Characteristic and quality control test in sector collimator gamma knife perfexion at Siloam hospital

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Abstract. In this study conducted to evaluate the collimator 4 mm, 8 mm, 16 mm to determine the level of precision Gamma Knife Perfexion there three years and eight months has not carried out measurements after the first year and verify the alignment of sector 1-8. Measurement with three axes (x-axis, y-axis, z-axis) using the film Gafcromic EBT-3, which will be signaled to a central point in the film to be measured and given a dose of 5 Gy for 10 minutes and then scanned and analyzed using ImageJ softwere 1.50 and dose rate in film comparison with measurent dose rate using electrometer. Alignment of Patient-Positioning System (PPS) with Radiation Focal Point (RFP) determination of quality control testing each collimator 4 mm in the standard test with < 0.1 and > 0.4 mm passive voice AAPM 54. The results of the standard are still in conformity item 0.21 mm for 4 mm and corelasi dose rate film and measurent using electrometer collimator 4 mm = 0.965, 8 mm = 0.964, 16 mm = 0.959.

1. Introduction

Stereotactic Radiosurgery is the best option in brain disorder treatment by one-day session dosage addressing. The archieve focus passive voice into something of the brain to cure disorder such as the tumor or functional disorder .One of the Stereotactic Radiosurgery device to cure tumor or functional disorder is Gamma Knife with its fifth generation called Gamma Knife Perfection. This Gamma Knife Perfection is better for it can focus the source of radiation to a tumor or functional disorder with 0,15 mm accuracy. Gamma Knife Perfection treatment is available in Indonesia since 2012. However, the cost is very expensive (Petti L Paula,2006).

Leksell Gamma Knife Perfection is produced on 2006, which is redesigned based on previous model (B and C with 201 Collimator). Gamma Knife Perfection has 192 collimator and Cobalt-60 source which is aligned with the collimation system. Both levels of dosage addressed through every collimator and biological effect passed by is small however, 192 collimator will lead them to focus point and will have high dosage. This radiation is called Gamma Knife Perfection radiation technique which is beneficial for normal tissue.

To point out to focus point, Gamma Knife Perfection has the stereotactic frame to achieve high precision. This stereotactic frame is put on patient head, and then the referential Cartesian coordinate known as Leksell coordinate system is set up. Patient has the an image of skeleton which attached by one of the equipment according to clinical MRI ½ Tesla, CT-Scan, DSA. These images are used by treatment planning system to find target in the coordinate chamber. Once the target's coordinate has

been found, the patient can somehow position into a unit to make the target right into radiation focus point.

Each cobalt-60 source is attached on each sector and moved by a motor. Each sector has collimator sized 4 mm, 8 mm, and 16 mm and each sector can be blocked or sealed (Maitz AH, et). With the advancement of collimator size precision, PPS (Positioning Patient System) and geometrical, on Gamma Knife Perfection (where the Cobalt=60 source collimator system is undetermined) and Patient Positioning System (where the frame attached to the treatment table), and the bed can move to one position to another, the head and neck will not change during treatment.

During treatment, eight sector can be moved independently on collimator tungsten ring for various exposure position in order to provide 4, 8, and 16 mm archive size or the combination of the mentioned archive size. Additionally, some sector can be blocked which mean the sources of sector do not align with one of the collimator holes. Further detail of the design of LGK PFX, Dosimetric Characteristic, radiation safety aspect, and clinical use are for evaluating regularity of individual sector output.

This research is conducted in order to evaluate Gamma Knife Perfexion which has not been done for 3,5 years and to verify beam alignment for all collimator (4mm, 8mm, 16mm) along with X-axis, Y-Axis, and Z-axis. It is done by phantom which use Gafronic film that radiated (x Gy), scanned, and analyzed using *software image j 1.50* and quality control test determination for each colimator 4mm, 8mm, 16mm which is tested by standart 0,1 and < 1,0% (Novotny, 2008). The determination of quality control accuration of output factor is recomended by AAPM (American Association of Physicist in Medicine) 54.

2. Method

A special film holder , made with very narrow geometric tolerance, is aligned between with its center in the PPS calibration in the PPS calibration center poin. When the tool is aligned in the PPS, the tip of a sharp needle, located in the tool, exactly points towords the PPS calibration center poin. Just prior to exposure a small piece of radiological film, also located in the tool, is pierced by the tip of the needly. During exposure the film plane coincides with the RFP. Two film are consecutively exposed, one with it's surface oriented perpendicularyrelative to the symmetry axis of the source distribution. The second film is rotated through 900 with respect to the first film.image intensity profiles are scaned by means of an automatic densitometer in three mutually perpendicular direction. the geometrical resolution of the flatbed scanner has been choseen close to 0.05 mm and the dynamic range was set to 16 bits. the obtained intensity profiles include the shift in intensity caused by the small hole pierced into the film. by measuring the asymmetry of the position of the hole in relation to the density distribution at approximately FWHM, the accuracy of the leksel gamma knife unit is determined.

3. Results and Discussion

3.1. Measurement accuracy stabilitas

The film image measurement gafcromic Collimator 4 mm of XZ axis high and FWHM values are generated through graphs, Figures below.

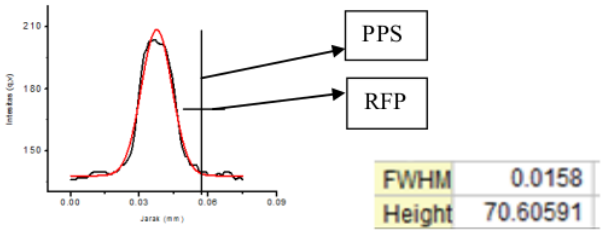

Figure 1. Result collimator 4 mm XZ

The film image measurement gafcromic Collimator 4 mm of YZ axis high and FWHM values are generated through graphs, Figures below.

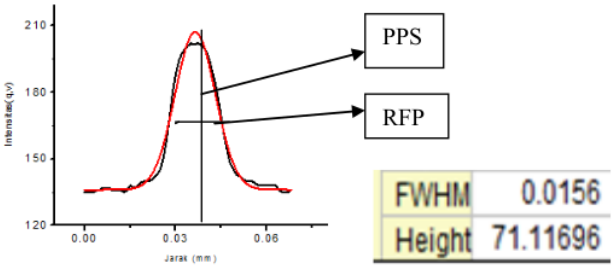

Figure 2. Result collimator 4 mm YZ

Table 1. Result measured image of film gafcromic collimator 4 mm sumbu X, Y, Z

No	ΔX	ΔY	ΔZ
1	-0.050	-0.036	-0.242
2	-0.021	0.032	-0.193
3	-0.079	0.026	-0.103
4	0	0	-0.22
5	0	0	-0.192
6	0	0	-0.255
Mean Deviation	-0.051	0.004	-0.201

$\Delta r = \sqrt{\Delta X^2 + \Delta Y^2 + \Delta Z^2}$

$\Delta r = \sqrt{(-0.051)^2 + (-0.004)^2 + -(0.201)^2}$

$\Delta r = 0.21$ mm

The measured distance,i, e. the accuracy PPS and RFP of the Gamma knife, is well within the specifications (0.4 mm). We hereby cerctify that the accuracy of the above Leksel Gamma Knife is in accordance with the Gamma Knife.

3.2. Correlation dose rate film and dose rate electrometer

The dose rate calculation equation

$$D_{DW} = KTP.\ N_{DtW}.M$$

Table 2. Comparison dose rate film Gafcromic with calculasion Dose rate Electrometer collimator 4 mm.

Dose rate collimator 4 mm (Gray/ menit)	
Film Gafcromic	Electrometer
0.851	0.849
0.848	0.846
0.844	0.841
0.859	0.854
0.865	0.862
0.85	0.848
0.846	0.846

0.855	0.853

The result measurement film Gafcromic and electrometer will be correlated to view the linearity of the dose rate.

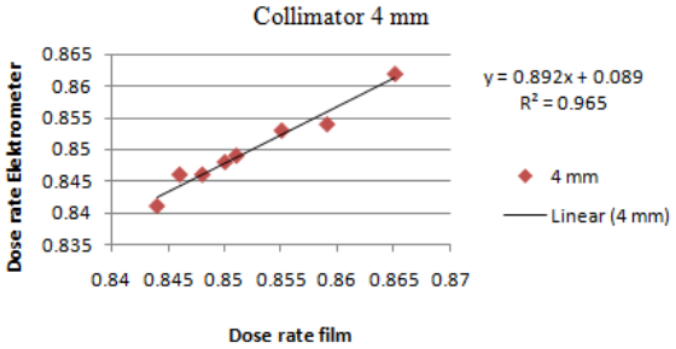

Figure 3. Corelasion dose rate film with Electrometer collimator 4 mm

The correlation results gafcromic the film dose rate and dose rate electrometer shows the correlation values $R^2 = 0.965$ for dose rate collimator 4 mm sector 1- 8.

Table 3. Comparison dose rate film Gafcromic with calculasion Dose rate Electrometer collimator 8 mm.

Dose rate collimator 8 mm (Gray/ menit)	
Film Gafcromic	Electrometer
1.983	1.984
1.95	1.934
1.89	1.887
1.915	1.897
1.911	1.909
1.898	1.888
1.906	1.903
1.97	1.964

The result measurement film Gafcromic and electrometer will be correlated to view the linearity of the dose rate.

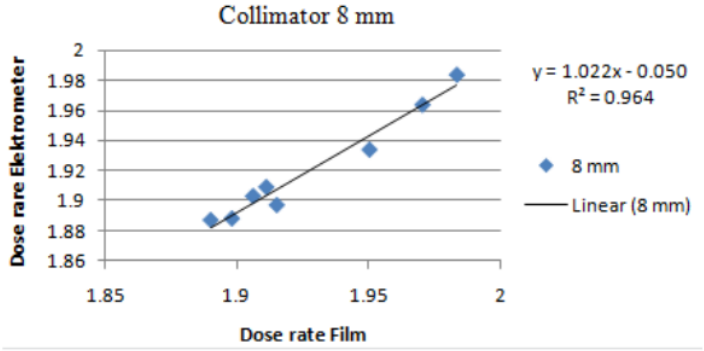

Figure 3. Corelasion dose rate film with Electrometer collimator 8 mm

The correlation results gafcromic the film dose rate and dose rate electrometer shows the correlation values R2 = 0.964 for dose rate collimator 8 mm sector 1- 8.

Table 4. Comparison dose rate film Gafcromic with calculasion Dose rate Electrometer collimator 16 mm.

Dose rate collimator 16 mm (Gray/ menit)	
Film Gafcromic	Electrometer
2.495	2.483
2.504	2.505
2.503	2.503
2.53	2.526
2.545	2.546
2.53	2.528
2.515	2.514
2.512	2.51

The result measurement film Gafcromic and electrometer will be correlated to view the linearity of the dose rate.

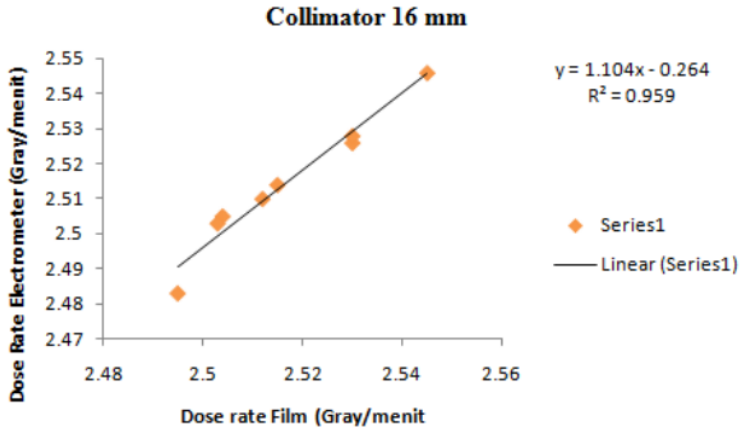

Figure 3. Corelasion dose rate film with Electrometer collimator 16 mm

The correlation results gafcromic the film dose rate and dose rate electrometer shows the correlation values R2 = 0.964 for dose rate collimator 16 mm sector 1- 8.

Conclusion : The results of the standard are still in conformity item 0.21 mm for 4 mm and corelasi dose rate film and measurent using electrometer collimator 4 mm = 0.965, 8 mm = 0.964, 16 mm = 0.959.

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