Original Article

Evaluation of Radiation Exposure in Open Dental Clinics Using Thermoluminescence Dosimeters and Questionnaires

Abstract

Aim: The aim of this study was to evaluate radiation exposure in dental open clinics in King Saud Bin Abdulaziz University for Health Sciences (KSAU-HS) using thermoluminescence dosimeters (TLDs) to check if it exceeds the annual assigned exposure limit and to assess students' practices regarding radiation protection measures and their knowledge regarding the application of digital remote-control settings and TLDs. **Materials and Methods:** This pilot institutional-based observational study was conducted among the clinical year students and interns at KSAU-HS College of Dentistry open clinical areas using TLDs and questionnaires. Sixteen lithium fluoride TLDs (TLD-100) were distributed evenly in the clinical areas occupied by clinical year dental students and interns for 24 working days from September 15 to October 20, 2019. Each TLD was labeled with a serial number and fixed at the assigned clinic of each specialty. The TLDs were placed in a zigzag manner at the right corner of the selected clinic to prevent overlapping of the area coverage by each dosimeter. **Results:** The mean monthly TLD readings were found to be 69.265 uSv with a higher mean value in the female clinical area (74.2975 uSv) than the male clinical area (64.234 uSv). Taking into account the 8 months of clinical exposure during the academic year, the expected annual radiation exposure would be 0.554 mSv which is significantly lower than the annual limit of radiation exposure recommended by the International Commission on Radiological Protection, i.e., 1 mSv. **Conclusion:** TLD readings concluded that radiation exposure was within safe limits with an estimation of 0.544 mSv per year. However, students require further education regarding protective and safety measures and the utilization of radiation equipment. **Clinical Significance:** The lack of studies regarding the amount of radiation exposure from dental imaging and the safety of intraoral radiographic machines present in open clinics in any educational institute necessitates conducting this kind of study.

Keywords: *Open clinics, pilot study, radiation exposure, thermoluminescence dosimeters*

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Introduction

Although dental radiography is a crucial diagnostic tool and an integral part of routine dental practice, exposure to ionizing radiation is not entirely risk free. Dental radiography is among the most frequently used radiological procedures in health-care workplaces.[1] Patients receiving dental care are certainly at risk from ionizing radiation, and dental practitioners are also more frequently and potentially exposed to the risk of radiation exposure. Radiation exposure risk from intraoral radiography (IOR) is generally low, but delayed somatic effects of these low doses can result in damaging DNA resulting in serious effects such as cancer and leukemia.[2]

A recent systematic review found that dental X-ray exposures are often associated with tumors in the head-and-neck region such as brain, laryngeal, parotid gland, salivary gland tumors, and thyroid cancer.[3] In addition, female dental practitioners were reported to have 13.1 times more risk of thyroid cancer.[3,4] When it comes to IOR, the primary beam is a few milligrays at the end of the collimator of the X-ray beam. This primary beam in IOR interacts with the patient's head area, and some amount of radiation will be scattered in all directions.[5] Although this scattered radiation constitutes a relatively minor part of the main X-ray beam, this still holds the possibility of the slightest increase in health risk which should not be ignored.

The International Commission on Radiological Protection (ICRP) recommends

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to limit radiation exposure dose to 1 mSv for the public, and 20 mSv per year for occupational workers, averaged over defined periods of 5 years.[6] ICRP also recommended that the dose limit should not exceed 50 mSv in any single year.[6] It has been estimated that the radiation exposure dose of intraoral bitewing for 4 images utilizing an F‑speed film and rectangular collimation would be around 0.005 mSv.[7]

In King Saud Bin Abdulaziz University for Health Sciences (KSAU‑HS), College of Dentistry (COD), there are a total of 204 dental clinics on both the ground and first floors. In each clinic, there is a fixed Planmeca ProX™ intraoral unit operating at 70 kVp (as recommended by the manufacturer) with a rectangular collimator. Although the scattered radiation would be a small fraction of the primary beam measured at a given point, this total of effective dose might place students at high risk of getting overexposed to scattered radiation.

To date, there is a lack of research highlighting the amount of radiation exposure from dental imaging, especially regarding the safety of fixed intraoral radiographic machines installed in open clinics in any educational institute. Therefore, this study aimed to evaluate radiation exposure in dental open clinics at KSAU‑HS using thermoluminescence dosimeters (TLDs) to check if it exceeds the annual assigned exposure limit and to assess students' practices regarding radiation protection measures and their knowledge regarding application of digital remote‑control settings and TLDs.

Materials and Methods

This institutional‑based study is a pilot observational study conducted to evaluate the amount of radiation exposure in the open clinics and assess the awareness regarding the TLDs and common radiation protection practices employed by the dental students at COD at KSAU‑HS in Riyadh, Saudi Arabia. An ethical clearance from King Abdullah International Medical Research Center (SP19/519/R) was obtained before the commencement of the study. The data were collected between September and October 2019. All dental students in the clinical years and dental interns studying at COD, KSAU‑HS, were eligible to participate in the study. Dental students studying in the preclinical years, dental supervisors, dental radiologists, dental assistants, and dental patients were excluded from the study. A convenient sampling technique was used to collect a sample size of 205 participants. This study was conducted in two parts: evaluation of radiation exposure in the open clinics using TLDs and assessing students' common clinical practices employed with regard to radiation protection measures and their knowledge regarding application of digital remote‑control settings and TLDs.

Highly sensitive lithium fluoride TLDs (TLD‑100, Thermo Fisher Scientific, USA) were distributed evenly in the clinical areas occupied by dental students and interns for 24 working days from September 15 to October 20, 2019 [Figure 1]. Sixteen TLDs were attached in fixed positions; seven TLDs were placed on each floor in seven selected dental clinics; each selected clinic represents a different dental specialty [Figure 2]. For reliability, an additional TLD was placed on each floor. Each TLD was labeled with a serial number and fixed in the assigned clinic of each specialty. The TLDs were placed in a zigzag manner at the right corner of the clinic to prevent overlapping of the area coverage by each dosimeter [Figure 3]. This arrangement also prevents double reading of doses as X‑ray beam moves in straight lines. The data collected from the dosimeters were analyzed by the radiology department using TLD reading 6600 Plus® software. The monthly exposure data were extracted, and the annual radiation exposure was approximated from these data. The data were entered in an assessment sheet [Table 1].

A self‑administered 19‑item questionnaire was distributed among the clinical year students and interns using both paper‑based and electronic forms along with a consent form. This study was targeted on the 258 clinical year dental students and interns of the COD, KSAU‑HS. A minimum valid sample of 169 subjects was calculated based on confidence level 95%, significance interval of 5%, and estimated population response distribution of 50%.

Before the distribution of the questionnaire, a pilot study was conducted to validate the questionnaire. The questionnaire is principally composed of seven parts with open‑ and close‑ended questions. The first section comprised mainly the demographic profile of the participants. The next four sections inquired regarding the following aspects: radiation practices, self‑protection measures, and radiographic techniques employed by students for both adult and pediatric patients. The last two sections measured the students' knowledge about the different digital settings and perspectives regarding the exposure time, TLDs, and protection measures.

Figure 1: Lithium‑thermoluminescence dosimeter‑100

Table 1: The data entered in the assessment sheet including the number of thermoluminescence dosimeters, their serial number, duration, specialty, and reading in uSv

Number of TLD	Serial number	Duration	Specialty	Readings in uSv
1	1612533	24 working days	PROD2 (male)	70.09
2	1414011	24 working days	PROD1 (female)	64.49
3	1315517	24 working days	ENDD2 (male)	73.59
4	1413445	24 working days	ENDD1 (female)	113.53
5	1414459	24 working days	RESD2 (male)	66.74
6	1612155	24 working days	RESD1 (female)	66.02
7	1612012	24 working days	PEDD2 (male)	63.57
8	1230271	24 working days	PEDD1 (female)	69.54
9	1611950	24 working days	MXFS2 (male)	52.84
10	1410451	24 working days	MXFS1 (female)	68.48
11	31045502	24 working days	OM/ORTD2 (male)	65.57
12	32104232	24 working days	OM/ORTD (female)	68.63
13	1611320	24 working days	PERD2 (male)	61.82
14	1612129	24 working days	PERD1 (female)	64.63
15	1611895	24 working days	ADDITIONAL2 (male)	59.65
16	2002299	24 working days	ADDITIONAL1 (female)	79.06

Figure 2: Positioning of the thermoluminescence dosimeter

Statistical analysis

The collected data were computed into an excel sheet and analyzed using IBM SPSS® statistical program version 21.0 (IBM Inc., Armonk, NY, USA). Frequency tables were used to evaluate the distribution of data in terms of demographics and specialty associated with the least and most number of radiographs. Chi-square test and nonparametric test (Kruskal–Wallis test, in case of skewed distribution of data) were used to analyze the association between gender, level of education, frequency of radiographs, protection practices, and knowledge and perspectives of the students.

Results

The highest TLD readings were observed in endodontic clinics in both male and female clinical areas. It is noteworthy that the exposure in the endodontic female clinics was the highest compared to the males. The least radiation exposure was associated with oral surgery and prosthodontic clinics [Figure 4]. The mean monthly TLD reading was found to be 69.265 uSv with a higher mean value in the female clinical area (74.2975 uSv) compared to the male clinical area (64.23375 uSv). Taking into account the 8 months of clinical exposure during the academic year, the expected annual radiation exposure would be 0.554 mSv which is significantly lower than the annual assigned safe limit of radiation exposure recommended by the ICRP, i.e., 1 mSv.

The self-administered questionnaire was distributed among 258 students attending the open clinics in KSAUHS, out of which 205 participants consented to respond to the questionnaire. Out of the respondents, 52.5% were males and 47.8% were females who belonged to the first clinical year (38%) [Figure 5], final clinical year (31.7%), and the newly graduated interns (30.2%) [Figure 6].

The participants reported taking intraoral radiographs every week with a frequency ranging from a minimum of two radiographs to a maximum of fifty radiographs. First clinical year students took more radiographs than students who belonged to the older batches. Unsurprisingly, endodontics was reported to be the specialty associated with the maximum frequency of radiographs, whereas the least frequency was reported with oral medicine specialty. Oral surgery was reported as the specialty associated with least number of radiographs taken by the female participants, whereas oral medicine was found to be that for male participants. When comparing batch-wise responses, oral surgery was one of the specialty clinics having the least number of radiographs taken by all the batches. The common clinical practices performed by the participants with gender- and batch-wise differences are demonstrated in Tables 2 and 3.

More than half of the students, i.e., 59.5% (79% of the males and 68.3% of the females), reported not wearing a lead apron when taking intraoral radiographs for patients, with majority (54%) justifying that the clinics provided only one lead apron which was always used for their

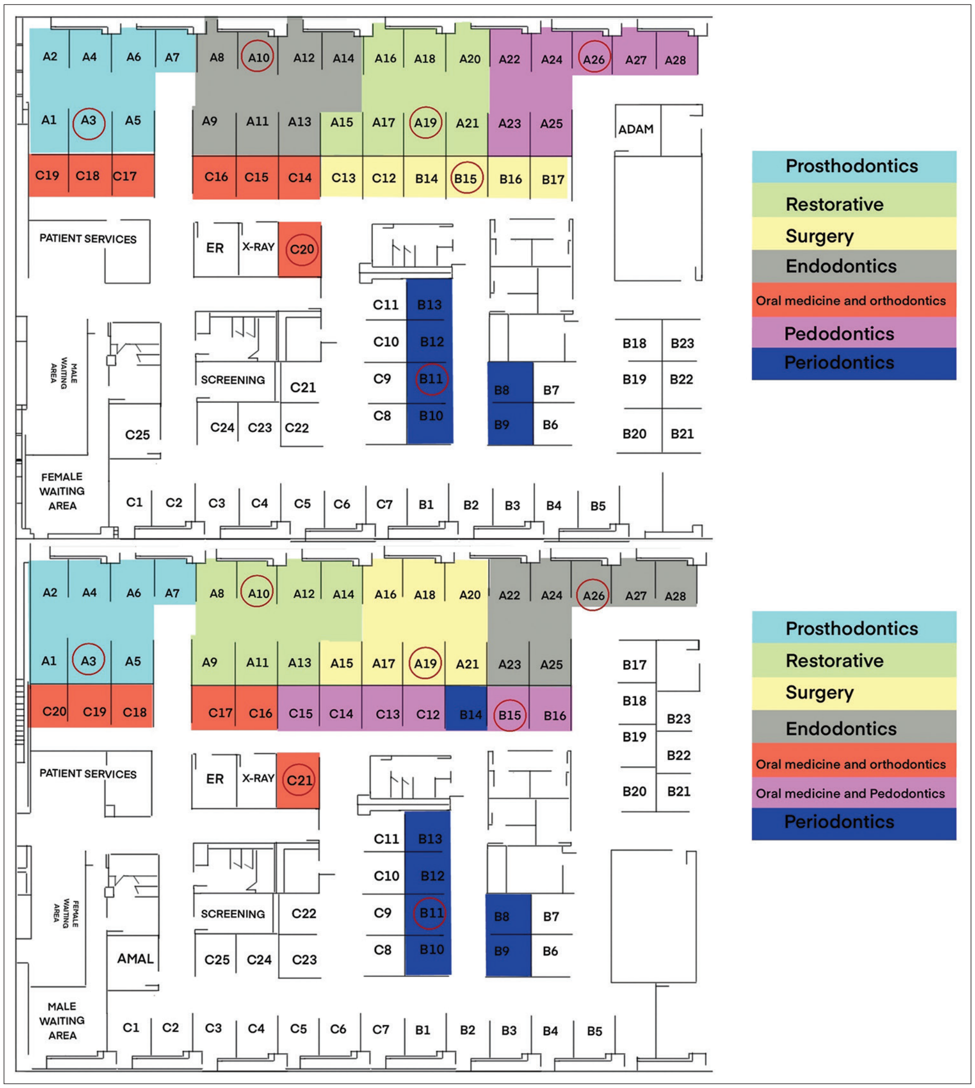

Figure 3: Placement of the thermoluminescence in a zigzag manner to avoid overlapping of readings

Figure 4: Monthly thermoluminescence readings in μSv in the ground (male) and the first (female) clinical floors

patients. As for other protective measures, 71.7% of the students walked out of the clinic as a means of protection, and this was found to be statistically significant.

Radiographic techniques performed by students were described under the following categories: operator position, distance in relation to the X-ray cone beam, and sensor stabilizing techniques. More than half of the student participants (56.1%) stood at a wrong angle from the X-ray beam, i.e., 45 degrees or less. Almost half of the participants (48.8%) stood 2 m away from the cone beam, while others stood closer or further from the beam (22% and 29.3%, respectively), and this was statistically significant taking into consideration gender-wise responses. The paralleling technique of radiographic exposure was the most preferred for both adult and pediatric patients by both males and females, and majority of the respondents belonged to final clinical years. About 40% of the respondents did not pay attention to the radiographic technique employed. Majority of the participants preferred stabilizing the digital sensor using the holder and ring and were mainly employed by the first clinical year students. In addition, the digital sensor was also stabilized by the adult patients, whereas the practitioner tried to hold the sensor during exposure in pediatric patients. The gender-wise difference in the opinions with regard to sensor stabilization in adult patients was found to be statistically significant (P = 0.021). The batch-wise responses of the participants with regard to the radiographic techniques and sensor stabilization methods for adult and pediatric patients were found to be statistically significant.

Majority of the respondents felt that they were not overexposed (28.9%) or were exposed within normal limits (42.15%) to X-radiations. With regard to knowledge regarding TLDs, more than half of the students (51.7%) lacked the knowledge. Moreover, participants who knew about TLDs reported a desire to wear one for personal protection (39%), but many were not aware of the existence of TLDs in COD open clinics [Figure 7]. Most of the respondents who were aware about the presence of TLDs in COD open clinics were male students.

For the radiographic remote settings, many participants were aware of the different exposure settings for adult and pediatric patients (50% – males and 65% – females), however, students lack the knowledge about the presence of different remote-control options and settings [Figure 8].

Discussion

Dosimeters are devices that aid in evaluating the efficacy of radiation protection measures.[8] These devices assist in following the principle of radiation safety which is as low as reasonably achievable (ALARA). Earlier studies measuring radiation exposure were conducted mainly involving dental personnel (nonstationary).[8] In this study, we proposed fixing TLDs in specific places for more accurate results and to establish a reproducible method of measuring radiation exposure in open clinical areas occupied by operating students. All radiographic units present in COD clinical areas and all aspects were pertinent to radiological protection, design and construction, operation, decommissioning, and maintenance, which are implemented as per ICRP guidelines and recommendations found in Publication 103 (The 2007 Recommendations of the ICRP).

Although there are 204 clinics distributed all over the institution, the study was focused on 94 clinics as they were commonly used by the study population. Among these selected areas, the 16 TLDs were placed in designated areas in a zigzag manner to avoid overlapping of the readings [Figure 3].

All clinical year dental students and interns (n = 205) studying in this institution were selected to participate in this survey as they are the ones who most frequently practice dental radiography inside the open clinical areas and, therefore, at a higher risk of radiation exposure. The dental assistants or technicians only perform advanced radiography in leaded rooms and therefore excluded from this study. All clinical years students and interns who participated in this study were taught and trained in radiography using F-speed films with digital sensors and rectangular collimation which adheres to ALARA

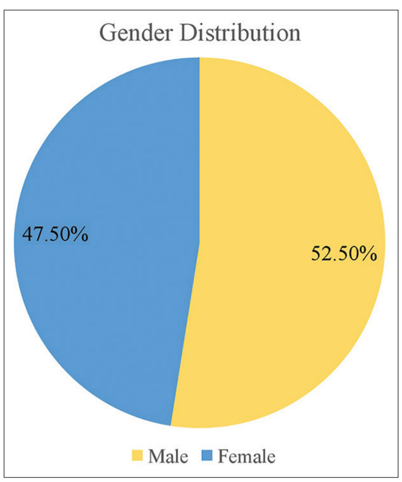

Figure 5: Gender-wise distribution of the participants

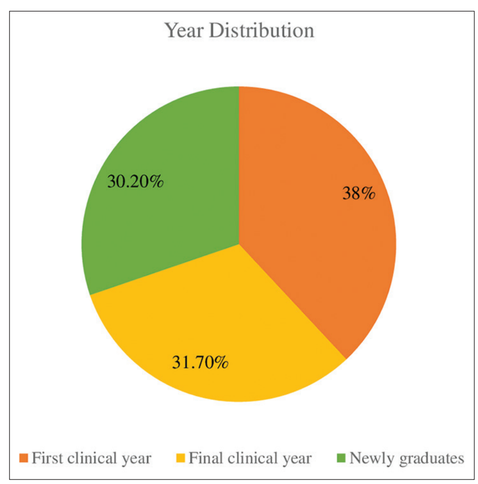

Figure 6: Batch-wise distribution of the participants

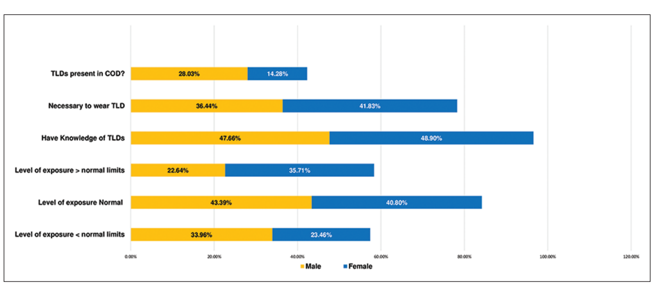

Figure 7: Perception of students regarding level of radiation exposure and thermoluminescence

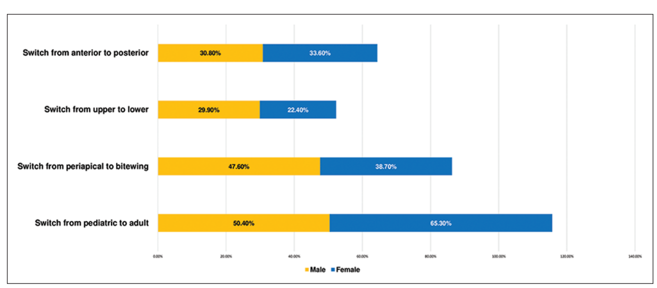

Figure 8: Students' practice of changing the digital settings before radiographic exposure

Table 2: The gender-based differences with common clinical practices related to radiography

Variables	Category	Gender		Total, *n* (%)	χ^2	*P*
		Male, *n* (%)	Female, *n* (%)			
Most specialty	Endo	86 (80.4)	58 (59.7)	Total=205 (100)	19.357	0.001*
	Prostho	1 (0.93)	2 (2.06)	204 (99.5)		
	Pedo	0	0	Missing 1 (0.5)		
	Perio	9 (8.4)	4 (4.12)			
	Ortho	0	0			
	OMED	0	4 (4.12)			
	Surgery	0	0			
	Resto	11 (10.2)	29 (29.89)			
Least specialty	Endo	1 (0.93)	1 (1.05)	Total=205 (100)	31.848	0.000*
	Prostho	7 (6.54)	9 (9.47)	202 (98.5)		
	Pedo	7 (6.54)	3 (3.15)	Missing 3 (1.5)		
	Perio	17 (15.88)	14 (14.73)			
	Ortho	12 (11.21)	20 (21.05)			
	Surgery	11 (10.28)	31 (32.63)			
	OMED	48 (44.85)	17 (17.89)			
	Resto	4 (3.13)	0			
Wearing lead apron	Yes	45 (42.05)	38 (38.77)	83 (40.48)	0.228	0.633
	No	62 (57.9)	60 (61.2)	122 (59.51)		
Angle of the cone beam	25	10 (9)	14 (14.43)	24 (11.82)	7.241	0.065
	45	41 (39.62)	50 (51.5)	92 (45.23)		
	>90	54 (50.94)	33 (2.71)	87 (42.85)		
Meters away from the cone beam	1 m	14 (13.08)	31 (31.6)	45 (21.95)	10.407	0.005*
	2 m	57 (53.27)	43 (43.87)	100 (48.78)		
	3 m	36 (33.64	24 (24.48)	60 (29.26)		
Most used protective measure	Lead wall	23 (21.49)	6 (6.12)	29 (14.14)	9.953	0.002*
	Walk out	80 (74.7)	67 (68.36)	147 (71.7)	1.032	0.31
	Wall as barrier	21 (19.62)	27 (27.55)	48 (23.4)	1.791	0.181
	None	7 (6.54)	14 (14.28)	21 (10.24)	3.336	0.068
Adult radiograph technique	Paralleling	60 (56.07)	52 (53.06)	112 (54.63)	1.850	0.396
	Bisecting	17 (15.88)	11 (11.22)	28 (13.65)		
	No attention	30 (28.03)	35 (35.71)	65 (31.7)		
Adult sensor technique	Practitioner holds the sensor	15 (14.01)	3 (3.06)	18 (8.78)	7.713	0.021*
	Patient holds the sensor	45 (42.05)	45 (45.9)	90 (43.9)		
	Use of sensor holder and ring	47 (43.92)	50 (51.02)	97 (47.31)		
Pedo radiograph technique	Paralleling	46 (43.8)	45 (45.91)	91 (44.82)	2.497	0.287
	Bisecting	20 (19.04)	11 (11.22)	31 (15.27)		
	No attention	39 (37.14)	42 (42.85)	71 (34.97)		
Pedo sensor technique	Practitioner holds the sensor	36 (34.61)	32 (32.65)	68 (33.66)	1.554	0.670
	The patient holds the sensor	6 (5.76)	8 (8.16)	14 (6.93)		
	The use of sensor holder and ring	62 (59.61)	57 (58.16)	119 (58.91)		
Perspective of exposure	Little	36 (33.96)	23 (23.46)	59 (28.9)	5.028	0.081
	Normal	46 (43.39)	40 (40.8)	86 (42.15)		
	Excessive	24 (22.64)	35 (35.71)	59 (28.9)		
Knowledge of TLD	Yes	51 (47.66)	48 (48.9)	99 (48.29)	0.035	0.851
	No	56 (52.33)	50 (51.02)	106 (51.7)		
Switch from pediatric to adult	Yes	54 (50.4)	64 (65.3)	118 (57.2)	4.611	0.032
	No	53 (49.5)	34 (34.6)	87 (42.2)		
Switch from periapical to bitewing	Yes	51 (47.6)	38 (38.7)	89 (43)	1.645	0.200
	No	56 (52.3)	60 (61.2)	116 (56.3)		
Switch from upper to lower	Yes	32 (29.9)	22 (22.4)	54 (26.2)	1.466	0.226
	No	75 (70.09)	76 (77.5)	151 (73.3)		

Contd...

Table 2: Contd...

Variables	Category	Gender		Total, *n* (%)	χ^2	*P*
		Male, *n* (%)	Female, *n* (%)			
Switch from anterior to posterior	Yes	33 (30.8)	33 (33.6)	66 (32.03)	0.188	0.665
	No	74 (69.1)	65 (66.3)	139 (67.4)		
Necessity to wear TLD	Yes	39 (36.44)	41 (41.83)	80 (39.02)	1.313	0.519
	No	12 (11.21)	7 (7.14)	19 (9.26)		
Available TLDs in the college of dentistry	Yes	30 (28.03)	14 (14.28)	44 (21.46)	8.354	0.015*
	No	21 (19.62)	33 (33.67)	54 (26.34)		

TLD: Thermoluminescence dosimeters. *P* value is < 0.05 which is considered statistically significant

Table 3: The clinical experience-based differences with common clinical practices related to radiography

Variables	Category	Batch			Total, *n* (%)	χ^2	*P*
		D3, *n* (%)	D4, *n* (%)	Interns, *n* (%)			
Number of radiographs		78 (38.805)	62 (30.845)	61 (30.348)	201	12.101# (Kruskal-Wallis)	0.002*
Most specialty	Endo	25 (12.25)	59 (28.9)	60 (29.4)	144 (70.55)	97.6	0.000*
	Prostho	1 (0.49)	2 (0.98)	0	3 (1.47)		
	Pedo	0	0	0	0		
	Perio	12 (5.88)	1 (0.49)	0	13 (6.37)		
	Ortho	0	0	0	0		
	OMED	3 (1.47)	1 (0.49)	0	4 (1.96)		
	Surgery	0	0	0	0		
	Resto	37 (18.13)	2 (0.98)	1 (0.49)	40 (19.6)		
Least specialty	Endo	1 (0.49)	0	1 (0.49)	2 (0.98)	42.5	0.000*
	Prostho	6 (2.9)	3 (1.47)	7 (3.4)	16 (7.77)		
	Pedo	2 (0.98)	8 (3.9)	0	10 (4.88)		
	Perio	16 (7.8)	7 (3.7)	8 (3.9)	31 (15.1)		
	Ortho	4 (1.96)	15 (7.3)	13 (6.3)	32 (15.56)		
	OMED	26 (12.7)	12 (5.8)	4 (1.96)	42 (20.46)		
	Surgery	22 (10.78)	16 (7.8)	27 (13.23)	65 (30.81)		
	Resto	1 (9.48)	2 (0.98)	1 (0.49)	4 (1.96)		
Wearing lead apron	Yes	36 (50.602)	27 (32.530)	20 (24.096)	83	2.812	0.245
	No	42 (34.426)	38 (31.147)	42 (34.426)	122		
Angle of the cone beam	25	10 (41.666)	8 (33.333)	6 (25)	24	3.132	0.792
	45	32 (22.826)	30 (32.608)	30 (32.608)	92		
	>90	35 (40.229)	26 (29.885)	26	87		
Meters away from the cone beam	1 m	21 (40.229)	11 (29.885)	13 (46.666)	45	4.316	0.365
	2 m	36 (36)	30 (30)	34 (34)	100		
	3 m	21 (35)	24 (40)	15 (25)	60		
Most used protective measure	Lead wall	5 (23.809)	13 (61.904)	11 (52.380)	21	6.337	0.042
	Walk out	56 (38.095)	39 (26.530)	52 (35.374)	147	8.913	0.012*
	Wall as barrier	11 (22.916)	19 (39.583)	18 (37.5)	48	6.089	0.048*
	None	11 (52.380)	5 (23.809)	5 (23.809)	21	?	?
Adult radiograph technique	Paralleling	38 (18.626)	44 (21.56)	30 (14.705)	112 (54.9)	14.523	0.006*
	Bisecting	6 (2.926)	9 (4.390)	13 (6.341)	28 (13.658)		
	No attention	34 (16.585)	12 (5.853)	19 (9.268)	65 (31.707)		
Adult sensor technique	Practitioner holds the sensor	7 (3.431)	3 (1.470)	8 (3.921)	18 (8.823)	29.540	0.000*
	Patient holds the sensor	17 (8.292)	39 (19.0242)	34 (16.585)	90 (43.902)		
	Use of sensor holder and ring	54 (26.341)	23 (11.219)	20 (9.756)	97 (47.317)		
Pedo radiograph technique	Paralleling	30 (14.778)	42 (20.689)	19 (9.359)	91 (44.827)	20.491	0.000*
	Bisecting	8 (3.940)	9 (4.433)	14 (6.896)	31 (15.270)		
	No attention	38 (18.718)	14 (6.792)	29 (14.285)	81 (39.901)		
Pedo sensor technique	Practitioner holds the sensor	23 (11.386)	23 (11.386)	22 (10.890)	68 (33.663)	6.788	0.341
	Patient holds the sensor	2 (0.990)	6 (2.97)	6 (2.97)	14 (6.930)		
	Use of sensor holder and ring	50 (24.752)	35 (17.326)	34 (16.831)	119 (58.910)		

P value is < 0.05 which is considered statistically significant principle that optimizes radiation protection by keeping the doses “ALARA” to ensure that all X-ray exposures taken are justified and doses are kept well below the allowable limits (ICRP Publication 105).

According to our findings in the present study, the total mean of TLD readings in both floors in 1 month was found to be 69.3 μSv with a mean of 64.2 μSv in the male floor and 74.3 μSv in the female floor. The academic year (8 months) was estimated to be 0.554 mSv average radiation exposure which is still within the safe limits. Kim *et al*. found a result with lower average of 0.17 mSv per year.[9]

The mean range of radiographs performed by students and interns was 2–50 per a week that is greater than a Korean study where the dentists reported taking 10–20 radiographs per week. Moreover, direct comparison to previous studies is limited because of variations in health-care systems and regulations employed by different schools and countries.[10] The number of radiographs usually taken from students was self-reported in the survey. The speciality associated with the highest and the lowest frequency of radiographs were found to be statistically significant [Table 3]. However, the number of radiographs taken per day was not retrieved. The highest number of radiographs taken per week by the participants was associated with endodontic specialty clinics, especially in female floor revealing higher TLD readings, while the least reported radiographic practice was in oral surgery and prosthodontic specialties. This could be attributed to the fact that teeth which require endodontic treatment necessitate taking various radiographs at different stages of root canal treatment (RCT) which include preoperative stage, working length stage, trial master gutta-percha stage, obturation stage, and recall stage. Moreover, students usually tend to repeat more radiographs due to lack of experience at different stages of RCT. For these apparent reasons, endodontic specialty depicted the highest TLD readings as compared to oral surgery and/or prosthodontic clinics where radiographs are usually taken only for diagnostic purposes in the initial stages.

According to our findings on self-protection, there are some evident and significant differences in respect to gender. In our findings, the most practiced protective measure is walking out of clinic with a male predilection. Male students were significantly more aware of recommended distance (2 m) in respect to the cone beams. This is also supported by a study conducted in 2013 reporting that the preferred distance from the cone beam should be 2.2 m.[11] In regard to other protective measures, findings have been shown that 56% of the students and interns were not wearing a lead apron which may be related to the given reason that one lead apron is provided per clinic which is primarily for the patient; therefore, they chose to walk out of clinic instead. This observation coincides with the findings of Arnout and Jafar which showed that 45.2% of the dental students do not wear a lead apron regularly.[8]

Available data suggest that long-term radiosensitivity in women is higher than that in men who received a comparable dose of radiation. The report on the biological effects of ionizing radiation VII published in 2006 by the National Academy of Sciences, United States, emphasized that women may be at significantly greater risk of suffering and dying from radiation-induced cancer than men exposed to the same dose of radiation.[12] Therefore, emphasis should be laid on protective measures, especially among the female students.

Paralleling technique was reported to be the most commonly employed technique for adult as well as pediatric patients in this study. This is the most preferred technique, as reported by various previous studies probably due to its accuracy and reproducibility.[11,13,14] However, students who preferred using paralleling technique in pediatric clinics were found to take more radiographs and was found to be statistically significant [Table 4]. This might be attributed to pediatric patients being more difficult to manage in taking radiographs while stabilizing the sensors in their mouths. Moreover, female students tend to use sensor holder as sensor stabilizing technique, and this finding is similar to a study by Arnout and Jafar, where most of the students prefer to use sensor holder and not to hold the sensor by themselves or the patients.[8] Batch-wise differences were significant. Final clinical year students preferred using paralleling technique, which might be due to its high repeatability and accuracy according to another study.[14] Moreover, they reported using a lead apron and clinic walls more than other batches.

With regard to digital radiography remote-control settings, the participants were aware of the existence of different exposure settings for adult and pediatric patients, however, they lacked the knowledge about the ability to switch between different locations of jaws. This lack of knowledge might result in poor quality radiographs and higher radiation exposure, especially when taking intraoral radiographs for pediatric patients.

Majority of the responders felt that they were not overexposed (28.9%) or were exposed within normal limits (42.15%) to X-radiations. With regard to knowledge regarding TLDs, more than half of the students (51.7%) lacked the knowledge. However, those who were aware about TLDs wanted to have it for personal protection (39%), but majority were not aware of the existence of TLDs in COD open clinics (26.3%). Out of the responders who were aware of the presence of TLDs in COD clinics, majority were male students [Table 2]. However, the difference in the level of knowledge with regard to TLDs or radiation exposure gender wise or batch wise was not statistically significant.

Like any scientific research, even our study has certain limitations: (a) it is a pilot and institutionally based study with a considerably small population that cannot

Table 4: The number of radiographs in relation to radiograph technique and sensor holding method

Variables	Category	Number of radiographs, *n* (%)	Total, *n* (%)	Kruskal-Wallis	*P*
Adult radiograph technique	Paralleling	110 (54.72)	201	1.938	0.379
	Bisecting	26 (12.935)			
	No attention	65 (32.338)			
Adult sensor technique	Practitioner holds the sensor	18 (8.995)	201	0.142	0.931
	Patient holds the sensor	89 (44.278)			
	Use of sensor holder and ring	94 (46.766)			
Pedo radiograph technique	Paralleling	89 (44.723)	199	7.017	0.030*
	Bisecting	29 (14.572)			
	No attention	81 (40.703)			
Pedo sensor technique	Practitioner holds the sensor	68 (34.517)	197	0.941	0.625
	Patient holds the sensor	13 (9.598)			
	Use of sensor holder and ring	116 (58.883)			

P value is < 0.05 which is considered statistically significant

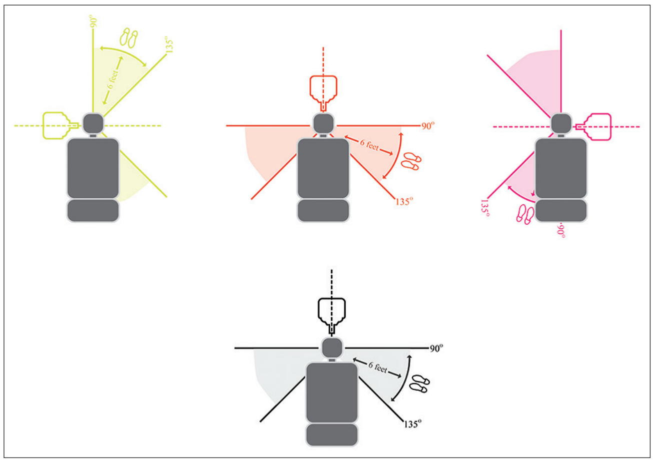

Figure 9: Recommendation of proper operator positioning to avoid exposure (White SC, Pharoah MJ. Oral Radiology: Principles and Interpretations. 6th ed. St. Louis, Missouri: Elsevier; 2009. p. 41.)

represent the whole population of dental students or interns. (b) Moreover, there could be a potential bias due to the convenience of sampling technique and, therefore, might not speak for the whole population of interest. (c) In addition, TLDs were positioned for a period of a month, which ideally should be positioned for at least 3 months for more accurate results.

We suggest setting certain drawings on clinical floors below the dental chair to demonstrate the correct X-ray beam and distance–angle relationship or by simply hanging an instruction manual of the correct measures as a reminder [Figure 9]. Future studies should include a larger sample including dental students and interns, dental assistants, and other subgroups of population of interest that were not included in this study. Furthermore, TLDs used for longer durations should be considered for more accurate reading.

Conclusion

TLD readings concluded that the radiation exposure was within safe limits with estimation of 0.544 mSv per year. However, students were found to need further education regarding protective and safety measures and utilization of radiation equipment. This study will serve as a good foundation for future research in related topic.

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Conflicts of interest

There are no conflicts of interest.

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