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Awareness level of dentists and dental students about radiation doses of dental imaging methods

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ABSTRACT

Background: To measure the knowledge levels of dentists and dental students about radiation doses of dental imaging techniques. ***Materials and Methods:*** A structured questionnaire containing 13 questions was conducted to 251 participants (168 dentists and 83 dental students). The first 6 questions were related to their personal and professional information, and the remaining 7 questions were about the participants' radiation education and knowledge about radiation doses. Chi-square test was used to determine the relationship between categorical variables, and $P < 0.05$ was considered statistically significant. ***Results:*** The data from 144 (57.4%) women and 107 (42.6%) men were obtained. Gender was not effective on knowledge about radiation doses during dental imaging ($p = 0.222$). The knowledge of dentists working at the university was statistically higher than those working in the state hospital or private dental offices ($p < 0.001$). Of the participants, 43.4% ($n = 109$) stated that the craniofacial mode of cone beam computerized tomography radiates less radiation than the actual dose range, while 32.7% ($n = 82$) said they had no idea. ***Conclusion:*** Most of the dentists and dental students underestimated the actual radiation doses of dental imaging techniques. The dental curriculum should be revised to emphasize radiation protection during imaging. In addition, compulsory vocational postgraduate courses should be organized.

Keywords: *Awareness, dental imaging, radiation dose, questionnaire.*

INTRODUCTION

Radiation may cause adverse biological effects for living organisms, and medical applications constitute the majority of the artificial radiation sources that contain ionizing radiation [1,2]. Ionizing radiation can induce mutations in DNA, thus increasing the risk of cancer [3,4]. Such harmful biological effects are not only related to the amount of radiation and duration of exposure but also depend on patient-related factors such as age, gender and size, technical factors, and selected devices [5]. The United Nations Scientific Committee on the Atomic Radiation (UNSCEAR) stated that 360 out of 1000 people are exposed to radiation for medical and dental purposes [6]. The literature in the fields contains studies about the knowledge of medical doctors, medical students, and radiology staff on the dose values of medical imaging techniques [1, 7-11]. Medical imaging researches have tried to highlight the potential risks and awareness of physicians to the doses of radiation exposure during the radiological procedures. Dental imaging devices have different imaging technologies and some techniques such as cone beam computed tomography (CBCT) contain relatively higher ionizing radiation than the other devices [4, 12, 13]. Additional units were presented in dental markets with various stages of development after the first approval of CBCT by the FDA for dental use in 2001 [14].

Due to the rapid development of contemporary and traditional dental imaging methods, the knowledge level of dentists requesting these imaging modalities is crucial. Although it is difficult to prove, it is believed that approximately 100–150 people die from cancer due to medical radiation exposure [7, 15]. Radiation doses of dental imaging techniques are relatively low, but these techniques constitute one-third of all radiological examinations in Europe [16]. Clinicians should take into account the cumulative effects of repeated exposure, which can increase the risk of parotid gland tumor, thyroid tumor, and intracranial meningioma [17–19]. In addition to initial diagnostic radiographs, dentists may require supplementary intraoral and extraoral radiological imaging to be performed throughout the dental treatment due to orthodontic, endodontic, and surgical reasons [12].

Ludlow *et al.* [20] reported that dental radiographic procedures are 32% to 422% riskier than previously considered. The aim of the present study was to measure the awareness level of dentists about radiation exposure doses of dental imaging techniques and encourage clinicians to redesign their diagnostic approaches and treatment plans to protect patients from unnecessary ionizing radiation. There are few studies in the literature on this subject; thus, the information presented here contributes to the literature on the radiation doses for dental imaging techniques and the knowledge level of clinicians.

MATERIALS AND METHODS

This descriptive and cross-sectional study was approved by the Ethics Committee of the Aydın Adnan Menderes University (Protocol no. ADUDHF2018/024) and was implemented between March 2018 and October 2018. A pilot survey was conducted for 20 students to validate the questionnaire. The questionnaires were applied to dental students and dentists (except dental radiologists) after the questionnaires were determined to be clear and valid. A structured questionnaire containing 13 questions was conducted to 251 volunteers living in the center of the city of Aydın. The questionnaires were delivered to the participants by the researchers themselves, and they were received after the surveys were completed under supervision. The first 6 questions addressed personal and professional information, including their age, gender, institution, area of expertise, and duration of professional practice, while the remaining 7 questions were about the participants' radiation education, attitudes regarding informing patients about radiation doses, and the level of their knowledge about radiation doses during dental imaging procedures. The designed questionnaire was based on the literature reviewed [1, 7, 9, 11]. The answers about doses of ionizing radiation during dental imaging procedures were evaluated according to the dose ranges accepted by the European Commission on Radiation Protection [21]. These dose ranges were: 280–1410 μSv for maxillo-mandibular multislice computed tomography (MSCT); 30–1073 μSv for craniofacial CBCT; 11–674 μSv for dentoalveolar CBCT; 2.7–24.3 μSv for a panoramic radiograph; <6 μSv for a cephalometric radiograph; and < 1.5 μSv for an intraoral radiograph using a photostimulable phosphor plate or F-speed film with rectangular collimation. For the CBCT device, large field of view (FOV) was referred to as “craniofacial” and small and medium FOVs as “dentoalveolar”.

Statistics

Data were analyzed using the statistical software package SPSS v22.0 (Armonk, NY: IBM Corp). To determine the relationship between categorical variables, Pearson and Yates' chi-square tests were performed. The Mann–Whitney U test and Kruskal-Wallis H test were used for the comparison of two and more than two independent groups, respectively. Descriptive statistics were given in frequency and percentage form for categorical variables, and a median (25–75 percentiles) was given for numerical variables. $P<0.05$ was considered

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statistically significant.

RESULTS

A total of 251 participants participated in the study. Mean age of the participants was 31.53 ± 10.74 years. Of these, 144 (57.4%) were female and 107 (42.6%) were male (ranging between 20 to 66 years). Of the participants, 168 (67.9%) were dentists, and 83 (33.1%) were dental students (19 fourth year and 64 third year). All the participating students had previously attended the lessons on radiation protection. Of the 168 dentists, 37 were employed in the state hospital, 64 in private dental offices, and 67 in the university. The distribution of the sociodemographic features of the study group is represented in table 1. Of the participants, 226 (90%) stated that they had radiation safety education.

Table 1. Distribution of sociodemographic features of the study group.

	n	%
Gender		
Female	144	57.4
Male	107	42.6
Institution		
University	150	59.8
State Hospital	37	14.7
Private office	64	25.5
Years of service		
Student	83	33.1
0-1 year	25	10.0
1-5 years	40	15.9
5-10 years	23	9.2
10 + years	80	31.8
Specialty		
Student	83	33.1
General dentist	83	33.1
Oral and Maxillofacial Surgeon	13	5.2
Pedodontist	12	4.7
Orthodontist	23	9.1
Periodontologist	9	3.6
Endodontist	9	3.6
Restorative Dentistry Specialist	6	2.4
Prosthodontist	13	5.2
Total	251	100.0

However, only 79 (31.5%) of the participants stated that they provided information to their patients about the radiation dose. The responses to the question, "What is your priority when you offer a radiograph?" were as follows: 33.1% (83) pay attention to the radiological algorithm, 22.3% (56) to fast imaging, 20.3% (51) to the radiation dose, and 18.3% (46) to easy accessibility. The average percentage of correct responses given by 251 individuals for all techniques was 36.8%. This rate was 35.5% for men and 37.8% for women, with no statistical differences between genders on knowledge of radiation dose ranges during dental imaging ($p=0.222$). Association of the participants' gender with imaging techniques is represented in table 2. The knowledge about radiation dose ranges during dental imaging was higher in dentists working at the university than in those working at the state hospital and private dental offices ($p<0.001$). Association of the participants' institution with their awareness about imaging techniques is represented in table 3. The knowledge of specialists and students was statistically higher than that of general dentists ($p<0.05$), and there was no significant difference between students and specialists ($p=0.191$).

When the duration of professional practice was considered, the knowledge of the <1 year, 1–5 years and 6–10 years groups was higher than that of the dentists working >10 years, and this difference was significant ($p<0.001$). Association of the participants' years of service with imaging techniques is represented in table 4. It was revealed that 35.1% (n=88) of the participants do not have knowledge of ultrasonography (USG), and 43.4% (n=109) did not know that magnetic resonance imaging (MRI) does not utilize ionizing radiation. While 49.8% (n=125) of the participants stated that MSCT emits less radiation, 32.7% (n=82) reported that they had no idea. Similarly, 43.4% of the participants (n=109) declared that craniofacial CBCT emits less radiation, while 32.7% (n=82) had no idea.

Distribution of the responses to the questions about the radiation exposure ranges for dental imaging techniques that use ionizing radiation is shown in table 5. As observed, 32.7% of the participants had no idea about the radiation

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exposure dose ranges with CBCT-dentoalveolar, CBCT-craniofacial and MSCT. Almost half of the participants declared lower than actual doses for MSCT. Similarly, 45.4% stated less than actual doses with panoramic, 43.4% with CBCT-craniofacial and 37.5% with CBCT-dentoalveolar imaging methods. Even though 63.8% accurately reported the radiation dose range of intraoral radiographs, 22.3% had no idea.

Table 2. Association of the participants' gender and imaging techniques.

Imaging Technique	Gender		Chi-square	P value
	Female n (%)	Male n (%)		
Intraoral Radiograph				
Right	95 (66.0)	65 (60.7)	0.725	0.394
Wrong	49 (34.0)	42 (39.3)		
USG				
Right	102 (70.8)	61 (57.0)	5.152	0.023
Wrong	42 (29.2)	46 (43.0)		
MSCT				
Right	24 (16.7)	20 (18.7)	0.062	0.803
Wrong	120 (83.3)	87 (81.3)		
Cephalometric Radiograph				
Right	44 (30.6)	33 (30.8)	0.002	0.961
Wrong	100 (69.4)	74 (69.2)		
CBCT-Dento-alveolar				
Right	34 (23.6)	26 (24.3)	0.016	0.899
Wrong	110 (76.4)	81 (75.7)		
CBCT-Craniofacial				
Right	21 (14.6)	20 (18.7)	0.487	0.485
Wrong	123 (85.4)	87 (81.3)		
MRI				
Right	87 (60.4)	55 (51.4)	2.031	0.154
Wrong	57 (39.6)	52 (48.6)		
Panoramic Radiograph				
Right	28 (19.4)	24 (22.4)	0.176	0.675
Wrong	116 (80.6)	83 (77.6)		

USG: ultrasonography, MSCT: multislice computed tomography, CBCT: cone beam computed tomography, MRI: magnetic resonance imaging

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Table 3. Association of the Participants' Institution and Imaging Techniques.

Imaging Technique	Institution				Chi-square	p
	Student n(%)	University n(%)	State hospital n(%)	Private office n(%)		
Intraoral Radiograph						
Right	50 (60.2)	49(73.1)	22(59.5)	39(60.9)	3.509	0.320
Wrong	33(39.8)	18(26.9)	15(40.5)	25(39.1)		
USG						
Right	59(71.1)	58(86.6)	13(35.1)	33(51.6)	34.607	0.000
Wrong	24(28.9)	9(13.4)	24(64.9)	31(48.4)		
MSCT						
Right	13(15.7)	19(28.4)	2(5.4)	10(15.6)	9.557	0.023
Wrong	70(84.3)	48(71.6)	35(94.6)	54(84.4)		
Cephalometric Radiograph						
Right	29(34.9)	17(25.4)	6(16.2)	25(39.1)	7.350	0.062
Wrong	54(65.1)	50(74.6)	31(83.8)	39(60.9)		
CBCT-Dento-alveolar						
Right	18(21.7)	19(28.4)	4(10.8)	19(29.7)	5.619	0.132
Wrong	65(78.3)	48(71.6)	33(89.2)	45(70.3)		
CBCT-Craniofacial						
Right	16(19.3)	8(11.9)	4(10.8)	13(20.3)	3.040	0.386
Wrong	67(80.7)	59(88.1)	33(89.2)	51(79.7)		
MRI						
Right	46(55.4)	55(82.1)	13(35.1)	28(43.8)	29.006	0.000
Wrong	37(44.6)	12(17.9)	24(64.9)	36(56.3)		
Panoramic Radiograph						
Right	15(18.1)	22(32.8)	4(10.8)	11(17.2)	9.040	0.029
Wrong	68(81.9)	45(67.2)	33(89.2)	53(82.8)		

USG: ultrasonography, MSCT: multislice computed tomography, CBCT: cone beam computed tomography, MRI: magnetic resonance imaging.

Table 4. Association of the participants' years of service and imaging techniques.

Imaging Technique	Years of service				Chi-square	p
	0-1 year n(%)	1-5 years n(%)	6-10 years n(%)	10+ years n(%)		
Intraoral Radiograph						
Right	20(80.0)	31(77.5)	13(56.5)	46(57.5)	7.959	0.047
Wrong	5(20.0)	9(22.5)	10(43.5)	34(42.5)		
USG						
Right	24(96.0)	32(80.0)	16(69.6)	32(40.0)	34.727	<0.001
Wrong	1(4.0)	8(20.0)	7(30.4)	48(60.0)		
MSCT						
Right	6(24.0)	13(32.5)	2(8.7)	10(12.5)	8.924	0.012*
Wrong	19(76.0)	27(67.5)	21(91.3)	70(87.5)		
Cephalometric Radiograph						
Right	4(16.0)	13(32.5)	8(34.8)	23(28.8)	2.675	0.445
Wrong	21(84.0)	27(67.5)	15(65.2)	57(71.2)		
CBCT-Dento-alveolar						
Right	8(32.0)	14(35.0)	7(30.4)	13(16.2)	6.416	0.093
Wrong	17(68.0)	26(65.0)	16(69.6)	67(83.8)		
CBCT-Craniofacial						
Right	6(24.0)	7(17.5)	3(13.0)	9(11.2)	2.707	0.258*
Wrong	19(76.0)	33(82.5)	20(87.0)	71(88.8)		
MRI						
Right	22(88.0)	28(70.0)	14(60.9)	32(40.0)	22.150	<0.00
Wrong	3(12.0)	12(30.0)	9(39.1)	48(60.0)		
Panoramic Radiograph						
Right	7(28.0)	12(30.0)	5(21.7)	13(16.2)	3.556	0.314
Wrong	18(72.0)	28(70.0)	18(78.3)	67(83.8)		

*Since the ratio of expected count which are less than 5 was larger than 20% the categories ''5-10 years" and "10+ years" were integrated. USG: ultrasonography, MSCT: multislice computed tomography, CBCT: cone beam computed tomography, MRI: magnetic resonance imaging

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Table 5. Distribution of responses to questions about radiation exposure dose range of dental imaging techniques that use ionizing radiation.

	No idea		Less than the actual dose range		In the dose range		More than the actual dose range	
Imaging Technique	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**
Intraoral Radiograph	56	22.3	0	0.0	160	63.8	35	13.9
MSCT	82	32.7	125	49.8	44	17.5	0	0.0
Cephalometric Radiograph	77	30.7	15	6.0	77	30.7	82	32.7
CBCT-Dento-alveolar	82	32.7	94	37.5	60	23.9	15	6.0
CBCT-Craniofacial	82	32.7	109	43.4	41	16.3	19	7.6
Panoramic Radiograph	57	22.7	114	45.4	52	20.7	28	11.2

DISCUSSION

Radiation dose is mostly expressed as effective dose (Sievert, Sv) and this was preferred in the study as it considers the radiation dose and the type, quantity, and sensitivity of the irradiated tissue [5,21]. It can be calculated by taking the equivalent doses to the exposed tissues in the body and multiplying them by the relevant tissue weighting factor. Then, the weighted doses are summed to obtain the effective dose, which is used to determine the risk of cancer in a person [1, 5, 22]. Since the measurement of effective dose is impossible in humans, it can be determined in laboratory conditions or via computer modeling to estimate the radiation risk [4, 23]. In the literature, many studies estimated and compared the radiation doses of MSCT, CBCT, intraoral, and extraoral dental imaging techniques using anthropomorphic phantoms with dosimeters [12, 19, 22, 24–26].

Nowadays, CBCT is the most preferred technique in dentistry because of minimal magnification, superimposition, and distortion [12, 13]. However, the radiation dose of CBCT is usually higher than that of conventional dental radiography techniques but lower than that of MSCT scans of the maxillary–mandibular region [19, 20, 25, 27]. The actual radiation dose of CBCT is not fully known by dentists because of the variations in exposure parameters, receptor technology, human factors and selected FOV [5]. Also, CBCT is frequently offered after conventional dental imaging techniques (intraoral, panoramic, and cephalometric radiographs) which lead to increased cumulative effects of radiation [12, 19]. Risk of death between 1 in 10,000 and 1 in 100,000 is considered an acceptable risk by the National Council on Radiation Protection and Measurements (NCRP). It is thought that the risk of cancer with CBCT is slightly greater than 1 in 1,000,000 [28], which is three times higher in children; and a large FOV and high-resolution CT scans can cause cancer to 1 in 10,000 children [5]. In one of the most recent studies, Ludlow *et al.* [26] suggested that CBCT doses could be further reduced by 36–51% with Lite (lower, kVp-reduced dose) exposure protocols, particularly in children and in cases where increased image noise will not interfere with the diagnostic task. In addition, Widmann and Al-Ekrish [29] suggested that application of ultralow dose MSCT with image reconstruction technology in dental implantology may have potential for large dose reductions.

Most of the studies that have evaluated the knowledge level of medical doctors and radiology staff with respect to radiation protection and radiation doses of medical imaging methods indicate that doctors, medical students, and staff have insufficient information of the same [1,7,10,11]. Similarly, the dentists and dental students surveyed in the present study also exhibited insufficient knowledge. In addition, most of the dentists failed to provide their patients with information about the radiation doses of dental imaging methods, which may be a result of their insufficient knowledge levels. Even though the participants have previously undergone radiation protection education, 20.3% and 12.4% of the participants, respectively, supposed that MRI and USG are the techniques that use ionizing radiation. In addition, 58 (23.1%) for MRI and 57 (22.7%) for

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USG had no idea whether these devices utilized ionizing radiation. This lack of knowledge may cause dentists to not prefer these techniques as additional dental imaging methods. General dentists have shown a lower level of knowledge, and this may be a consequence of relatively lower number of radiological examination requests during their clinical practice. Also, the low knowledge levels of dentists with over ten years of work experience can be attributed to their reluctance to participate in voluntary vocational training. The results of this study also revealed that the knowledge level of dentists may vary according to occupational differences such as institution, service years, and whether or not they were academicians. The relationships among specialist dentists could not be evaluated statistically because of large differences between the number of participants from different departments. Conducting a similar study with dentists from across the country may be more appropriate to determine differences in knowledge levels between specialist dentists according to their departments. Since the participants' ages cannot reflect the exact knowledge of the dentists in dental radiology, this feature was not evaluated.

This study provides important information about dentists' knowledge about the radiation doses of dental imaging techniques, i.e., most of the dentists and dental students surveyed underestimated the actual radiation doses during dental imaging procedures. This lack of knowledge may lead to dentists seeking radiological imaging more than necessary. Since stochastic radiation effects can cause cancer or hereditary problems, any dose of radiation for dental imaging should be considered a potential health risk [24,27]. Therefore, it is crucial for dentists and radiology staff to ensure the minimal dose of radiation for patients in accordance with the "as low as diagnostically acceptable" (ALADA) principle [30].

CONCLUSION

Dentists should request radiographs only if they will provide positive benefits for diagnosis and treatment planning, and they should consider the radiograph selection criteria to avoid unnecessary ionizing radiation. Thus, dental curriculum should be revised to devote more time to radiation safety issues to ensure minimum radiation exposure of patients and radiology personnel. Moreover, compulsory postgraduate vocational courses should be organized to update the knowledge about radiation doses.

Conflicts of interest: *Declared none.*

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