Vol 13 No 2 (2024) DOI 10.5195/d3000.2024.734

Determination of Operators' Portable X-ray Safety

Mohammed Ayad Taha, Ahmed I. Al-Jobory, Haitham Y. Mohammed

College of Dentistry, Tikrit University, Iraq

Abstract

Objective: Ionizing radiation in the form of rays interacts with matter and has immediate and delayed impacts. Applications in dentistry include extraoral and intraoral X-rays and machines can be portable and fixed. A portable X-ray machine is a mobile X-ray device that is smaller than a stationary one. The radiation dose from portable devices to which exposure is allowed should not be higher than 20 mSv annually. The purpose of this study was to compare three portable dental X-rays to determine the quantity of dispersed radiation that affects radiography operators.

Methods: Three types of portable X-ray devices (portable X-ray system (Clarox, Eightieth, and QiN high-frequency microfocus dental X-ray units) were used. An extracted tooth was used for testing. The tooth was X-rayed laying on a flat surface after pouring it into a stone base. Three different radiation devices of different sorts were positioned in front of the tooth individually, with identical dimensions for each device. More than one radiological image was obtained with each of the radiation devices, and radiation levels were recorded.

Results: It was discovered that as radiological images were being taken, the scattered radiation readings for two devices (Clarox and Eightieth) progressively decreased. The recorded readings for QiN were lower.

Conclusion: Comparing the radiometer results revealed that the portable X-ray equipment emits radiation that has an impact on radiation workers. Therefore, radiation safety precautions must be followed, and radiation shields must be employed.

Keywords: Portable X-ray unit, scattered radiation, radiation dose, occupational dose, measuring radiation device.

Citation: Taha MA, et al. (2024) Determination of Operator's Portable X-ray Safety. Dentistry 3000. 1:a001 doi:10.5195/d3000.2024.734
Received: September 20, 2024
Accepted: September 22, 2024
Published: October 7, 2024

Email: Mohammedayad@tu.edu.iq

Introduction

As it meets matter, ionizing radiation may take the form of rays, which are a subtype of this kind of radiation. Radiation is a natural occurrence that may also be produced artificially, and it can come from either natural or man-made sources.

The induction of cellular damage by radiation has a dramatic impact on living organisms and poses a risk to both healthy and sick tissues. There is a wide range of responses to radiation in humans, and these responses are determined by several factors. These factors include the radiation source, the radiation dosage (the amount of radiation energy received), the length of exposure, and, most importantly, the genetic and epigenetic makeup of the individual who was exposed to the radiation [1]. The German scientist Wilhelm Konrad Rontgen discovered X-rays in 1895 when he was researching the effects of electron beams, which were termed cathode rays at the time. Rontgen was observing the effects of electrical discharges passing through low-pressure gases [2]. A screen that was coated with fluorescent material and put outside of a discharge tube would glow even when it was insulated from the direct visible and ultraviolet light that was emitted by the gaseous discharge, which was a striking phenomenon that was discovered by Roentgen. After that, radiation that was not visible from the tube traveled through the surrounding air and caused the screen to fluoresce [3]. Roentgen was able to determine that the radiation that was responsible for the fluorescence came from the location where the electron beam contacted the glass wall of the disc fluorescence. This was made possible by the fact that Roentgen

Vol 13 No 2 (2024) DOI 10.5195/d3000.2024.734

was able to determine the origin of the radiation. Disc fluorescence, when put between the tube and the screen, was found to be transparent to the newly discovered kind of radiation. Rontgen vividly showed this by taking a photographic picture of the bones of the human hand [4]. Together with the discoveries of radioactivity and the electron (1897), it ushered in the study of the atomic world and the period of modern physics (1896). His discovery, which he termed Rontgen rays, was received with enthusiasm both in the scientific community and in the general public all across the globe [1]. In the beginning, the uses of X-rays were limited to medicine, given that these rays were a turning tool [1-5]. Areas of the body to look for any physical imbalance in the various areas of the self-Roentgen rays swept the world. Everyone took advantage of it, including the doctors who excelled and went to great lengths in depicting the disease's skeletons. At that time, they considered that the long period of exposure to these photons may cause diseases, including cancer [6]. There are several applications of X-rays in Medicine [7], and dental radiographs, more often known as X-rays, are pictures that are used to assess dental health. Images of the inside of teeth and gums may be taken using these low-radiation X-rays, which are used to examine patients' oral health. This may be useful in assisting dentists in the diagnosis of issues such as cavities, dental decay, and impacted teeth. While dental X-rays may seem to be complicated, they are rather frequent and are just as vital as regular teeth cleaning [8].

Types of dental X-rays include extra and intraoral X-rays. Extraoral X-rays include:

(a) Panoramic radiography is a kind of radiography that offers information in two dimensions on the teeth and the maxillofacial skeleton. It enables one-time imaging of all teeth, the mandible, and parts of the maxilla, including a large portion of the maxillary sinus, the hard palate, and the temporomandibular joints (TMJs), making it a useful adjunct for the diagnosis and planning of treatment [9].

(b) Tomograms highlight a specific layer, sometimes known as a "slice," of the mouth while blurring out the surrounding layers. This X-ray investigates features that are difficult to detect because of the presence of additional structures in the immediate area that impede vision [10].

(c) Cephalometry is an imaging method that is used in orthodontics to measure the size of the head, jaws, and teeth by using landmarks or points on the skull. This approach is used to determine the spatial connections between the head, jaws, and teeth. It is used for diagnosis, the planning of therapy, and the evaluation of dentofacial changes as treatment progresses [11].

(d) Magnetic resonance imaging, often known as MRI, is a procedure that utilizes magnetism and radio waves to create pictures of a patient's anatomy that are cross-sectional. This approach also takes a perspective in three dimensions of the oral cavity, showing the jaw and the teeth. This is perfect for assessing the condition of soft tissue [12].

The use of radiographic film is being phased out in favor of e-digital imaging. The patient is exposed to a lower radiation dose with this new technology, images are available almost instantly without the need for chemical film processing, and there is the possibility of image enhancement and computer-aided feature extraction. These advantages are all brought about by the advancement of technology. Traditional film-based imaging has its limitations as compared to digital radiography, which paves the way for novel diagnostic

Vol 13 No 2 (2024) DOI 10.5195/d3000.2024.734

techniques that were previously unavailable [13].

The F-Dental cone beam computed tomography (CT) X-ray machine is a specialized sort of imaging device that is used in instances in which standard dental or face X-rays are not enough. Since the radiation dose from this scanner is substantially higher than that which is received through standard dental X-rays, it is rarely used daily [14].

Intraoral X-rays include:

(a) Periapical X-rays are those that show the whole tooth, from the crown down to where the tooth is attached in the jaw, which is beyond the end of the root. Each periapical X-ray displays this whole tooth dimension and includes all the teeth that can be seen in either the upper or lower jaw region where the image was taken. X-rays taken from the periapical region are examined for any abnormalities in the root structure and the bone structure that surrounds it [15].

(b) Bite-wing X-rays focus on one region of the mouth and provide specifics about the upper and lower teeth there [16]. Each bitewing exposes a tooth from the top of the tooth down to a level approximately equivalent to the level of the supporting bone. X-rays taken with a bitewing are used to identify cavities between teeth as well as shifts in bone density brought on by periodontal disease. They may also be used to determine the correct fit of a crown (or cast restoration) and the marginal integrity of fillings, both of which are very important applications [17].

(c) Occlusal radiography is described as those intraoral radiographic methods that are taken using a dental X-ray system in which the image receptor (film packet or digital phosphor plate - 5.7 x 7.6 cm) is positioned in the occlusal plane. This kind of radiography is used to examine the teeth and jaws. There are no solid-state digital sensors of an appropriate size that are presently available [18].

The dentist will utilize X-rays to take photographs of the patient's teeth using film. This will allow the dentist to identify any damaged teeth and place an order for their repair. Unfortunately, film development takes some time. In addition to the difficulties of keeping and capturing such videos, there is a limited amount of space available [19].

As a result, it pioneered the technique of photography using film and gradually started to phase it out in favor of digital photography with digital sensors. Throughout the imaging procedure, the patient will be subjected to a lower level of radiation exposure if this approach is used. The picture is shown in real-time on the display of the monitor [20].

Types of digital X-ray machines include portable, fixed and mobile X-rays [21]. Radiographers, veterinarians, and dental professionals can take X-ray images of patients without having to call them into a special lead-lined room. Radiographs are an essential component of routine clinical dentistry. Equipment is typically either fixed (mounted to the wall, floor, or ceiling) or mobile (mounted on a tripod that is moved around on a set of wheels) [22]. The portable X-ray unit that can be carried in one's hand and is powered by a battery is a device that is relatively new to the market. In the past, the vast majority of handheld, portable X-ray devices were modified versions of existing equipment. These machines were designed for use in military medical, humanitarian missions, and training exercises. Moreover, they find uses in veterinary medicine, crime and catastrophe situations for forensic dental imaging, and archaeological excavation sites. Individuals in need of dental care who are

Vol 13 No 2 (2024) DOI 10.5195/d3000.2024.734

confined to their homes or institutionalized and have restricted mobility, as well as those who are receiving general anesthesia, may benefit from the use of these devices [23].

When the effective dosage is computed directly, handheld portable X-ray machines emit radiation below the recommended dose. This was determined by comparing the amount of radiation to the effective dose [24].

The distance away from the body varies, depending on the position of the hands and how the portable X-ray equipment is handled by the operator. This is because the distance away from the body is dependent on the position of the hands. In addition to this, a backscatter shield is the sole integrated protection that is provided for the operator [25,26]. Because of this, it is still debatable as to whether these precautions are enough to protect the operator from being unnecessarily exposed to radiation. Occupational dose monitoring is often advised for these operators [27]. When utilizing either stationary or mobile X-ray units, it is always recommended to keep a safe distance, remain outside the "controlled zone," and refrain from holding the X-ray equipment to reduce the risk of radiation exposure caused by radiation leakage from the X-ray tube head and backscatter [28]. There is a concern with handheld portable X-ray devices regarding the exposure of the operator [29].

When X-ray equipment is being used, it is customary to have a certain location that is known as a "controlled area" in the United Kingdom. This is done to protect the personnel and the public from any possible radiation exposure that may not be required. The "controlled region" is defined as a zone that is 1.5 meters away from both the patient and the head of the X-ray tube and is located anywhere along the path of the primary X-ray beam. Any radiation that occurs beyond the "restricted region" is adequately dampened by the combination of distance and shielding. In addition to this, the operator needs to be at a safe distance away from the "controlled region," at least two meters away from the X-ray source [30].

The radiation dose resulting from the portable devices to which exposure is permitted should not exceed 20 mSv per year [31]. The permissible amount of radiation exposure during the radiation shot should not exceed 10 mSv per shot [32]. Any dose exceeding that is considered dangerous and threatens the life of the worker in the field of radiation [33]. The aim of this work was to compare three portable dental X-rays to determine the quantity of dispersed radiation that potentially affects radiography operators.

Material and Methods

We used three types of portable X-rays devices: Clarox, Eighteeth, and QiN high-frequency microfocus dental X-ray unit (Figure 1 and Table 1).

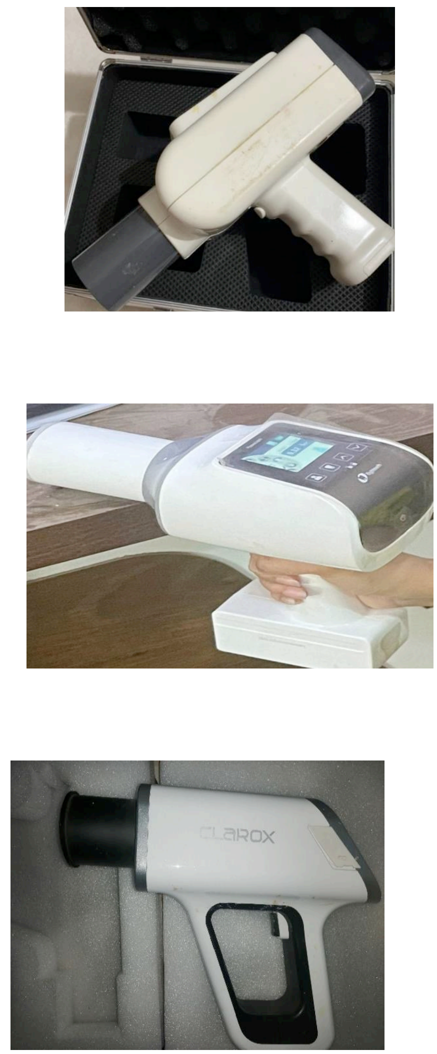


Figure 1. The three portable X-ray devices used in the study.

Vol 13 No 2 (2024) DOI 10.5195/d3000.2024.734

Device Name	Eightieth	Portable X-ray system	QiN high-frequency microfocus dental X-ray Unit
Model	Hyperlight	Clarox vx-3DE	Class IBF type
Tube voltage	70 kv	70kv	70kv
Exposure time	0.35	0.35	0.1_2
Focal spot size	0.4mm	0.4mm	0.3mm
Tube current	2mA	2mA	1mA
Manufacture	China	Korea	China

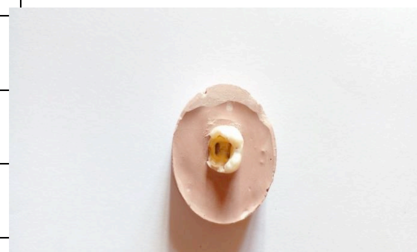
Table 1: Information about the three portable X-ray devices used in the study.

We also used a radiometer for measuring scattered radiation from the X-ray machines (Figure 2) and an Intraoral Digital Imaging Sensor model Pos-Ray1 (Figure 3).

Figure 2. Radiation measuring device used in the study.

Figure 3. Intraoral digital sensor used in the study.

We used an extracted tooth (lower left first molar), simulating a root canal treatment, fixed on stone to perform the analysis (Figure 4).



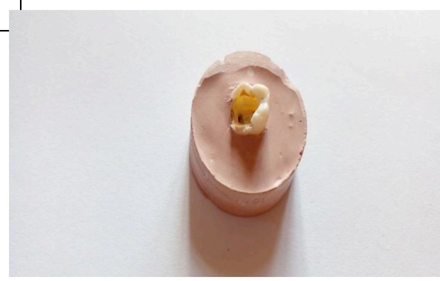
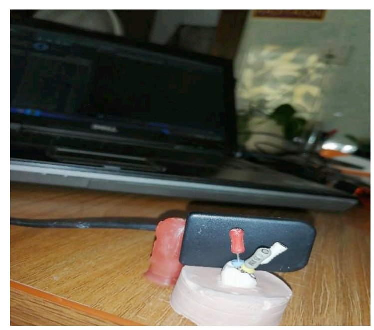


Figure 4. Tooth used for testing.

The tooth was placed and fixed on a stable horizontal surface, and the sensor was placed directly behind the sample. The tooth was fixed by making a small mold of wax connected to the electric wire as shown in Figure 5, to keep it stable throughout the work period.

For all X-ray units, they were placed 5 cm from the tooth then the radiometer was placed 20 cm from the field of work as shown in Figure 6. The X-ray machine was turned on and radiological images were taken at an exposure time of 0.35 seconds and 70 Kv for all images.



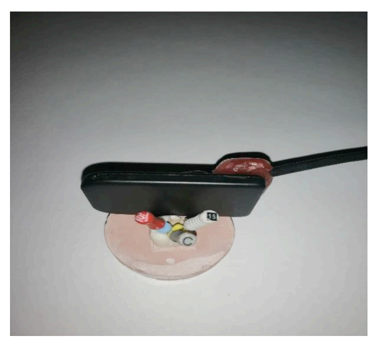


Figure 5. Standardized position of the sensor.

Vol 13 No 2 (2024) DOI 10.5195/d3000.2024.734

Figure 6. Distance between sample X-ray device and radiation measuring.

Descriptive statistics including minimum, maximum, mean, and standard deviation were calculated for the dye penetration obturating material for each group. The data were collected and analyzed using SPSS (version 23) for statistical analysis.

One-way analysis of Variance (ANOVA) was used to determine whether there was a statistical difference in the radiation readings among the groups. Then, post hoc Duncan's Multiple range was used to determine the exact location of difference between groups. A P-value of <0.05 was considered statistically significant.

Results

According to the results obtained after using the Clarox and Eightieth devices, there was a decrease in the readings of the X-ray, which meant the amount of radiation diffused from the X-ray device and reaching the operator decreased (Tables 3 and 4). The QiN high frequency microfocus dental X-ray unit showed lower readings compared to the other units, as shown in Table 4.

Table 2. Recorded readings for Clarox.

Radiograph	Recorded readings (mSv)	mSv Statistics
1st	349	Mean: 197.6 Standard Deviation: 90.97 Median: 195 Minimum: 50 Maximum: 349
2nd	284	
3rd	260	
4th	243	
5th	202	
6th	188	
7th	170	
8th	123	
9th	98	
10th	50	

Table 3. Recorded readings for Eightieth.

Radiograph	Recorded readings (mSv)	mSv Statistics
1st	350	Mean: 231.4 Standard Deviation: 50.84 Median: 207.5 Minimum: 192 Maximum: 350
2nd	286	
3rd	245	
4th	211	
5th	231	
6th	197	
7th	192	
8th	203	
9th	195	
10th	204	

Table 4. Recorded readings for QiN high frequency microfocus dental X-ray unit.

Radiograph	Recorded readings (mSv)	mSv Statistics
1st	93	Mean: 103.6 Standard Deviation: 17.49 Median: 100 Minimum: 71 Maximum: 129
2nd	129	
3rd	71	
4th	121	
5th	97	
6th	103	
7th	87	
8th	105	
9th	110	
10th	120	

Discussion

The maximum occupational effective dose, according to ICRP (The International Commission on Radiological Protection), is 20 mSv/year averaged over five years (i.e., a cap of 100 mSv in five years), with no annual effective dosage surpassing 50 mSv/year. The work dose limit is defined by NCRP (National Council on Radiation Protection and Measurements) as 50 mSv in any one year and a lifetime limit of 10 mSv multiplied by the person's age in years and the permissible dose for daily use is 2mSv [34].

Patients and dental practitioners are constantly exposed to radiation

Vol 13 No 2 (2024) DOI 10.5195/d3000.2024.734

during diagnosis, but the percentage is small compared to medical staff. Continuous exposure to radiation, even at low doses, may have long-term health effects on radiation practitioners [35].

It is important to evaluate and measure the radiation between the portable device and the doctor after taking the radiation, meaning that the focus is on the personal protection of radiation practitioners from dangerous doses [36].

A handheld portable X-ray unit is a useful addition to the dental practice or public health sector when used appropriately. It has been showed that there is no additional radiation when compared to a conventional wall-mounted unit [37].

In accordance with previous data, we found that there is a potential effect of radiation [38].

Routine radiology device calibration is thought to be important and has an impact on the accuracy of the device's readings [39].

Radiation-related workers who lack the proper training, may be at higher risk [40].

The validity of the used instruments of this study may have an impact on the reading of the resulting rays [41].

The radiation measurements are also impacted by the subpar aluminum filter, area locator, and cone in the X-ray machine [42].

Conclusion

The radiation produced by portable x-ray machines potentially affects workers, but are still within permissible limits, and routine use of them may result in tissue damage. Therefore, it is especially important to follow radiation protection procedures and to wear a lead shield for daily use. This confirms the invalidity of the companies' words about the absence of radiation emitted and the lack of the need to wear protective equipment.

Conflicts of interest

The authors declare no competing interest.

References

1-Ribeiro DA, de Oliveira G, de Castro G, Angelieri F 2008. Cytogenetic Biomonitoring in patients exposed to Dental X-rays: comparison Between adults and children. Dentomaxillofac Radiol Oct;37(7):404-407

2-Alternate titles: Röntgen radiation, X-radiation. https://www.britannica.com/science/Auger-effect

3-Alternate titles2021: X-Rays Mine Antique "Locked Letter," Prompting Look at X-Ray Tech December 6 https: //icetonline.com/x-rays-mine-antique-locked-letter-prompting-look-at-x-ray-tech/

4-Imaging Final – Unit 1, Unit 2, Basics of Digitalhttps://quizlet.com/755964842/imaging-final-unit-1-unit-2-basics-of-digital-flash-cards/

5-Early clinical use of the X-ray, Trans Am Clin Climatol Assoc. 2016; 127: 341–349.https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5216491/

6- Understanding 2017 tests used to detect bone problems Created: November 7, 2013; Last Update: December 27, Next update: 2020.

7-Brian Krans2020. X-Ray. Retrieved on the 12th of December, https://my.clevelandclinic.org/health/articles/11199-dental-x-rays

8- Medically reviewed,2023, by Christine Frank, DDS — By Brian Krans — Updated on February 21,

9 -Ingrid Różyło Kalinowska 2021, Panoramic radiography in dentistry, August 2021 / Accepted: 5 October 2021 / Published online: 7 December

Vol 13 No 2 (2024) DOI 10.5195/d3000.2024.734

https://doi.org/10.1007/s41894-021-00111-4

10-Luisa Vigorelli,2021 X-ray Micro-Tomography as a Method to Distinguish and Characterize Natural and Cultivated Pearls 15 October.

11- World J Radiol,2014 Recent advances in imaging technologies in dentistry, Oct 28; 6(10): 794–807.

12- Lav Kumar Niraj 2016, MRI in Dentistry- A Future Towards Radiation Free Imaging – Systematic ReviewOct 1. Doi: 10.7860 /JCDR/2016/19435.8658.

13-Medicine, 2012, Digital Radiography with DR There is a specialized digital plate that replaces the conventional cassette from: the Manual of Exotic Pet Practice.

14-CEO,2018: Tomislav Mihaljevic https ://www. Radiologyinfo.org/ en/info/dentalconect.

15-Dentomaxillofac Radiol. 2002 May;31(3):159-6https://my.clevelandclinic.org/health/articles/11199-dental-x-rays

16-Mabak, 2018 Dental X-rays – What They Reveal by Medikabazaar 2021· September 24.

17-https://dental-south.com/dental-x-rays-what-they-reveal.

18-A complete guide to portable medical X-ray machines 26.03.20 | X-Ray, Equipmenthttps://pocketdentistry.com/11-occlusal-radiography/

19-Coy J. aHnd-held 2023Academy of General Dentistry. X-rays. (http://www.knowyourteeth.com/infobites/abc/?abc=x) Accessed 2/9/.

20-Coy J, Vandre RH 2023, The Photographic Process and Film Sensitivity http://www.sprawls.org/ppmi2/FILMSEN/

21-Danforth RA, Herschaft EE, Leonowich JA2009. Operator exposure to scatter Radiation from a Portable hand-held dental radiation emitting device (Aribex NOMAD) while making 915 intraoral Dental radiographs. J Forensic Sci. 2009 Mar;54(2):415-21. Epub Jan 29. https://www.browiner.com/products-solutions/

22- Radiation protection of patients in dental radiology https://www.iaea.org/resources/rpop/health-professionals/dentistry/patients 2022

23-Jimmy Makdissi The effects of device position on the operator's radiation dose when using a handheld portable X-ray device. Dentomaxillofac Radiol. 2016 Mar; 45(3): 20150245.

24- Ravikiran R Pawar, 2016 The effects of device position on the operator's radiation dose when using a handheld portable X-ray device https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4846146/

25-Korean J Pain 2017 https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4846146/

26- E: ChiltonInformatio, 2016, Guidance on the Safe Use of Hand-held Dental X-ray Equipment

27-almrsal.com was first indexed by Google more than 10 years ago https://www.almrsal.com/post/879295

28-Vissink A, Jansma J2003, Spijkervet F, Burlage F, Coppes R. Oral sequelae of Head and neck radiotherapy. Crit Rev Oral Biol Med; 14(3):199-212

29-Kazuki Otomo 2023 et al. Bioengineering (Basel). Feb 16;10(2):259

30-Course of Radiological Technology, Health Sciences, Tohoku University Graduate School of Medicine, 2-1 Seiryo, Aoba-ku, Sendai 980-8575, Japan

Vol 13 No 2 (2024) DOI 10.5195/d3000.2024.734

31- Dental radiographic examinations2012: recommendations for patient selection and limiting radiation exposure. Chicago: American Dental Association, Council on Scientific Affairs; 27p.

32- Makdissi, J., Pawar2015, R. R., Johnson, B., & Chong, B. S. (2016). The effects of device position on the operator's radiation dose when using a handheld portable X-ray device. Dent maxillofacial Radiology, 45(3), 1-7. Doi: 10.1259/mfr. 0245

33-Dr. Zeyad Alani 2018 (Dr. Zeyad Alani is a dentistry practitioner in Rancho Cordova, CA. He currently practices at Rancho Cordova Smiles Dentistry Dental Group. Publication of a scientific article in History 31 October

34-T.J. Boal, M. Pinak 2014, Dose limits to the lens of the eye: International Standards related Safety Basic and guidance,https://www.icrp.org/docs/ICRP2013%20S2%20Boal.pdf

35-Su-Yeon Hwang, 2018, Health effects from exposure to dental diagnostic X-ray, Environ Health Toxicol. Dec; 33(4): e2018017.

36-B. E. Keane 1975, Manual on radiation protection in hospitals and general practice, Volume 3, X-Ray Diagnosis Medical Physics Department, Royal Sussex County Hospital, Brighton, England.

37- W E R Berkhout,2015, Justification and good practice in using handheld portable dental X-ray equipment: a position paper prepared by the European

Academy of Dent Maxillofacial Radiology (EADMFR), Dentomaxillofac Radiol. Jul; 44(6): 20140343.

38- https://abcnews.go.com/Health/Wellness/century-ray-machine-shows-radiation-risks-yore/story?id=13140857.

39-Ngoc Toan Tran,2012. Calibration of KVp meter used in quality control tests of diagnostic X-ray units, PMID: 21447505 DOI: 10.1093/rpd/ncr037

40-Salman Akram; Yuvraj S. Chowdhury.2022, Radiation Exposure of Medical Imaging Last Update: November 14.

41-Adrian P. Brady 2017, Error and discrepancy in radiology: inevitable or avoidable, Insights Imaging. Feb; 8(1): 171–182.

42-MS.Tech.Khaldun, 2020, Techniques of Medical Radiological Devices https://www.esraa.edu.iq/modules/lect/lect/73154600593314464.pdf