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Clinical Assessment of the Jaw-tracking Function in IMRT for a Brain Tumor

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Intensity-modulated radiotherapy (IMRT) improves dose conformity and saves critical organs. IMRT is widely used in cases of head and neck, prostate, and brain cancer due to the close location of the targets to critical structures. However, because IMRT has a larger amount of radiation exposure than 3 dimensional-conformal radiation therapy (3D-CRT), it has disadvantages such as increases in the low dose irradiation to normal tissues and in the accumulated dose for the whole volume due to leakage and transmission of the multi-leaf collimator (MLC). The increased accumulated dose and the larger low dose may increase the occurrence of secondary malignant neoplasms. For these reasons, the jaw-tracking function of the TrueBeam (Varian Medical Systems, Palo Alto, CA) was developed to reduce the leakage and the transmission dose of the MLC with linear accelerators. However, the change in the superficial dose has not been verified with a quantitative analysis of the dose reduction in a brain tumor. Therefore, in the present study, we intended to verify the clinical possibility of utilizing the jaw-tracking function for a brain tumor by comparing treatment plans and superficial doses. To accomplish this, we made three types of original treatment plans using Eclipse11 (Varian Medical Systems, Palo Alto, CA): 1) farther than 2 cm from the organs at risk (OAR); 2) within 2 cm of the OAR; and 3) intersecting with the OAR. Jaw-tracking treatment plans were also made with copies of the original treatment plan using Smart LMC Version 11.0.31 (Varian Medical Systems, Palo Alto, CA). A comparison between the original treatment plans and

jaw-tracking treatment plans was performed using the difference of the mean dose and maximum dose to the OARs in cumulative Dose Volume Histogram (DVH). In addition, the dependencies of the effects of transmission and the scattering doses according to jaw motion were assessed through the difference in the surface doses. In the DVH comparison, a maximum dose difference of 0.4% was observed between the planning methods in the case of over 2 cm distance, and the maximum dose of 0.6% was obtained for within the 2 cm distance. For the case intersecting with the OAR, the maximum dose difference of 2.3% was achieved. According to these results, the differences in the mean doses and the maximum doses to the OARs ware larger when the OARs and the planning target volume (PTV) were closer. In addition, small differences in the surface dose measurements were observed. In the case of the inside field, the differences were under 2% of the prescription dose while the difference was under 0.1% in the case of the outside field. Therefore, treatment plans with the jaw-tracking function consistently affected the dose reduction for a brain tumor, and the clinical possibility could be verified as the surface dose was not increased.

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I. INTRODUCTION

The development of computed tomography (CT) made the delineation of patients' internal organs possible. Consequently, 3 dimensional-conformal radiation therapy (3D-CRT) is widely used because it has dose conformity and spares normal tissues closely located to the target [1].

Intensity-modulated radiotherapy (IMRT) improves the dose conformity while sparing critical normal organs. IMRT is widely used in cases such as head and neck, prostate, and brain cancer, as these cancers are closely located to critical structures. However, because it has a larger amount of radiation dose than 3D-CRT, IMRT has the disadvantages of increasing both the low dose of irradiation to normal tissues and the accumulated dose for the whole volume due to leakage and transmission of the multi-leaf collimator (MLC) [2–6].

In general, IMRT may potentially increase the incidence of secondary malignant neoplasm due to the larger amount of radiation exposure. Although a clear definition has not been given, risk of developing gliomas, meningiomas and schwannomas has been reported to be increased by an average dose of at least 1.5 Gy to the normal tissue of patients being treated for tinea capitus. When the IMRT technique is used, the low dose absorption should be carefully considered [7–10].

Conventional linear accelerators determine the rectangular radiation field for the upper and the lower jaw. MLC systems are also utilized to provide of detailed radiation beam shapes. In this case, MLC can move horizontally and vertically in accordance with the rotation of the collimator. Generally, collimation of the radiation field is made by the fitting jaw within the maximum open size of the MLC position. Thus, only the area blocked by the MLC may cause the increased MLC leakage and transmission [11,12]. For the Truebeam (Truebeam stx, Varian Medical Systems, Palo Alto, CA), the jaw-tracking function was added in order to make up for this. During the beam on time, jaws can be made to fit the maximum position of the MLC edge continuously, leading to reduced MLC leakage and the transmission dose. However, the mechanism for the superficial dose change has not been verified, neither has the amount of the dose reduction in the brain tumor. Thus, in this study, the jaw-tracking function of Truebeam was evaluated with comparison of the radiation treatment plans and superficial dose measurements with an anthropomorphic phantom for brain tumor

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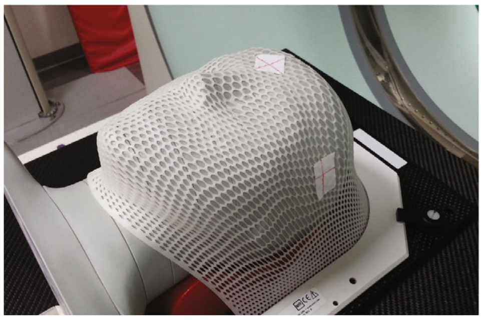

Fig. 1. (Color online) Anthropomorphic phantom setup for CT image acquisition.

II. EXPERIMENTS AND DISCUSSION

1. Treatment Planning

In order to acquire medical digital imaging and communications in medicine (DICOM) CT images, we set the anthropomorphic phantom (ATOM® phantoms 702, CIRS, Norfolk, VA) with a mask (Uni-frame® Perforated Mask, Civco, Orange City, IA), as shown in Fig. 1. The CT images of 2 mm thick slices were acquired with