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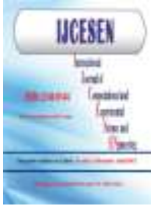

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Research Article

Radiation Dose Levels in Submandibular and Sublingual Gland Regions during C-Arm Scopy

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Abstract:

The subject of this study is to determine the radiation dose exposure to the sublingual glands and submandibular glands during c-arm fluoroscopy imaging by measuring them with dosimeters (TLD-100). The results of this study will contribute to understanding the effects of radiation exposure on the human body. Data for the research was collected by measuring the radiation exposure at specific time intervals: 0.5, 1, 2, 4, and 8 minutes. Measurements were taken for three regions: right and left submandibular glands, and sublingual gland.
The maximum radiation exposure for the right submandibular gland at 0.5, 1, 2, 4, and 8 seconds were 1294, 3119, 5916, 11925, and 21274 microSieverts (µSv) respectively. The maximum radiation exposure for the left submandibular gland at the same intervals were 877, 2104, 3704, 7816, and 14618 µSv respectively. For the sublingual gland, the maximum radiation exposure at these intervals were 958, 2081, 3815, 8332, and 14128 µSv respectively

1. Introduction

Radiation refers to the emission or transmission of energy through electromagnetic waves or particles. X-rays, also known as electromagnetic waves or photon beams, have an energy range of 0.125 to 125 kV or a wavelength of 10 to 0.01 nm [1]. C-arm fluoroscopy and CT(computed tomography) are scanning technologies that can capture detailed internal and external geometric information of a structure or object using X-rays. X-rays are also employed when utilizing the C-arm fluoroscopy device, which is specifically designed for use during surgery. The C-arm fluoroscopy device is intended for surgical applications in orthopedics, traumatology, general surgery, urology, neurosurgery, and various endoscopic studies, depending in part on the selected memory systems. While the C-arm fluoroscopy device captures images of deep areas, it does not cause any deformation[2]

Radiation types are examined in two main groups. These are Ionizing Radiation and Non-Ionizing Radiation. Ionizing radiations; Particle (alpha rays, beta rays, neutrons) and wave (x-rays, gamma rays) rays are those that remove electrons from the atoms they encounter. Non-ionized rays are lower-energy rays. These are examples of infrared, visible light, and microwaves. In non-ionized form, it does not cause the formation of any ions with the atom or molecule it encounters [3].

The biological effects of radiation vary depending on the type, type of radiation, exposure time, and dose [4].

There are various regulations for those working in radiation exposure around the world and in Turkey. The maximum annual radiation dose amount and limit table determined by the legal regulations in Turkey is shown in table 1. [5]:

Table1: *Regulation on Radiation Dose Limits and Working Principles of Personnel Working with Ionizing Radiation Sources in Health Care Services*

	Occupation exposed to radiation	**Individual Members of the Public**
Annual average*	20 mSv/year	1 mSv/year
Eye	150 mSv/year	15 mSv/year
Skin	500 mSv/year	50 mSv/year
Hand feet	500 mSv/year	50 mSv/year

Annual Average: *Average of 5 consecutive years

The X-rays used in the C-arm scope are in the ionizing radiation group. This causes damage to human health in long-term exposure.

When using a C-arm scope, most of the radiation emitted is absorbed rather than reflected by our bodies. In our study, we aimed to determine the amount of radiation dose to which the submandibular and sublingual glands are exposed. During this process, we utilized a phantom. The characteristics of the phantom used resemble those of a female individual who is 155cm tall and weighs 50 kg.[6]

The Alderson Rando phontom was used as a representative model of the human body and served as a tool for assessing radiation exposure levels. For this evaluation, TLD-100 dosimeters were strategically placed in the 9th section of the phantom, designated as the thyroid region, and measurements were made at intervals of 0.5, 1, 2, 4, and 8 minutes. The findings of this investigation, conducted using the Alderson Rando phantom supplied by Istanbul University-Cerrahpaşa Department of Radiation Oncology, were assessed at the Çekmece Nuclear Research Center

2. Material and Methods

The Alderson Rando Phantom (ART) utilized in our research emulates the physique of a woman (fig-1) standing 155cm tall and weighing 50kg[6]. This phantom serves as a pivotal tool in gauging radiation levels, offering highly precise outcomes in simulated human dosimetric assessments. Crafted in alignment with ICRU-44 standards, ART phantoms aremeticulously fashioned from tissue-equivalent materials and

meticulously contoured to mirror human anatomy[Radiation Products Design Inc.].The dosimeters are positioned within the ART phantom by dividing it into horizontal slices,each 2.5 cm thick. This segmentation allows for precise placement of the dosimeters in targeted regions for measurement. Tissue equivalent pins are utilized to cover the areas designated for TLD detection pin placement. The material composing the ART phantom has a density of 0.985 g/cm³. This approach ensures accurate and controlled measurements of radiation dosage in specific areas of interest[6].

Figure 1*: The ART phantom*

Figure 2*: The dose measurements were conducted using the ART simulation on the C-arm scope system*

TLD-100 dosimeters serve as personal radiation exposure meters for individuals operating in radiation-exposed environments. With dimensions of 3.2x3.2x0.89 mm, these dosimeters contain

LiF:Mg,Ti material, chosen for its close equivalence to human tissue. This selection ensures accurate measurement of radiation exposure, as the material closely mimics human tissue properties[7].

To meticulously calibrate the dosimeters, a stringent procedure was adhered to. Initially, the dosimeters underwent annealing, being subjected to 400°C for one hour followed by 100°C for two hours[8]. This critical annealing process is indispensable for optimizing the dosimeters' performance. Subsequently, measurements were executed with meticulous care, ensuring that standard deviations remained below approximately 3%[8]. The evaluation of C-arm Skope imaging and dosimeter calibration occurred at the secondary standard dosimetry (SSDL) laboratory situated within the Çekmece Nuclear Research Center(TENMAK). This cutting-edge facility provides a controlled environment for precise assessment and calibration of dosimeters, upholding impeccable standards in radiation measurement.

In this study, TLDs were placed in the sublingual, right submandibular gland and left submandibular gland regions of the phantom and scopy imaging was performed for 0.5, 1, 2, 4, 8 minutes, respectively. TLDs were removed, read and radiation dose levels were determined.

3. Results and Discussions

The experiment aimed to assess the minimum and maximum doses encountered by the Sublingual, right Submandibular, and left Submandibular glands over various time intervals. The findings reveal a progressive increase in radiation exposure over time for each gland. For instance, at 0.5 minutes, the Sublingual gland registered a minimum dose of 814 microSieverts (µSv) and a maximum dose of 958 µSv. These values escalated significantly by the 8th minute, where the minimum dose surged to 12982 µSv and the maximum reached 14128 µSv.

***Table 2**: Sublingual gland min. and max. Radiation Dose value (µSv)*

Time (min)	Sublingual gland min. Radiation Dose value (µSv)	Sublingual gland max. Radiation Dose value (µSv)	Average Radiation Dose value (µSv)
0.5	814	958	886
1	1892	2081	1986.5
2	3326	3815	3570.5
4	7012	8332	7672
8	12982	14128	13555

Such escalating trends demonstrate the dynamic nature of radiation exposure during the experiment, with dose levels doubling from the 4th to the 8th minute. These results underscore the importance of monitoring radiation dosage over time, especially in critical anatomical regions like the salivary glands, to ensure effective radiation protection protocols are in place. The values are shown in the table (Table 2)

The radiation exposure levels for the Right Submandibular gland were meticulously documented throughout. In the initial 0.5 minutes, the gland experienced a minimum dose of 1092 µSv and a maximum of 1294 µSv. These values notably increased to 2724 µSv minimum and 3119 µSv maximum per minute by the 1st minute and further surged to 5003 µSv minimum and 5916 µSv maximum per minute by the 2nd minute. By the 4th minute, the radiation dosage peaked at 10728 µSv, with its maximum value reaching 11925 µSv. Ultimately, at the 8th minute, the gland encountered a minimum dose of 19263 µSv and a maximum of 21274 µSv. These comprehensive findings underscore the critical importance of monitoring radiation exposure levels over time, particularly in sensitive anatomical regions such as the submandibular glands, to ensure adequate protection measures are implemented. These data are also shown in the table (Table3).

***Table 3:** Right Submandibular gland min. and max.Radiation Dose value (µSv)*

Time (min)	Right Submandibular gland min. Radiation Dose value (µSv)	Right Submandibular gland max. Radiation Dose value (µSv)	Average Radiation Dose value (µSv)
0.5	1092	1294	1193
1	2724	3119	2921.5
2	5003	5916	5459.5
4	10728	11925	11326.5
8	19263	21274	20268.5

In our study, the Left Submandibular gland was the final component measured. The dose amounts recorded at the end of half a minute were 743 µSv and 877 µSv, with the minimum and maximum doses measured, respectively. Subsequently, at the 1st minute, the doses escalated to 1718 µSv and 2104 µSv per minute. By the 2nd minute, these values increased to 3195 µSv and 3704 µSv, and by the 4th minute, they peaked at 6514 µSv and 7816 µSv. Finally, at the 8th minute, which marks the conclusion of our measurements, the minimum dose recorded was 12953 µSv, while the maximum reached 14618 µSv. The results are listed in table 4.

Table 4: *Left Submandibular gland min. and max.Radiation Dose value (μSv)*

Time (min)	Left Submandibular gland min. Radiation Dose value (μSv)	Left Submandibular gland max. Radiation Dose value (μSv)	Average Radiation Dose value (μSv)
0.5	743	877	810
1	1718	2104	1911
2	3195	3704	3449.5
4	6514	7816	7165
8	12953	14618	13785.5

1mSv = 1000 μSv

Radiation refers to the emission or transmission of energy through electromagnetic waves or particles. X-rays, also known as electromagnetic waves or photon beams, have an energy range of 0.125 to 125 kV or a wavelength of 10 to 0.01 nm[1].

Ionizing radiation is a factor that affects the human body by damaging cells with damage at the atomic or molecular level. This radiation can damage vital components of cells, lead to cell death, and directly or indirectly damage human DNA. When in direct contact, radiation can cause DNA strands to break. Indirect effects occur through the ionization of molecules; Radiation ionizes water molecules, promoting the formation of hydroxyl ions, which can interact with DNA and cause damage. Generally, cells have mechanisms that can repair DNA damage, but if the damage cannot be repaired, the cells undergo apoptosis. Deficiency or incorrect repair of DNA repair mechanisms can lead to genetic mutations and the formation of cancer types such as carcinoma[9,10].

Radiation protection principles focus on the justification of exposure, balancing the effects and benefits of radiation exposure. The Optimization ("As Low As Reasonably Achievable" - ALARA) principle aims to minimize radiation doses as much as possible, considering socio-economic factors. Dose limitations are set at 50 mSv annually for radiation workers, with a 5-year average of 20 mSv, and 1 mSv annually for the public. For radiation workers, the annual dose limit for the lens of the eye was previously 150 mSv, and with the new standards, it is 20 mSv, while for the public, it remains at 15 mSv. The annual dose limit for hands, feet, and the whole skin is set at 500 mSv for radiation workers and 50 mSv for the public. The Maximum Permissible Dose defines the level of ionizing radiation that will not induce significant bodily harm or genetic effects. The Limitation principle underscores that these dose limits are established to control potential effects like cancer and genetic damage. Natural radiation and medical exposures are excluded from these limits[11].

In cases where deemed necessary, individuals who wish to assist patients under medical diagnosis and treatment, provided they are voluntary and informed, or visitors coming for patient visits, will not exceed an effective dose of 5 mSv throughout the diagnosis and treatment period[12]. The value of 5 mSv is equivalent to 5000 μSv, and this value is much lower than some of the data we obtained in our study. The radiation dose received by the submandibular and sublingual glands exceeds the maximum dose set by the Republic of Turkey. One important consideration in the use of C-arm fluoroscopy is the duration of use. In the research conducted, as the exposure time increases, the radiation exposure dose also significantly increases. This is an indicator that the risk of damage in humans also increases. In order to be least affected by radiation, the imaging time with C-arm scope should be kept to the maximum extent.

Radiation protection encompasses two main categories: internal and external. Internal radiation occurs when radioactive materials enter the body through ingestion, inhalation, or skin contact, potentially harming various organs. To guard against this, maintaining good hand and oral hygiene, ensuring proper home ventilation, and covering open wounds are essential to prevent exposure to substances like Radon. Conversely, external radiation emanates from sources in our environment emitting radiation. To reduce exposure, it's vital to limit the duration of time near radiation sources, maintain distance, and use protective shielding. By adhering to these principles of time, distance, and shielding, we can effectively shield o1urselves from both types of radiation, but remaining aware and cautious is always crucial[13].

Figure-3, 4 and 5 shows the graph of the time-dependent change in the radiation level to which the tissues are exposed. There is a positive correlation between radiation dose level and time. correlation coefficients were calculated as 0.9951 in sublingual tissue, 0.9958 in right submandibular tissue and 0.9993 in left submindubular tissue.

4. Conclusions

In conclusion, the study includes the measurement and interpretation of radiation levels experienced during the use of the C-arm fluoroscopy device. The measurements made and the average of the measurements are shown in the tables.

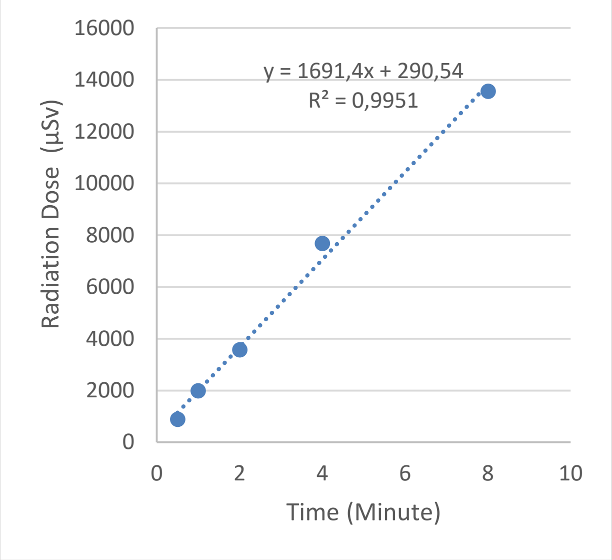

Figure 3: *Sublingual Average Radiation Dose Value*

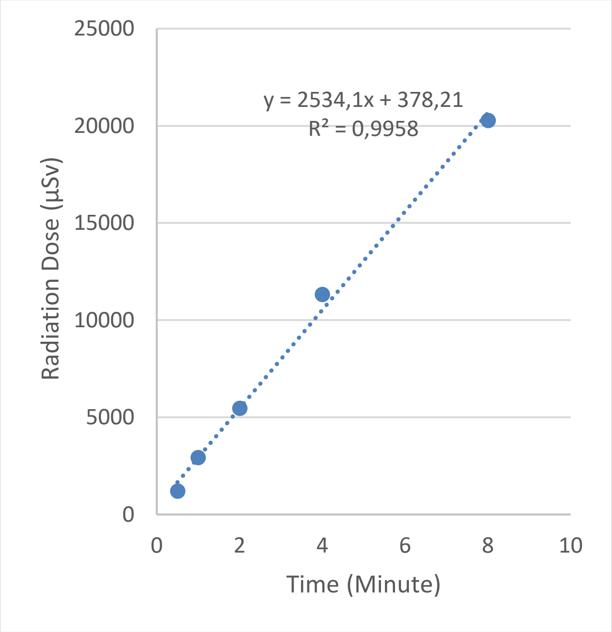

Figure 4: *Right Submandibular Average Radiation Dose Value*

While a separate average dose graph is shown for each region, the last graph shows the average dose amount of the data taken from 3 regions during the measurement periods graphically. Performing radiologic imaging on a c-arm scope for prolonged periods of time results in exposure to high doses of radiation.

Author Statements:

- **Ethical approval Statements**: The conducted research is not related to either human or animal use.

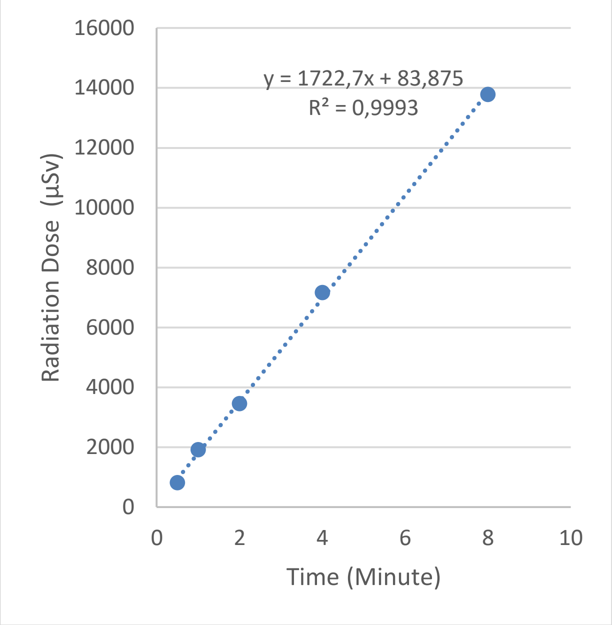

Figure 5: *Left Submandibular Average Radiation Dose Value (µSv)*

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- **Data availability Statements:** The data supporting the study findings can be obtained upon request from the corresponding author. Nevertheless, it is not accessible to the public because of privacy or ethical restrictions.

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