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Wedge Filter Variation on *Wedge Factor* in Patients Cancer Breast in Sub Installation Radiotherapy RSUP Prof. Dr. I.G.N.G Ngoerah

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The aim of the study was to determine the effect of irradiation time, the percentage of the maximum dose, the distribution of doses at the center point, and *the wedge factor* on *wedge filter variations*. The research method uses *a wedge filter* to measure irradiation time, maximum dose percentage, dose distribution at the center point, and *the wedge factor*. *Wedge* value *factor* without *wedge*, *wedge* 15 °, *wedge* 30°, *wedge* 45° and *wedge* 60° of 1.000, 1.0059, 1.0102, 1.0137, and 1.0092 respectively. The results of the maximum dose percentage values without *wedge*, *wedge* 15 °, *wedge* 30 °, *wedge* 45° and *wedge* 60° were 106.76%, 106.80%, 106.79%, 106.85%, and 106.81%,

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respectively. Conclusion is the value of *the wedge factor* does not comply with the ICRU standard but the percentage of the maximum dose is in accordance with the *International Commisson on Radiation Units* (ICRU) standard, there is a *wedge effect factor,* and irradiation time on the variation of *the wedge filter*, but there is no effect of the maximum dose percentage and distribution at the center point on the variation of *the wedge filter*.

Keywords: Wedge filter; wedge factor; breast cancer; maximum dose; exposure time.

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1. INTRODUCTION

Breast cancer is a type of malignant tumor that develops in breast cells. According to the Global Center Observatory in 2012, the highest incidence of breast cancer was in Southeast Asia, namely in Indonesia with 48,998 cases, followed by the Philippines with 18,327 cases, Thailand with 13,652 cases, and Malaysia with 5,410 cases. Breast cancer is treated with high-energy radiation which is called radiotherapy [1]. The radiation used in radiotherapy can be internal or external. Internal radiation therapy (brachytherapy) is a therapy in which a radiation source is inserted into the body. External radiation therapy is a therapy where the radiation source is outside the body, which can be done using radiotherapy tools such as Co-60 teletherapy, Linear Accelerator (LINAC), Gamma Knife, and Cyberknife [2]. One of the roles and responsibilities of a medical physicist is to plan the amount of dose, the direction of radiation irradiation and the use of wedge filters in radiotherapy services. One of the efforts made to minimize damage to healthy tissue due to dosing and form a more homogeneous dose distribution in areas with an uneven surface such as the breast area is with the help of a wedge filter. Wedge filters are usually made of solid material in the form of right-angled triangular prisms which have a high absorption of ionizing radiation, while the function of the wedge filter is to change the radiation emission with the aim of optimizing the distribution of the absorbed dose received by the patient, so that the shape of the isodose curve will be modified [3].

In the Radiotherapy Sub-Installation of Prof. Hospital. Dr. I.G.N.G Ngoerah, services for breast cancer patients using tangential techniques. The tangential technique is an irradiation technique from two directions, namely the tangential technique mid-lateral and medial-lateral. According to the inclination of the right breast surface, the irradiation direction used is 60° and 238° while the left breast surface, the irradiation direction used is 300° and 122°. In the process of calculating the time of irradiation of breast cancer patients is done using Treatment Planning System (TPS). The dose for PTV must be in accordance with the cancer target because the dosage is regulated in the *International Commisson on Radiation Units* (ICRU) *Report* 50 and 62, namely if it is less than 95%, irradiating the cancer is ineffective, while more than 107% will harm surrounding organs. The Co-60 teletherapy aircraft has wedge filter variations, namely 15°, 30°, 45° and 60° which are default from the manufacturer and have become the Standard for Radiotherapy Services in Indonesia. A Comparison of the dose received by breast cancer using a *wedge filter* variation with no *wedge filter* is called the *wedge factor*. The Co-60 teletherapy device, which is the default from the manufacturer, has a slice factor using one direction of the irradiation field, namely a 15° slice filter value of 0.669; a 30° wedge filter of 0.787; wedge filter 45° of 0.683 and wedge filter 60° of 0.550 (source Prof. Dr. IGNG Ngoerah Hospital).

1.1 Radiotherapy

Radiotherapy is a medical procedure using ionizing radiation to kill cancer cells as much as possible with minimal damage to surrounding normal cells. The dose given to the target organ of cancer in radiotherapy must be precise by trying to keep the dose to other parts of the body as low as possible. Radiotherapy is divided into 2, namely Brachytherapy and Teletherapy. Brachytherapy (close-up radiation) is a method of radiation therapy by placing a radiation source near the cancer volume area. Meanwhile, teletherapy is radiation therapy that uses a radiation source that is at a certain distance from the body [4-6].

1.2 Co-60 Teletherapy Device

Teletherapy device is an external therapy device that is widely used in hospitals that use radioactive substances. The Co-60 teletherapy device emits gamma radiation which can be used for cancer treatment [7]. Gamma rays have great penetrating power and are more sensitive in

killing cancer cells in the body without having to go through surgery. The characteristics of gamma rays are massless, uncharged, in the form of electromagnetic waves or photons, and have very high penetrating power [8].

1.3 Treatment Planning System (TPS)

Treatment Process The Planning System is carried out in 2 dimensions (2D) using image data from the simulator. There are two targets of irradiation in TPS, namely PTV which is the main target of cancer, and OAR which are healthy organs around the cancer that are at risk of exposure to radiation. The dosing of PTV is related to the principle of optimization where the dosing of the target cancer must be optimized, therefore the dosing of PTV radiation is regulated in the *International Commisson on Radiation Units* (ICRU) *Report* 50 and 62, namely (95-107)% [9].

1.4 Wedge Filters

The *wedge filter* functions to change the radiation beam with the aim of optimizing the absorbed dose distribution in the form of a modified isodose curve. *Wedge filters* are made of solid materials that have a high absorption of radiation. In general, the materials used for *wedge filters* are aluminum, copper, brass, lead, and cerrobend. The effect of the *wedge filter* is one of the efforts in the radiotherapy method to homogenize the absorbed dose distribution on the target volume [10]. The *wedge factor* is the ratio of the absorbed dose of irradiation using a *wedge filter* and without a *wedge filter* at a point in the center of the radiation beam. The wedge value factor can be used to estimate the absorbed dose rate received by the patient at the time of irradiation using the aid of a *wedge filter* [11]. The factory-compatible Co-60 teletherapy kit has a *wedge factor* with a 15° *wedge filter* value of 0.669; *wedge filter* 30° of 0.787; *wedge filter* 45° of 0.683 and *wedge filter* 60° of 0.550 (source Prof. Dr. I.G.N.G Ngoerah Hospital).

2. METHODS

2.1 Research Design

This research is analytic quantitative observational research carried out by the process of analyzing the relationship between the test variables, namely the dependent variable and the independent variable. Analysis of this relationship requires tools in the form of data analysis using SPSS to perform multivariate statistical tests.

2.2 Research Population

The population in this study were patients with breast cancer at Prof. Dr. I.G.N.G Ngoerah.

2.3 Inclusion and Exclusion Criteria

This research was conducted on 30 right breast cancer patients and 30 left breast cancer patients at the Radiotherapy Sub-Installation of Prof. Hospital. Dr. I.G.N.G Ngoerah. In this study, the selection of breast cancer patients with inclusion criteria was to complete the biopsy results which stated malignant cancer while the exclusion criteria were data that were not used in breast cancer patients who had been operated on because of an uneven surface that did not need wedge filter assistance.

2.4 Research Procedures

The stages of this research are as follows: first, the patient will be scheduled for a simulation, the simulation process is carried out on the simulator for the imaging results to be sent to TPS for imaging by a radiation oncologist specialist in the form of cancer targets and OAR. Furthermore, the medical physicist will perform calculations on the TPS using several parameters including the dose per fraction of 2Gy, the field area used is 5 cm ×16 cm, and the wedge filter variations used are without wedge, 15°, 30°, 45° and 60°. From each calculation, irradiation time, maximum dose percentage, and distribution at the center point and wedge will be obtained factor. The calculation results will be compared with the default from the manufacturer and *International Commisson on Radiation Units* (ICRU) *Reports* 50 and 62.

2.5 Data Analysis

Data obtained from measurement results such as irradiation time, maximum dose percentage, dose distribution at the center point, *wedge factor*, and *wedge filter* (without filter, 15°, 30°, 45°, 60°), will be compared with the default from the manufacturer and *International Commisson on Radiation Units* (ICRU) *Reports* 50 and 62. To analyze the data, statistical tests were carried out using SPSS software version 26, namely the one-sample t-test, anova test, and manova test. The one-sample t-test is a statistical test to compare one sample of measurement results

against two groups. In this study, the statistical t-test was used to determine the value of the variables against the standards set by Prof. RSUP. Dr. I.G.N.G Ngoerah. The anova test is a statistical test to compare one measurement variable against more than two groups. In this study, the anova test was used to determine the effect of the *wedge factor* to *wedge filter* (without filter, 15°, 30°, 45°, 60°). If it is significant <0.05, it means that there is a wedge effect factor with wedge filters. The manova test is a statistical test to compare more than one measurement variable against two or more two groups. In this study the manova test was used to determine the effect of irradiation time, the percentage of the maximum dose, the distribution of doses at the center point, and the *wedge factor* to *wedge filter* (without filter, 15, 30, 45, 60). If it is significant <0.05, it means that there is an effect of irradiation time, the percentage of the maximum dose, the distribution of doses at the center point, and the wedge factors that affect the *wedge filter* (without filter, 15, 30, 45, 60).

3. RESULTS AND DISCUSSION

Based on the results of research conducted from TPS on 30 patients with right breast cancer and 30 patients with left breast cancer with wedge filter variations at the Radiotherapy Sub-Installation of Prof. Hospital. Dr. I.G.N.G Ngoerah obtained secondary data in the form of the irradiation time value, the percentage of the maximum dose, and the distribution of doses at the central point. TPS display is shown in Fig. 2 and Fig. 3.

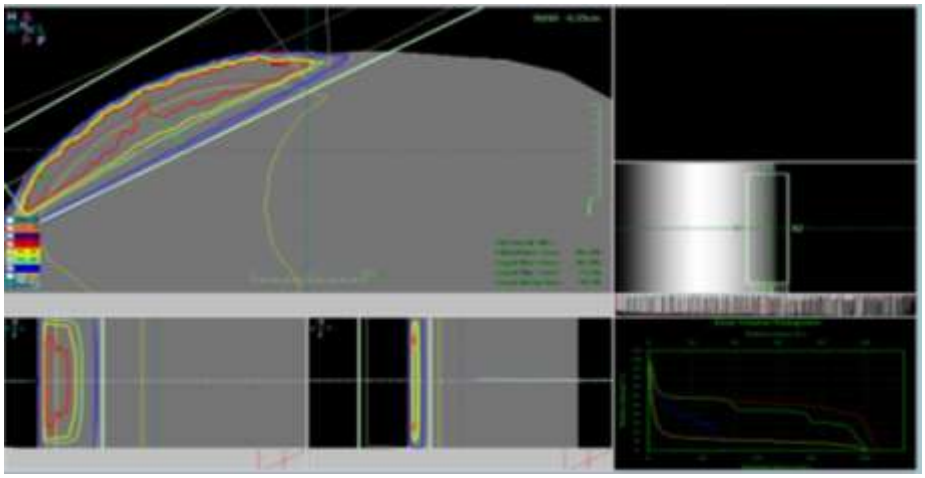

Fig. 1. Distribution of right breast cancer in TPS

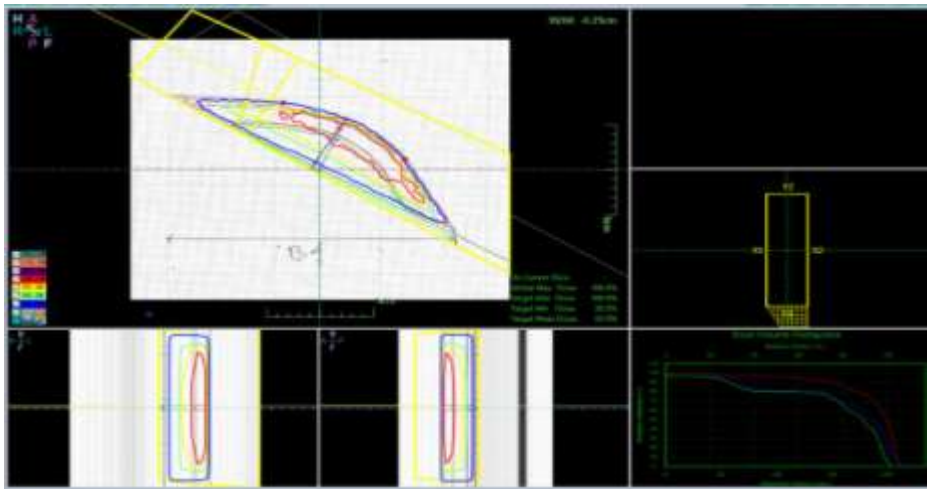

Fig. 2. Distribution of left breast cancer in TPS

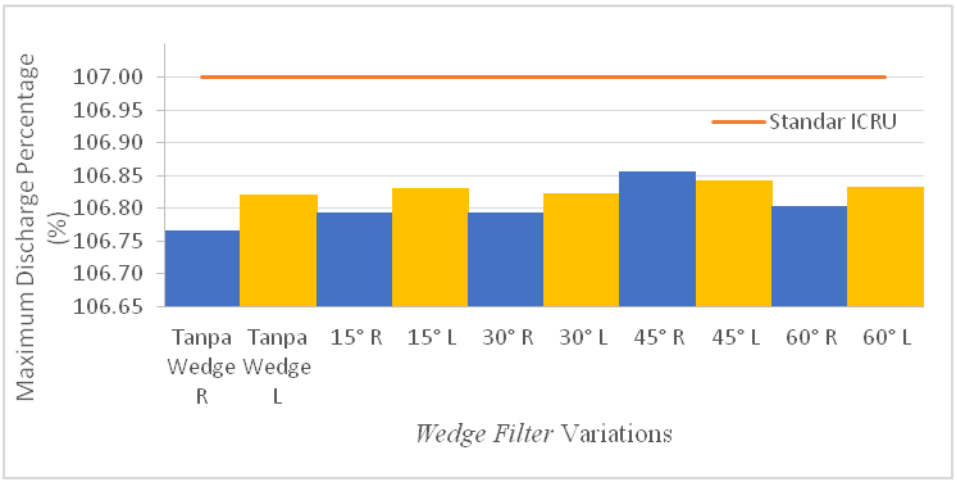

Fig. 3. The relationship between the percentage of the maximum dose and the variation of the filter wedge

Based on the calculation value of TPS data based on 30 patients with right breast cancer and left breast cancer, a graph of the maximum percentage comparison according to the *International Commission on Radiation Units* (ICRU) standard *Reports* 50 and 62 and *wedges factor* based on default standards from the manufacturer. The comparison chart can be seen in the following graph.

a Graph of Maximum Dose Percentage Comparison for Each Patient in Breast Cancer

Based on the graph in Fig. 4, the percentage of the maximum dose for the wedge filter variation for right breast cancer and left breast cancer is carried out by an average of each wedge filter variation used. For right breast cancer, maximum dose percentage value without wedge, wedge 15°, wedge 30°, wedge 45 °, wedge 60° each of 106.76%, 106.80%, 106.79%, 106.85%, 106.81%. For left breast cancer, maximum dose percentage value without wedge, wedge 15 °, wedge 30 °, wedge 45 °, wedge 60 ° each of 106.82%, 106.83%, 106.82%, 106.84%, 106.83%. From the overall results the percentage of doses in right and left breast cancer is still within normal limits because it does not exceed the International Commission on Radiation Units (ICRU) standard Report 50 and 62 are more than 95% and less than 107%.

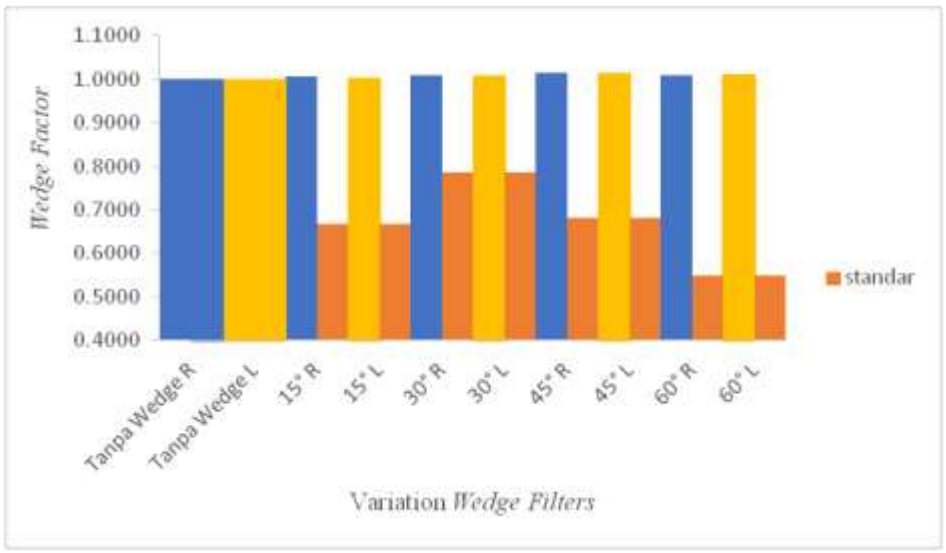

Fig. 4. Wedge relationship factor against wedge filter variation

b. Wedge Comparison Chart Factor on Wedge Filter Variation in Breast Cancer

Based on the graph in Fig. 4, wedge The factor for variations in the wedge filter for right breast cancer and left breast cancer was carried out by an average of each variation of the wedge filter used. For right breast cancer, wedge score factor without wedge, wedge 15°, wedge 30°, wedge 45°, wedge 60° each of 1.000, 1.0059, 1.0102, 1.0137, 1.0092. For left breast cancer, wedge score factor without wedge, wedge 15°, wedges 30°, wedge 45°, wedges 60° each of 1.000, 1.0049, 1.0087, 1.0146, 1.0088. From this study, the wedge value factor exceeds that of the manufacturer, due to calculations at TPS for this study using a two-way tangential technique of irradiation field in breast cancer, while compared with a standard wedge the factory default factor uses one direction of the irradiation field, namely 0°.

Table 1. Wilcoxon maximum dose percentage test results in right breast cancer

Hypothesis Test Summary

No.	Null Hypothesis	Sig.
1.	No *wedges*	0.064
2.	*Wedge filters* 15°	0.403
3.	*Wedge filters* 30°	0.268
4.	*Wedge filters* 45°	0.195
5.	*Wedge filters* 60°	0.501

Table 2. Wilcoxon maximum dose percentage test results in left breast cancer

Hypothesis Test Summary

No.	Null Hypothesis	Sig.
1.	No *wedges*	0.596
2.	*Wedge filters* 15°	0.795
3.	*Wedge filters* 30°	0.957
4.	*Wedge filters* 45°	0.364
5.	*Wedge filters* 60°	0.717

Table 3. Wilcoxon test results wedge factors in right breast cancer

Hypothesis Test Summary

No.	Null Hypothesis	Sig.
1.	*Wedge filters* 15°	0.000
2.	*Wedge filters* 30°	0.000
3.	*Wedge filters* 45°	0.000
4.	*Wedge filters* 60°	0.000

Table 4. Wilcoxon test results wedge factors in left breast cancer

Hypothesis Test Summary

No.	Null Hypothesis	Sig.
1.	*Wedge filters* 15°	0.000
2.	*Wedge filters* 30°	0.000
3.	*Wedge filters* 45°	0.000
4.	*Wedge filters* 60°	0.000

Based on the results of calculations performed on breast cancer patients, statistical tests were then carried out, namely the one-sample t-test, anova test and manova test . Data requirements before being tested statistically, the data must be normalized so that the data results are normally distributed. From the results of the normalization test that has been carried out, the research data used is not normally distributed. Where from the data that is not normally distributed, statistical tests will then be carried out using the *t-test nonparametric*.

The following is a statistical test used.

a. Test T- Test Nonparametric (Wilcoxon Test)

From the research data, a normalization test has been carried out, all data is not normally distributed for the percentage of maximum dose and *wedge factor* in breast cancer patients will then be tested *t-test nonparametric* (Wilcoxon test). From the dose percentage data, the median value of 30 patients was 106.85 and for *wedge, the standard factor* from the manufacturer using one-way irradiation field is the value of *wedge filter* 15° of 0.669, *wedge filter* 30° of 0.787, *wedge filter* 45° of 0.683 and *wedge filter* 60° of 0.550. The following is a Wilcoxon test of percentage dose and *wedge Factors* in breast cancer.

a. Anova test

From the research data that has been normalized, all data is not normally distributed for variations of *wedge filter* to *wedge factors* in breast cancer patients will then be carried out with an anova test (Krusal-Wallis). The following is an anova test (Krusal-Wallis) of the variation of *the wedge filter* against *the wedge Factors* in breast cancer.

The results of the anova test for right breast cancer and left breast cancer are shown in Table 5. For right breast cancer, the results are sig. *wedges factor* of 0.000 <0.05, then there is a

Table 5. Anova test results for wedge filter variation against wedge factors in breast cancer

Test Statistics	
	Wedge Factor
Sig right.	0.000
Left sig.	0.000

Table 6. Manova test results of wedge filter variation on exposure time, percentage of maximum dose, dose distribution at center point and wedge factors in breast cancer

Test Statistics				
	Exposure Time	**Maximum Dose Percentage**	**Dosage Distribution at Central Point**	***Wedge Factor***
Sig right.	0.000	0.210	0.354	0.000
Left sig.	0.000	0.966	0.385	0.000

difference in the variation of *the wedge filter* to *the wedge factor*. As for left breast cancer, the results of the sig. *wedges factor* of 0.000 <0.005, then there is a difference in the variation of *the wedge filter* to *the wedge factor*.

b. Manova test

From research data that has been normalized, all data is not normally distributed from irradiation time, maximum dose percentage, dose distribution at the center point, *wedge factor* on the variation of *the wedge filter* in breast cancer patients will then be carried out by the manova test (Krusal-Wallis). The following is the manova test (Krusal-Wallis) from irradiation time, maximum dose percentage, dose distribution at the center point, *wedge Factors* for *wedge filter variation* in breast cancer.

The results of the manova test for right breast cancer and left breast cancer are shown in Table 6. For right breast cancer, the results are sig. irradiation time of 0.000 <0.05, then there is an effect of irradiation time on the *wedge filter variation*. The thicker the wedge filter used, the longer the irradiation time required. The sig value result. the percentage of the maximum dose is 0.210> 0.05, so there is no difference in the percentage of the maximum dose with the *wedge filter variation*. The sig value result. the dose distribution at the center point is 0.354> 0.05, so there is no difference in the dose distribution at the center point to the variation of *the wedge filter*. The sig value result. *wedges factor* of 0.000 <0.05, then there is a difference in *wedge factor* on *wedge filter variations.*

For left breast cancer, the results are sig. irradiation time of 0.000 <0.05, then there is an effect of irradiation time on the *wedge filter variation*. The sig value result. the percentage of the maximum dose is 0.966> 0.05, so there is no difference in the percentage of the maximum dose with the *wedge filter variation*. The sig value result. the dose distribution at the center point is 0.385> 0.05, so there is no difference in the dose distribution at the center point to the variation of *the wedge filter*. The sig value result. *wedges factor* of 0.000 <0.05, then there is a difference in *wedge factor* on *wedge filter variations*.

4. CONCLUSION

Based on the results of the study it can be concluded that the *wedge value factor* without *wedge*, *wedge* 15°, *wedge* 30 °, *wedge* 45° and *wedge* 60 ° respectively 1.000, 1.0059, 1.0102, 1.0137, and 1.0092. The maximum dose percentage values without *wedge*, *wedge* 15 °, *wedge* 30 °, *wedge* 45 ° and *wedge* 60 ° were 106.76%, 106.80%, 106.79%, 106.85% and 106.81%, respectively. *Wedge* value *factor* is not in accordance with the ICRU standard but the percentage of the maximum dose is in accordance with the ICRU standard. The results of the anova test show that there is an effect of wedge filter variations (without *wedge*, *wedge* 15°, *wedge* 30°, *wedge* 45° and *wedge* 60°) on the wedge factor. The results of the manova test show the effect of irradiation time and *wedge factor* on the *wedge filter variation* , but there is no effect of the maximum dose percentage and distribution at the center point on the *wedge filter variation*.

CONSENT

It is not applicable.

ETHICAL APPROVAL

This research has been examined according to ethical clearance from the Research and Development Ethics Commission FK Unud/Sanglah Hospital with number 1143/UN14.2.2.VII.14/LT/2023 on 03 May 2023.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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