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Improvement of Dose Homogeneity in a 3-Dimensional Conformal Radiotherapy for Head and Neck Cancer

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1. Introduction

When an electron field is abutted at the surface with a photon field for head-and-neck cancer (HNC) treatment, the traditional method using bilateral field gives rise to an extreme inhomogeneity of dose distribution with both very hot and very cold regions[1,2,3].

When we consider clinically only tumor doses of primary concern regardless of dose to normal tissues, the hot spots can be accepted, depending on their magnitude, extent, and location. However, an extreme inhomogeneity inside the radiation field is generally undesirable. An overdose to normal tissues around a target region or an underdosage in the tumor may be problematic.

This study intends to develop a novel approach to improve the dose distribution inside the photon-electron abutting fields for HNC treatment.

2. Methods and Results

A comparative analysis between the conventional and the alternative method is performed which employs the bilateral fields and the oblique fields, respectively. Considering a case of supraglottic cancer, both plans are generated and compared concerning coverage and homogeneity of dose distribution within the target volume and sparing the organs at risk.

2.1 Bilateral Irradiation

In the conventional method, two photon beams and two electron beams are irradiated bilaterally, as shown in Fig. 1. In both region using photon fields and electron fields, the point dose of 180 cGy is prescribed.

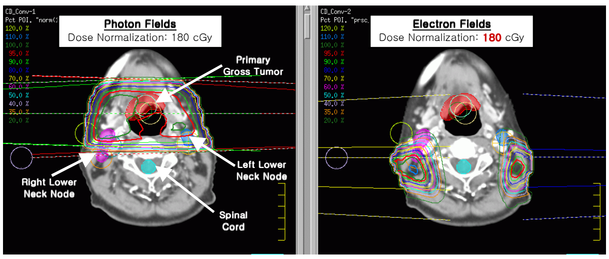

Figure 1. Radiation fields setup in the bilateral irradiation.

2.2 Oblique Irradiation

In Fig. 1, it can be noticed that the dose inhomogeneity in the abutting region is caused by electron scattering. We should remind that the electron beams in the bilateral setup delivers 100% of prescribed dose to the neck nodes. In this viewpoint, this study starts from an idea about alternative method to minimize a contribution of electron beam to dose delivery to lower neck nodes so as to reduce dose inhomogeneity.

We introduce a novel approach to radiation field setup using oblique beams with replacement of bilateral fields. Fig. 2 shows the radiation fields set up in the new method using oblique irradiation of photon and electron beams. It is shown that the oblique irradiation setup can decrease the contribution of electron dose in the oblique irradiation to 70 cGy (40% of the prescribed dose), because the photon beam is overlapped in the neck node to deliver 60% of the prescribed dose, 110 cGy.

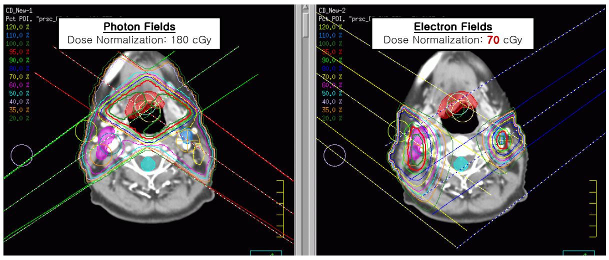

Figure 2. Radiation fields setup in the oblique irradiation.

In order to assess the feasibility of new method, both the quantitative and the qualitative comparison were performed by using dose volume histogram data and isodose curves, respectively.

3. Results and Discussions

Fig.3 shows the isodose distribution of both plans comparatively. All the isodose lines are normalized to the prescribed dose, 180 cGy. It is noted that the isodose line of 120% in the lateral irradiation is spread out inward to the photon fields. On the other hand, not only 120% line but also 110% line disappears in the oblique irradiation. This indicates that the oblique irradiation can remove or reduce hot regions in the abutting regions without formation of any cold region.

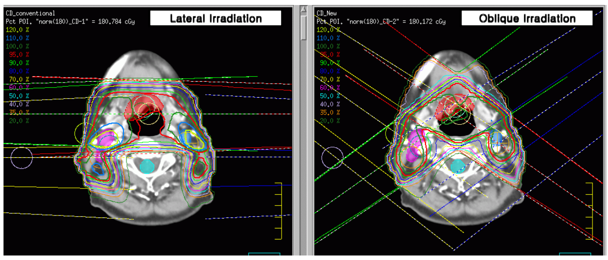

Figure 3. Comparison of isodose curves.

The dose statistics data are compared in Table 1. In the case of lateral irradiation, the hot regions of primary gross disease receiving 107% of prescribed dose are spread over the 38.9% of volume. However, the oblique irradiation can reduce dramatically the volume fraction of V107% to 5.3%. Concerning the lower neck lymph nodes, the lateral irradiation increases the maximum dose more than 250 cGy in both the right and the left neck node. Their volume fractions are considerably large, as shown in the column of V115%. On the other hand, the hot region in the case of oblique irradiation is removed clearly; the values of V115% are zero in both neck nodes.

Table 1. Comparison of dose statistics data.

Target	D_min [cGy]	D_min [cGy]	D_min [cGy]	V95%a) [%]	V107% [%]	V115% [%]
Lateral Irradiation						
Primary Gross Tumor	170.8	190.5	216.1	99.9	38.9	1.6
Left Lower Neck Node	121.8	199.9	252.1	86.6	66.5	43.1
Right Lower Neck Node	134.1	214.9	262.2	93.0	79.2	66.2
Oblique Irradiation						
Primary Gross Tumor	171.1	186.7	196.9	99.9	5.3	0.0
Left Lower Neck Node	120.8	182.4	196.4	88.5	8.9	0.0
Right Lower Neck Node	157.1	184.4	193.2	94.3	4.9	0.0

a) V95% denotes the fraction of target volumes receiving more than 95% of the prescribed dose.

In Fig. 4, the dose volume histograms (DVH) are compared. The improvement of dose homogeneity in the target region, especially the lower neck node, is noticed clearly. It is also noted that the DVH for spinal cord is not different from each other. This indicates that the oblique irradiation does not give rise to increase in the dose to spinal cords.

To sum up all the obtained results, the oblique fields can reduce the dose inhomogeneity in the region of photon-electron abutting fields for treatment of HNC without any significant increase in dose to spinal cord.

4. Conclusion

The obtained results in this study suggest that the extreme inhomogeneity of dose distribution inside radiation field for treatment of HNC can be resolved by employing oblique irradiation of both photon and electron beams.

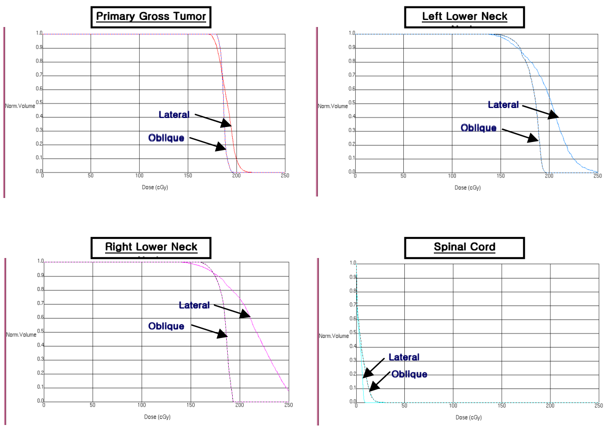

Figure 4. Comparison of dose volume histograms.

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