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DESIGN AND CONSTRUCTION OF ORBITA PROTECTION EQUIPMENT FOR PANORAMIC EXAMINATION

Mega Indah Puspita[1],Bagus Abimanyu[2],Bagus Dwi Handoko[3],Ardi Soesilo Wibowo[4],Susi Tri Isnoviasih[5],Erwin Darmawan, Amd.Rad[6],Ella Fitriana[7]

[1-5]Poltekkes Kemenkes Semarang, Indonesia
[6]RSUD dr.R. Soeprapto Cepu, Indonesia

Mega Indah Puspita, S.ST, M.Kes
Email: megaindahpuspitaa@gmail.com

ABSTRACT

Panoramic dental radiography uses X-rays to produce radiographs of the jaw and facial structures, from the teeth to the TMJ and the entire dental arch. Exposure to X-rays during an examination can be problematic because sensitive areas such as the thyroid gland and eyes adjacent to tooth structure also receive radiation exposure. Patients in panoramic examinations do not use eye radiation protection equipment for the orbit, namely Pb glasses, while the eyes are close to the dental arch which can receive radiation exposure, so eye radiation protection equipment is needed in panoramic examinations for patient safety. The aim of the research is to determine the function test and performance test of the Eye Radiation Protection Device.

This type of research is quantitative research with an experimental approach. The research sample was 3 patients with variations of 3 kV: 70, 76, and 86 kV with a setting of 10 mA. The radiation dose to the eye was measured using a phantom and pocket dosimeter before and after using the radiation protection design tool, then looking for the average, difference and percentage and carrying out the Kruskal-Wallis SPSS st.

The results of the three radiographs showed no artifacts, the exposure factor before using the device was 70 kV = 0.08 mSv, 76 kV = 0.17, 86 kV = 0.27 mSv while the radiation dose received after using the device with an exposure factor of 70 kV = 0 mSv, 76 kV = 0.86 kV = 0.003 mSv, while from the Kruskall-walls statistical test pre-test and post test kV 70 shows a significant value of 0.034 <0.05, kV 76 does not show a significant value of 0.121 > 0.05, kV 86 shows a significant value of 0.043 <0.05. The design of this eye radiation protection device has succeeded in reducing or reducing the radiation dose around the eyes by up to 100%. Meanwhile, the level of feasibility of the tool has a respondent score of 80%. Suggestions for using a thermoluminescence radiation measuring instrument (TLD) with smaller units, namely µSv.

Keywords: Panoramic, Design of radiation protection equipment, Pocket Dosimeter

Introduction

Panoramic is an important method in the field of dental radiography of the entire jaw and facial structure, starting from the teeth to the Temporo Mandibular Joint (TMJ) and covering the entire dental arch. The main advantage is that it captures an image of the entire tooth in one exposure. However, the duration of time required for one panoramic exposure can vary between 10 to 20 seconds, depending on the type of equipment used. X-ray exposure during a panoramic examination can be problematic because sensitive areas such as the thyroid gland and eyes adjacent to tooth structures also receive radiation exposure. The eyes or orbits are the human sense of sight which functions to detect light, focus objects and produce images that are directly transmitted to the brain. The patient on the Panoramic examination did not use Eye Radiation Protection Equipment for the orbit, namely Pb glasses, while the eye organ was close to the dental arch which most likely received radiation exposure. Based on these reasons, radiation protection is very necessary to protect the eye organs. In accordance with the aim of radiation protection, namely limiting the opportunity for stochastic effects and preventing non-stochastic effects.

Orbital protection devices should be comfortable and safe for use by patients and can be used on all patients, both adults and children. This orbital protection device is able to reduce the radiation dose received by the area around the eyes during panoramic examinations, so it is hoped that all hospital installations will have this eye or orbital protection device. Therefore, the author wants to innovate another tool from Pb glasses in the form of an eye mask or sleeping mask. Hospitals, especially Radiology Installations, are also one of the diseases that are of concern in one of the Health Transformation Pillars of the Indonesian Ministry of Health, namely the second Pillar of Referral Service Transformation, this pillar focuses on equal distribution of referral services through optimizing the national hospital network.

Methods

This study uses a quantitative method with an experimental approach. Eye radiation protection devices are made and designed, then radiation dose measurements are carried out around the phantom eye head using a pocket dosimeter. The data collected is in the form of data documentation and from the suitability of the device, which can be assessed with the following characteristics. (Very poor, score 1-39 criteria ≤ 25 %, Poor good score 31-60 criteria 26% - 50%, Fairly good score 61-90 criteria 51% - 75%, and Very good 91-120 criteria 76% - 100%)

Results

This research was carried out at the Radiology Installation of Cepu Regional Hospital between October and December 2023. The Radiology Installation of Cepu Regional Hospital has 1 unit of Computed Tomography Scanning (CT SCAN) modality, 1 unit of conventional modality, 1 unit of Ultrasonography (USG) modality, 1 unit of Computed Radiography (CR) and 1 unit of Panoramic modality.

The design of this Eye Radiation Protection Device is shaped like an eye patch for a panoramic examination which is attached around the head in the eye or orbital area, where the aim of this Eye Radiation Protection Device is to protect the eyes and reduce the dose of radiation exposure received by the eye or orbit. This Eye Radiation Protection Device is 79 cm long, the width at the eye patch is 8.5 cm, and the width at the right and left ends is 6 cm.

This Eye Radiation Protection Device consists of two components, a layer and an adhesive. The layer consists of several layers: the first outer layer is made with a length of 7 cm and a width of 8.5 cm with cotton fabric which has a soft texture so that the patient is comfortable and does not irritate the skin. The second layer is a lead (Pb) coating layer or a barrier between the outer layer, namely cotton fabric and lead (Pb). The third is that the main layer is lead (Pb) which functions as radiation protection that can be received by the eye or orbit and has a thickness of 1 mm.

This orbital design tool was carried out on three patients who underwent panoramic examinations. From the results of the radiographs it was found that there were no artifacts in the radiographs when using eye radiation protection devices. The following are the results of radiographs on panoramic examinations using orbital protection devices when panoramic examination was carried out.

Functional test results were carried out by measuring the radiation dose around the eyes of the head phantom using a pocket dosimeter during panoramic examination before and after using the design tool. Radiation dose measurements were carried out using varying exposure factors of 70 kV, 76 kV, and 86 kV with the same mAs, namely 10 mA. Based on the functional tests carried out, the results of measuring the radiation dose in the area around the head phantom eye were obtained before and after using the Eye Radiation Protection Device. Each measurement of the radiation dose around the eyes before and after using the Eye Radiation Protection Device is carried out three times to obtain an average of the measurement results, where for each of the three measurements the position of the pocket dosimeter is always in the same area, namely glued transversely above the earlobe. and the front end is parallel to the outer canthus of the head phantom eye.

Figure 1 Panoramic aircraft at the Radiology Installation at Cepu Regional Hospital

Figure 2 Design of Eye Radiation Protection Equipment

Figure 3 Layers of Eye Radiation Protection Devices

Information :

1. Cotton cloth lining
2. Flannel fabric lining
3. Lead layer (Pb)
4. Flannel fabric lining
5. Cotton fabric lining

Figure 4 Results of Panoramic Examination Radiograph (First Patient)

Figure 5 Results of Panoramic Examination Radiograph (Second Patient)

Figure 6 Results of Panoramic Examination Radiograph (Third Patient)

Figure 7 Third Area for Radiation Dose Measurement Around the Eyes of the Head Phantom

Information :

1. Outer canthus
2. Third area measurement

The results of radiation dose measurements can be seen in table 1 and table 2.

Table 1 Results of Radiation Dose Measurements Around the Eyes of the Head Phantom

Exposure Factor (kV)	Radiation Dose (mSv)							
	Before (x_A)				After (x_B)			
	x_{A1}	x_{A2}	x_{A3}	$\overline{x_A}$	x_{B1}	x_{B2}	x_{B3}	$\overline{x_B}$
70	0,1	0,05	0,1	0,08	0	0	0	0
76	0,2	0,1	0,2	0,17	0	0	0	0
86	0,3	0,2	0,3	0,27	0,01	0	0	0,003

Information :

xA: Results of radiation dose measurements before using the device

xA1: First measurement result before using the tool

xA2: Second measurement result before using the tool

xA3: Third measurement result before using the tool

x̅A: Average of the results of the three measurements before using the tool

xB: Results of radiation dose measurements after using the device

xB1: First measurement result after using the tool

xB2: Second measurement result after using the tool

xB3: Third measurement result after using the tool

x̅B : Average of the results of the three measurements after using the tool

Table 4.2 Difference in Average Radiation Doses Before and After Using Eye Radiation Protection Devices

Exposure Factor (kV)	$\overline{x_A}$ (mSv)	$\overline{x_B}$ (mSv)	$\overline{x_A} - \overline{x_B}$ (mSv)	Precentage (%) $\overline{x_A} - \overline{x_B}$
70	0,08	0	0,08	100%
76	0,17	0	0,17	100%
86	0,27	0,003	0,26	99%

Information :

$\overline{x}_A$: Average the results of the three measurements before using the Tool

$\overline{x}_B$: The average of the results of the three measurements after using the tool

$\overline{x_A} - \overline{x_B}$: Difference in average radiation dose before and after using the device

Based on data From table 1, there are different radiation doses from the three measurements before and after using Eye Radiation Protection Equipment and at the same exposure factor settings. Additionally, on tabel 2 There is a change in the average radiation dose before and after using the Eye Radiation Protection Device which can be seen in the diagram in Figure 8

The diagram in Figure 8 shows that there is a decrease in radiation dose before and after using Eye Radiation Protection Devices. When setting an exposure factor of 70 kV, the average radiation dose before using the Eye Radiation Protection Device is 0.08 mSv and after using the Eye Radiation Protection Device is 0 mSv, resulting in a reduction in radiation dose of 0.08 mSv with a percentage of the ability to reduce the radiation dose. by 100%.

When setting an exposure factor of 76 kV, the average radiation dose before using the Eye Radiation Protection Device is 0.17 mSv and after using the Eye Radiation Protection Device is 0 mSv, resulting in a reduction in radiation dose of 0.17 mSv with a percentage of the ability to reduce the radiation dose. by 100%.

Meanwhile when setting an exposure factor of 86 kV, the radiation dose before using the Eye Radiation Protection Device is 0.27 mSv and after using the Eye Radiation Protection Device is 0.003 mSv, resulting in a dose reduction of 0.26 mSv with a percentage ability to reduce the radiation dose of 99%. .

The results of statistical tests using the Kruskal-Walls test showed the following results:

Interpretation of the results of the Kruskal-Wallis non-parametric statistical test on pre-test and post-test variables using kV 70, kV 86, and kV 76 is as follows:

1. kV 70:

- The significance value (0.034) is less than the specified significance level (0.05), so there is a difference significant difference between radiation doses before and after using Eye Radiation Protection Devices at kV 70.
- The mean rank at kV 70 is higher after using Eye Radiation Protection Devices, indicating an increase in radiation dose.

2. kV 86:

- The significance value (0.043) is also less than 0.05, indicating a significant difference between the radiation dose before and after using the Eye Radiation Protection Device at kV 86.
- The mean rank at kV 86 was also higher after using the Eye Radiation Protection Device, indicating an increase in radiation dose.

3. kV 76:

- The significance value (0.121) is greater than the specified significance level (0.05), so there is no significant difference between the radiation dose before and after using the Eye Radiation Protection Device at kV 76.

Even though it is not significant, the mean rank value at kV 76 is still higher after using the Eye Radiation Protection Device, but the difference does not reach the significance level. The use of Eye Radiation Protection Devices has a significant impact on radiation dose at kV 70 and kV 86, but does not show a significant difference at kV 76. Although at kV 76 there is an increase in the mean rank after using Eye Radiation Protection Devices, this is not statistically significant enough. It can be determined that kV 76 is the best kV setting for panoramic examinations and this radiation protection design tool for the eyes or orbit is an Eye Radiation Protection Device which plays a very important role in reducing radiation exposure to the patient's eyes during the panoramic examination process.

The results of the performance test for eye radiation protection equipment were carried out by filling in a cross (X) on the questionnaire sheet which aims to determine the level of satisfaction of respondents regarding the use of eye radiation protection equipment which has been carried out by three patients who previously underwent panoramic tomography examinations using eye radiation protection equipment and three radiographer at the Radiology Installation at Cepu Regional Hospital. The questionnaire with patient respondents contains statements regarding patient comfort using eye radiation protection equipment and design of eye radiation protection equipment, while the questionnaire with radiographer respondents contained statements about the quality of panoramic tomography examination radiographs using eye radiation protection equipment and design of eye radiation protection equipment. The results of the cross (X) are coded to classify the respondent's answers. The code used is number 4 if the answer is very good, number 3 if the answer is good, number 2 if the answer is not good and number 1 if the answer is very bad.

Figure 8 Diagram of radiation dose around the eyes in the head phantom

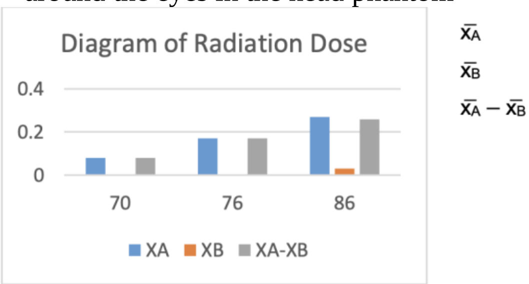

Table 3 Kruskal-Walls Test Calculation Results

variabel	p-value	Mean Rank	
		pre	**post**
Pre-post test kV 70	0,034	5.00	2.00
Pre-post test kV 76	0,121	4.50	2.50
Pre-post test kV 86	0,043	5.00	2.00

From filling out the questionnaire, the results obtained are presented in table 4 and table 5 below.

Table 4 Results of the Patient Statement Questionnaire

No	Statement	Respondent		
		1	2	3
1	Feel comfortable when using the innovative design of eye radiation protection equipment during panoramic examinations.	3	2	3
2	Does not cause irritation or allergies around the eyes due to wearing eye radiation protection equipment	4	4	4
3	Feel protected from exposure to X-ray radiation after using eye radiation protection equipment	4	4	4
4	Had no difficulty in using and removing	3	3	4
5	The design of the innovative eye radiation protection device for panoramic examination is very simple and attractive.	3	2	3
	Number of Assessments	17	15	18

Table 5. Results of the Radiographer Statement Questionnaire

No	Statement	Respondent		
		1	2	3
1	The use of innovative designs for eye radiation protection equipment in panoramic examinations does not interfere with the panoramic examination procedure.	4	3	3
2	Does not cause artifacts in radiograph images caused by the design of eye radiation protection equipment in panoramic examinations.	3	2	3
3	The use of innovative designs for eye radiation protection equipment in panoramic examinations does not affect the quality of the radiograph image.	3	3	3
4	The use of innovative designs for eye radiation protection equipment in panoramic examinations does not reduce the medical information that doctors use to make diagnoses.	4	4	3
5	The design of the innovative eye radiation protection device for panoramic examination is very simple and attractive	3	3	2
	Number of Assessments	17	15	14

From this data, the results of the questionnaire can be calculated using the following formula:

$$\frac{\sum \text{score from data collection}}{\sum \text{number of criteria scores}} \times 100\%$$

The percentage of equipment feasibility level is:

$$= \frac{96}{120} \times 100\%$$
$$= 80\%$$

Discussion

Based on the radiographs of three patients who used eye radiation protection devices on panoramic examination, there were three radiographs that did not contain artifacts. Test results of eye radiation protection equipment before and after using eye radiation protection equipment measured the radiation dose received by setting an exposure factor of 70 kV, the average radiation dose before using eye radiation protection equipment was 0.08 mSv and after using eye radiation protection equipment of 0 mSv, resulting in a reduction in radiation dose of 0.08 mSv with a percentage ability to reduce radiation dose by 100%. Setting the exposure factor to 76 kV, the average radiation dose before using eye radiation protection equipment is 0.17 mSv and after using eye radiation protection equipment is 0 mSv, resulting in a reduction in radiation dose of 0.17 mSv with a percentage ability to reduce radiation dose by 100%. Meanwhile, setting the exposure factor to 86 kV, the radiation dose before using eye radiation protection equipment was 0.27 mSv and after using eye radiation protection equipment was 0.003 mSv, resulting in a dose reduction of 0.26 mSv with a percentage of the ability to reduce radiation dose, namely 99%.

The threshold dose for eye lenses is estimated to be 0.5 Gy or 500 mSv (ICRP, 2011). Meanwhile, the radiation dose received by the area around the eyes before using radiation protection devices for the eyes setting the exposure factor 70 kV = 0.08 mSv, 76 kV = 0.17, 86 kV = 0.27 mSv, so it is still within safe limits. However, radiation protection is very necessary in accordance with the aim of radiation protection, namely limiting the opportunity for stochastic effects and preventing non-stochastic effects. Therefore, researchers designed a radiation protection device that succeeded in reducing or reducing the radiation dose around the eyes by up to 100%.

Meanwhile, the results of this research were tested using the Kruskall-Wallis non-parametric statistical test, the results obtained on the pre-test and post-test variables kV 70, resulting in a significance value of 0.034 <0.05, indicating a significant difference. Thus, the use of radiation protection equipment at 70 kV has a real impact on the radiation dose, with a difference in dose before and after of 0.08 msv. Analysis at kV 86 also showed a significant difference (sig 0.043 <0.05) with a dose difference of 0.26 msv, while at kV 76 did not show a significant difference (value 0.121 >0.05) with a dose difference of 0.17 msv. These results indicate that radiation protection devices at 70 kV have the highest effectiveness, which can be attributed to the use of low kV which produces consistently lower radiation doses. However, further attention is needed regarding kV 86 and kV 76 to understand the factors that might influence the results of radiation dose when using eye radiation protection devices.

The assessment questionnaire obtained a respondent score of 80%. By category The percentage of equipment suitability level, the level of satisfaction of respondents with eye radiation protection equipment is in the very good category with a value range of 91–120 (Sugiyono, 2015). From these results, it can be concluded that eye radiation protection equipment is very suitable for use during panoramic examinations, as well as being feasible for these devices to help reduce the radiation dose received by the eye organs during panoramic examinations.

Conclusion

The design of this eye radiation protection device functions to reduce the radiation dose around the eye during a panoramic examination which is shaped like an eye patch that surrounds the patient's head. Average radiation dose around the eyes of the head phantom at different exposure factor settings with the same mAs, namely the radiation dose received in the area around the eyes before using eye radiation protection equipment at an exposure factor setting of 70 kV =0,08 mSv, 76 kV = 0,17, 86 kV = 0,27 mSv. Meanwhile, the radiation dose received by the area around the eyes after using eye radiation protection equipment at exposure factor settings of 70 kV = 0 mSv, 76 kV = 0.86 kV = 0.003 mSv, whereas from the Kruskall-walls statistical test pre-test and post test kV 70 shows a significant value of 0.034 <0.05, kV 76 does not show a significant value of 0.121 > 0.05, kV 86 shows a significant value of 0.043 <0.05. The design of this eye radiation protection device has succeeded in reducing or reducing the radiation dose around the eyes by up to 100%. Meanwhile, the level of feasibility of the tool has a respondent score of 80%.

Suggestion

The best way to measure the radiation dose around the eye area using a radiation protection measuring instrument that is capable of measuring in smaller units such as a thermoluminescence dosimeter (TLD), namely µSv.

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