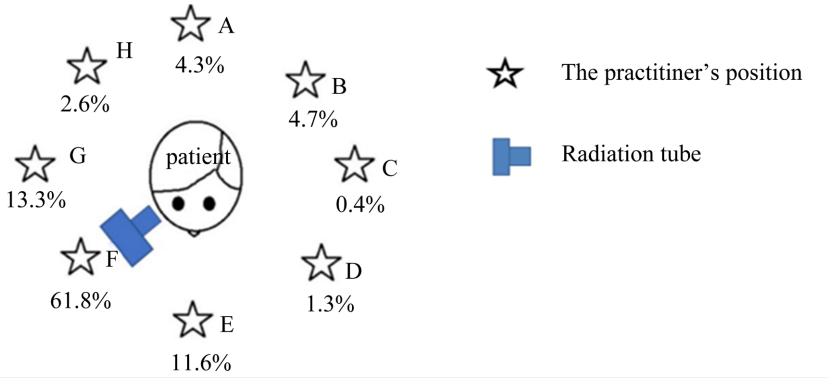

Figure 1. Diagram showing the positions chosen by practitioners to minimise their exposure toradiation.

Table 6. Radiation protection.

		(N)	(%)
Position in which the practitioner will position himself in order to minimise exposure to radiation by referring to a diagram (Figure 1).	A	10	4.3
	B	11	4.7
	C	1	0.4
	D	3	1.3
	E	27	11.6
	F	144	61.8
	G	31	13.3
	H	6	2.6
Use of a protective wall during radiation exposure	Yes	36	15.5
	No	197	84.5
Distance between X-ray machine and practitioner when taking intra-oral X-rays	Less than 2 m	71	30.5
	2 m	56	24
	More than 2 m	77	33
Other precautions taken to protect against radiation during exposure	The practitioner comes into contact with the patient	29	12.4
	Use of the lowest exposure parameters	110	47.2
	Wearing a lead apron	63	27
	Using a rectangular collimator	19	8.2
	Wearing a thyroid cove	15	6.4
	Standing outside the room when X-rays are taken	5	2.1
	Wearing lead gloves	2	0.9
Dosimetric monitoring for the practitioner	Yes	10	4.3
	No	223	95.7
Dosimetric monitoring for assistants	Yes	6	2.6
	No	227	97.4

Knowledge of the Risks of Ionising Radiation: (Table 7)

In the survey, 82% of dentists demonstrated awareness of the deterministic effects of ionizing radiation, while 57.1% were knowledgeable about the stochastic effects. Nearly all respondents (99.1%) claimed no personal experience with complications resulting from ionizing radiation exposure. However, among the rare instances where complications occurred, one dentist reported headaches, and another developed a thyroid nodule. None of the surveyed dentists reported any cases of complications among their paramedical staff due to ionizing radiation exposure. Additionally, 73% of dentists identified the thyroid as the organ most sensitive to irradiation (See Table 7).

Table 7. Knowledge of the risks of ionising radiation.

		(N)	(%)
Knowledge of the deterministic effects of ionising radiation	Yes	191	82
	No	42	18
Knowledge of the stochastic effects of ionising radiation	Yes	133	57.1
	No	100	42.9
For the practitioner: presence of a complication related to exposure to radiation	Yes	2	0.9
	No	231	99.1
For a member of the paramedical staff: presence of a complication related to exposure to radiation	Yes	0	0
	No	233	100
The most sensitive organ to irradiation	Thyroid	170	73
	Gonad	44	18.9
	Bone marrow	38	16.3
	Skin	34	14.6

4. Discussion

In this study, it was found that 45.1% of practitioners were unaware of the voltage of their generator, while 29.2% used a generator with a voltage ranging from 65 to 70 kVp. Similar findings were reported in a study conducted in India by Bali et al. in 2018, where 51.4% of practitioners were unaware of their equipment's voltage, with 21.5% using generators operating at 65 to 70 kVp [5].

Conversely, two other studies in India indicated higher rates of unawareness, with 82.3% and 89% of practitioners reported to be unfamiliar with their generator's voltage [6] [7].

Additionally, a survey of Flemish dentists found that 75% were unaware of the current intensity of their generator, while a similar result was observed among 57% of Brazilian practitioners [8] [9].

The cone spacer, situated at the forefront of the X-ray generator, serves as a sighting device. Its length functions to minimize X-ray divergence, consequently reducing both the irradiated volume and exposure dose [10] [11]. In this study, it was found that 55.8% of practitioners used an intra-oral X-ray machine with a long cone. Similar findings were found in studies from India and Türkiye, where 51.6% and 52.3% of practitioners, respectively, employed an intra-oral X-ray machine with a long cone [6] [12].

In Iran, a separate investigation found that 88% of specialist dentists and 82.7% of general practitioners employed intra-oral X-ray equipment featuring a long cone [13].

Despite its potential to decrease exposure and enhance image quality, only 7.7% of participants in our study utilized rectangular collimation. Comparable studies conducted in Australia, Türkiye, Korea, and India revealed that 5%, 5.5%, 14.6%, and 20.6% of practitioners, respectively, employed a rectangular

collimator [6] [12] [14] [15].

With the emergence of digital radiography, sensors offer numerous advantages that address the limitations of film-based systems. They facilitate the capture of high-quality images with enhanced resolution while reducing exposure time and, consequently, radiation dosage. This likely accounts for the preference of 84.1% of the surveyed dentists for digital sensors in this study. Comparable figures from studies in Australia and Korea show that 98% and 77.2% of practitioners, respectively, opt for digital sensors [14] [15].

Conversely, studies in Senegal and India reveal lower adoption rates, with only 25% and 28.9% of practitioners, respectively, utilizing digital sensors [16] [17]. Moreover, in this study, only 19.3% of dentists conducted regular checks on their X-ray equipment. Similar patterns were observed in studies from India and Türkiye, where 25.9% and 16.7% of practitioners, respectively, performed periodic checks on their X-ray equipment [6] [12].

Nevertheless, findings from a study conducted in Australia indicate that 92.1% of practitioners perform periodic checks on their X-ray equipment [14]. The concerning statistic uncovered in the current study may be attributed to the fact that, despite Moroccan legislation having a legal framework addressing quality control, the specific procedures and requirements are not clearly defined.

As per the standard operating protocol in modern endodontics, periapical intraoral radiographs are the preferred imaging modality throughout the endodontic treatment process. Consequently, four periapical intraoral radiographs are typically captured at various stages of treatment for each tooth undergoing endodontic therapy: a preoperative radiograph, a radiograph to ascertain the working length, a radiograph to verify the fit of the master cone before obturation, and a postoperative radiograph to assess the quality of the obturation [18].

And since the intra-oral radiograph is a two-dimensional image of a three-dimensional structure, two or more eccentric radiographs may be necessary for a better assessment [19].

Two techniques are commonly employed for capturing retro-alveolar images: the bisector technique and the parallel planes technique. Endodontic guidelines recommend the parallel planes technique due to its ability to produce precise radiographs with minimal dimensional distortion and high reproducibility [19].

Conversely, studies from Türkiye, Iran, and India revealed a preference for the bisector technique, with 62%, 88%, and 94.1% of practitioners, respectively, opting for it when capturing intraoral radiographs [6] [12] [20].

It is advised to use an angulator to hold the receiver in the mouth when capturing a retro-alveolar image. This practice not only standardizes and replicates the images but also stabilizes the receiver without exposing the patient's or practitioner's fingers. This recommendation is supported by multiple studies [10] [21] [22].

Similar studies conducted in India and Iran reported that 28.8% and 36% of dentists respectively used the position and distance rule correctly for their own protection [17] [20].

In the current study, only 15.5% of dentists positioned themselves behind a protective wall during exposure. This percentage contrasts starkly with findings from a study conducted by Bali Harleen *et al.* in India, where 53.3% of dentists opted to stand behind a protective wall during exposure [5].

The dosimetric monitoring findings echoed those from studies conducted in India and Iran, indicating that a significant portion of practitioners—93.6% in India and 83.1% in Iran—lacked access to dosimetric monitoring [23] [24].

The observed percentages could be attributed to the significant proportion of dentists in this study who were unaware of the availability of an application for dosimetric monitoring submission to the National Radiation Protection Centre (CNRP). Concerning familiarity with the ALARA principle, findings from a study in Saudi Arabia indicated that 68.1% of respondents were acquainted with it, similar to the 65% of dentists in Pakistan who demonstrated familiarity with the principle [4] [25].

A significant percentage of dentists surveyed exhibited inadequate practices regarding radiation protection during dental procedures. This includes not using protective barriers, positioning themselves too close to the X-ray machine, not optimizing exposure parameters, not wearing lead aprons, lacking dosimetric monitoring for themselves and their assistants, being unfamiliar with radiation protection principles and recommendations, and not receiving training in radiation protection.

A study conducted among dental students in Saudi Arabia revealed that only 30.2% were knowledgeable about the deterministic and stochastic effects of ionizing radiation [26].

In our study, only one practitioner reported experiencing a thyroid nodule associated with ionizing radiation exposure. The risk of carcinogenesis, particularly in the context of repeated exposure to low doses of radiation common in dental radiography, is of paramount concern. A case-control study conducted in Connecticut from 2010 to 2011, involving 462 cases and 498 controls, highlighted a significant increase in the risk of papillary thyroid micro carcinoma among healthcare professionals, including dentists with over 10 years of work experience [27].

5. Conclusions

Intra-oral radiography is an indispensable tool in endodontics, it participates in the diagnosis and monitoring of the various phases of treatment, enabling the therapy to be carried out successfully. Nevertheless, while the many advantages of using X-rays in endodontics are indisputable, their use is likely to cause undesirable effects and they must therefore be used intentionally while complying with radiation protection guidelines.

Raising awareness among dentists of the need to comply with these recommendations is therefore of considerable importance, and must begin in the early years of their studies.

To prevent the shortcomings observed in this study, we propose to:

-Emphasise the importance of compliance with radiation protection measures during the years of clinical training.

-Provide all dentists with initial and continuing training in radiation protection.

-Plan seminars and round tables dealing with radiation protection in dentistry.

Conflicts of Interest

The authors declare no conflicts of interest.

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