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A Study on the Change in Surface Dose Caused by Electromagnetic Radiation According to the Angle of the Collimator

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During radiation therapy, the mobility of the multi-leaf collimator varies according to the shape of the tumor and the angle of the collimator. Therefore, the purpose of this study is to understand the change in surface dose according to the collimator angle and the shape of the tumor. Using 10MV electromagnetic radiation, a treatment plan was implemented according to the length and short axis ratio of the tumor and the collimator angle, and the surface dose was compared with the actual measured value. As a result of the evaluation, the surface dose increased as the length of the tumor decreased and the angle of the collimator increased. If it is necessary to reduce the surface dose through this, the collimator angle should be applied in consideration of the short/long ratio.

Keywords : linac, collimator angle, electromagnetic scattering, surface dose

1. Introductions

Radiation therapy is a study that treats tumors and other diseases in the body using high-energy electromagnetic radiation and high-energy electron beams using a medical linear (linac) [1]. External irradiation radiation therapy, a field of radiation therapy, has been continuously developed until now, starting with external irradiation treatment using cesium, a radioactive isotope in 2007 [2]. With the development of radiation therapy using a medical linear accelerator in the early 1990s, the external irradiation treatment method using a radiation generator has become the mainstream from the radiation treatment method using radioactive isotopes in the past [3-5]. Currently, external irradiation radiation therapy using a medical linear accelerator occupies a large part [6, 7]. These medical linear accelerators have been developed along with the development of science and technology, allowing various treatment techniques to be applied [8, 9]. In particular, as the multi-leaf collimator (MLC) was applied, it not only replaced the existing shield, but also created a basis for operating intensity-modulated radiation therapy and volume-modulated arc radiation therapy [10]. Intensity modulated radiation therapy is a method that gives different intensity of each irradiation direction in the existing three-dimensional stereoscopic treatment [11]. In order to make the intensity distribution of each irradiation surface different, each irradiation surface is divided into detailed areas called beamlets, and the radiation dose according to each beamlet is differentially irradiated to configure the intensity distribution differently [12]. In order to differentiate the dose distribution according to the beamlet, it is necessary to shield the area other than the beamlet, so various shielding types must be configured for each type, but as the MLC is developed, it can be implemented easily and quickly [13]. Also, in the case of volume-modulated rotational radiation therapy, it is a method that continuously configures the gantry rotation in the intensity-modulated radiation therapy method [14]. Therefore, it should be possible to implement the precise movement of the multi-leaf collimator [15]. As such, the MLC is a necessary component to realize the optimal dose distribution, and it is a configuration that has the advantages of convenience and quick irradiation range [16]. However, multi-layered collimators have disadvantages compared to conventional shielding [17]. There are limitations in curve expression, implementation limitations in the form of a central block, and occurrence of friction and leakage dose

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[18-24]. In the case of intensity-modulated radiation therapy and volume-modulated rotational radiation therapy using these MLCs, the treatment plan is performed by fixing the collimator angle during treatment planning [25, 26]. In the past studies, changes in the deep dose distribution according to the collimator angle were evaluated, but no studies on surface dose were conducted. There are various factors that affect the surface dose, but one of the factors that intuitively affects the surface dose is the collimator scatter factor [27, 28]. This is an index indicating the effect of scattered rays generated by the collimator affected by the primary beam within the irradiation surface, and it can be said that it is generally affected by the irradiation range [29]. However, this evaluation is applied only to 3D stereoscopic radiation therapy, and in the case of intensity-modulated radiation therapy and volume-modulated arc radiation therapy, it is predominantly affected by the area inside the MLC [30, 31]. This is because the MLC moves continuously, not in a stationary state. Therefore, the influence of scattered rays due to the MLC varies depending on the direction of the collimator, and the surface dose also varies [32]. Therefore, in this study, the difference in surface dose according to the direction of the collimator is evaluated, and the angle suitable for the purpose is identified, and the basis for realizing the optimal radiation treatment plan is to be prepared.

2. Material and Method

CLinac-ix (VARIAN, USA) was used for the medical linac (linear accelerator), and the MLC operation was set on the RayStation (RaySearchLab, Sweden) radiation treatment planning system. As shown in Fig. 1, after scanning a 30 × 30 × 22 cm^3 solid phantom with a 5 mm slice thickness through a CT simulator, the size of the tumor is changed from a minimum of 2 cm to a maximum of 10 cm in the long axis and 10 cm in the short axis in the radiation treatment planning system. The treatment plan is to apply the volume modulation rotational radiation therapy method using 10MV photon beam, and set the coverage of 200 cGy to 97 % or more and 102 % coverage for the tumor, and set the coverage to 30 % or less for the surrounding area for a total of 2 Time optimization was performed. The collimator angle is applied while changing as shown in Fig. 2 as 0°, 10°, 20°, 30°, and 45°. Through this, the surface dose is obtained

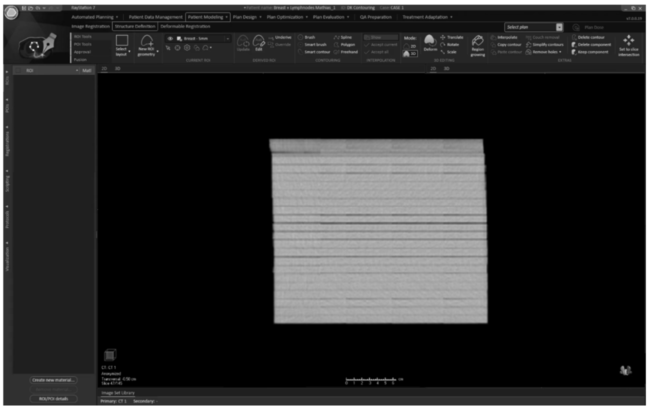

Fig. 1. Images implemented in the radiation treatment planning system after CT scan using 22 solid phantoms of 30 × 30 × 1 × 25 cm^3.

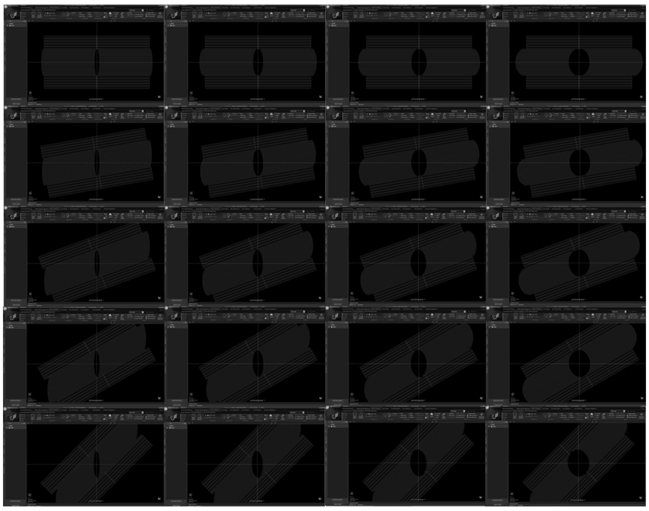

Fig. 2. By changing the collimator angle to 0 degree, 10 degree, 20 degree, 30 degree, 40 degree, 45 degree, the shape of the tumor is changed from 20 % to 100 % relative to the long axis at 20 % intervals, adjusting the collimator to fit the shape of the tumor. Implementation of radiation treatment plan image.

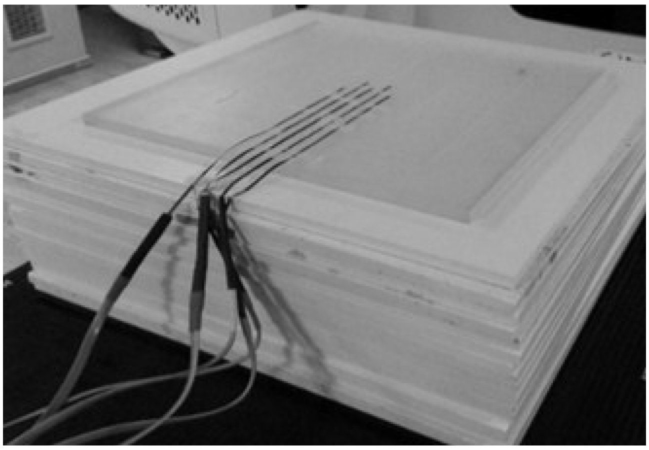

Fig. 3. Measure the surface dose according to the shape of the tumor and the change of the collimator angle after being located on the surface of the phantom using a MOSFET.

and compared in the gantry direction. Next, based on the treatment plan results according to the conditions, it is operated through the actual radiation therapy machine, and the surface dose is measured using the MOSFET (Metal Oxide Semiconductors Field Effect Transistors) dosimetry as shown in Fig. 3. By comparing the results of the treatment plan with the results of actual measurements, we compare the surface dose according to the length and short axis ratio of the tumor and the collimator angle. SI (MKS) units are preferred and CGS units may be used.

3. Result and Discussion

The difference between the treatment plan and the actual measured value according to the change of the tumor type and collimator angle is expressed in a table. Table 1 compares the surface dose in the treatment plan according to the tumor type and collimator angle. As shown in Fig. 4, as the shape of the target deepens in the long direction, the deviation for each collimator angle increased. Also, as the angle increased, the deviation of the surface dose decreased. In the case of the same tumor type, the surface dose tended to increase as the angle of the collimator increased. Table 2 compares the actual

Table 1. Results according to the planning result collimator angle and target shape [Unit : cGy]

Collimator angle / Target shape	0°	10°	20°	30°	45°
5:1	30.00	31.96	34.13	35.93	37.88
5:2	35.70	37.05	38.29	39.67	40.79
5:3	36.99	38.13	39.18	40.47	41.42
5:4	39.46	40.51	41.43	42.51	43.59
1:1	44.09	44.12	44.15	44.18	44.21

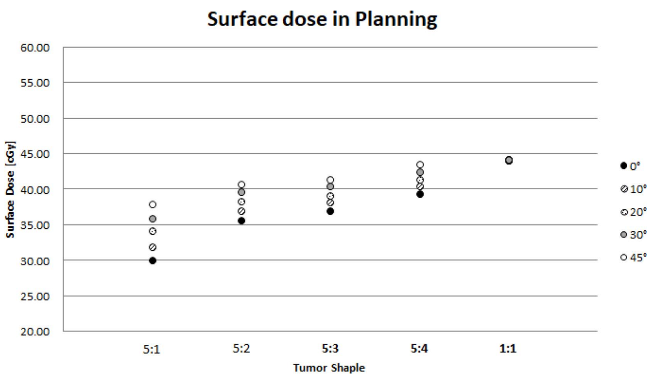

Fig. 4. Graphical representation of the surface dose value on the radiation treatment planning program according to the change in the shape of the tumor and the angle of the collimator.

Table 2. Results according to the actual measurement collimator angle and target shape [Unit : cGy]

Collimator angle / Target shape	0°	10°	20°	30°	45°
5:1	30.20	32.06	35.09	36.78	39.01
5:2	35.70	36.87	37.65	38.77	40.07
5:3	36.99	38.05	39.05	40.56	41.46
5:4	39.46	40.45	41.46	42.84	43.80
1:1	44.09	44.21	44.34	44.47	44.59

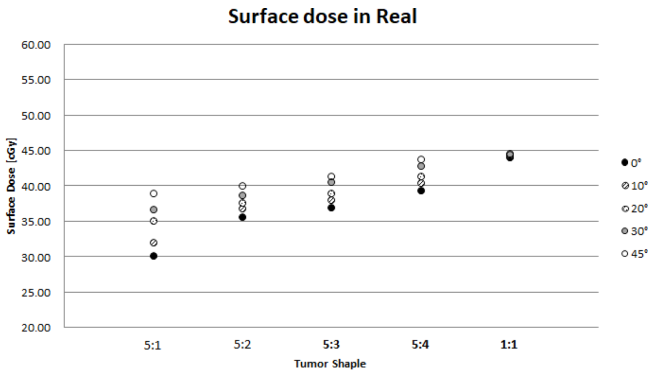

Fig. 5. Graphical representation of surface dose values using MOSFETs according to tumor type and collimator angle change.

measured surface dose according to the tumor type and collimator angle. As shown in Fig. 5, as the shape of the target deepens in the long direction, the deviation by angle of the collimator increased similarly to the treatment plan. In addition, as the angle increased, the deviation of the surface dose decreased, and in the case of the same tumor type, the surface dose showed a tendency to increase as the angle of the collimator increased. However, as the shape of the tumor approaches the forward direction, the difference in surface dose between treatment plans and actual measurements tends to decrease.

When applying techniques such as intensity-modulated radiation therapy and volume-modulated rotational radiation therapy, compared to the radiation therapy technique using a shield in the past, the dose distribution is different depending on the angle of the collimator as a MLC consisting of multiple leaves is applied only on the horizontal axis. you will lose As various studies on dose distribution according to the collimator angle are conducted, the collimator angle according to the purpose is suggested. In this study, we tried to figure out the change in surface dose by considering the effect of the distance at which the leaf collimator of the multi-leaf structure is driven, the number of leaves, and the movement of the collimator for shielding the normal part due to the occurrence of surplus area. It can be judged that the importance of the surface dose is low compared to the deep dose, but depending on the patient, the treatment area, and the dose distribution, the increase in surface dose may cause discomfort to the patient and the refusal of treatment due to the occurrence of pain due to radiation burns. There is also. Therefore, we would like to identify the degree of influence of the collimator angle among the factors affecting the surface dose and suggest the setting of the collimator angle as a way to reduce the surface dose according to the patient's condition. As a result of the evaluation, the amount of change in surface dose according to the change in tumor shape and collimator showed an average deviation of 31.4 % from a minimum of 6.5 % to a maximum of 47.4 % in the case of the treatment plan, and in the case of the actual measured value, the average was from a minimum of 6.2 % to a maximum of 47.6 %. There was a difference of 30.9 %. As for the shape of the tumor, the surface dose showed a tendency to increase due to the increase of the area as it changed in the forward direction, and it was confirmed that the surface dose increased as the collimator angle increased. The increase in surface dose as the angle of the collimator increases is judged to be the effect of the generation of excess area as the ratio of the expressed area to the area of the tumor increases as the angle increases. However, as this study is applied to uniform tumors, additional research needs to be conducted on non-uniform tumors in clinical practice. However, due to the change of the surface dose according to the change of the angle of the collimator, it is possible to secure the continuity of treatment by changing the angle of the collimator for patients who have difficulty in continuing treatment due to surface disorders during radiation treatment in the future.

4. Conclusion

In this study, we tried to examine the accuracy of dose delivery through the error in the implementation of the collimator according to the tumor type. As shown in the conclusion, the dependence on the tumor type does not differ greatly individually, but acts as a factor that changes the tendency according to the collimator direction. Therefore, the change in surface dose according to the angle of the collimator is lower as the angle is smaller, whereas the change in surface dose is higher as the shape of the tumor changes in the longitudinal direction. Based on this, both the shape of the tumor and the angle of the collimator must be considered in order to set the direction for attenuation of the surface dose in the future radiation treatment. Therefore, it is necessary to consider the selection of the collimator angle to reduce the surface dose in the area where overlapping skin occurs. This study does not stop at simply evaluating the change in surface dose according to the shape of the tumor and the angle of the collimator, but also the criteria for selecting the angle of the collimator by considering the area where the attenuation of the surface dose should be considered based on the results of the study when planning radiation treatment. wanted to provide. Based on this, it is thought that excellent results in the treatment of cancer patients can be expected by increasing the effect of radiation therapy through the reduction of side effects such as skin erythema and blisters caused by radiation therapy.

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