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Original research article

Evaluation of dose calculations accuracy of a commercial treatment planning system for the head and neck region in radiotherapy

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ABSTRACT

Aim: The objective was to quantify dose calculation accuracy of TiGRT TPS for head and neck region in radiotherapy.

Background: In radiotherapy of head and neck cancers, treatment planning is difficult, due to the complex shape of target volumes and also to spare critical and normal structures. These organs are often very near to the target volumes and have low tolerance to radiation. In this regard, dose calculation accuracy of treatment planning system (TPS) must be high enough.

Materials and methods: Thermoluminescent dosimeter-100 (TLD-100) chips were used within RANDO phantom for dose measurement. TiGRT TPS was also applied for dose calculation. Finally, difference between measured doses (D_{meas}) and calculated doses (D_{calc}) was obtained to quantify the dose calculation accuracy of the TPS at head and neck region.

Results: For in-field regions, in some points, the TiGRT TPS overestimated the dose compared to the measurements and for other points underestimated the dose. For outside field regions, the TiGRT TPS underestimated the dose compared to the measurements. For most points, the difference values between D_{calc} and D_{meas} for the in-field and outside field regions were less than 5% and 40%, respectively.

Conclusions: Due to the sensitive structures to radiation in the head and neck region, the dose calculation accuracy of TPSs should be sufficient. According to the results of this study, it is concluded that the accuracy of dose calculation of TiGRT TPS is enough for in-field and out of field regions.

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1. Background

Head and neck cancers (HNCs) consist of the oral cavity, nasopharynx, oropharynx, larynx, hypopharynx, nasal cavity, salivary glands, par nasal sinuses and thyroid cancers.[1] These cancers arise from digestive tracts, mucous lining of respiratory, lymph nodes, and salivary glands.[2] Radiotherapy is applied as a HNC treatment modality either alone or in combination with chemotherapy or surgery.[1,3] One of the techniques in radiation therapy of head and neck cancer is the wedged field technique.[4] Wedge filters are commonly applied to modify the dose distribution and make it uniform within the target volume.[5–8]

Treatment planning for head and neck cancers is difficult, due to the complex shape of target volumes and also to spare critical organs such as the parotid glands, mandible, spinal cord, brainstem, and normal structures. These organs often are near to the target volumes and have low tolerance to radiation.[4] Hence, special attention needs to deliver dose to the tumor, while to keep the dose of the organs at risk as low as possible. To achieve this goal, treatment planning systems (TPSs) should calculate the dose exactly.

There are several studies relevant to dose calculation accuracy of different algorithms and TPSs in radiotherapy; however, most of them were carried out in a water phantom and/or in regions other than the head and neck.[9–19]

2. Aim

To the best of our knowledge, there is no investigation on the accuracy of dose calculations of TiGRT TPS in head and neck region. Therefore, the aim of this study was to assess the accuracy of dose calculations in this region for TiGRT TPS in the presence of wedged fields.

3. Methods and materials

3.1. *Treatment planning and irradiation of the phantom*

A computed tomography scan of the head and neck region of a RANDO phantom (Phantom Laboratory, NY, USA) was taken to produce a treatment plan. The Rando phantom is made of bone-equivalent, soft tissue-equivalent or lung-equivalent tissues. Each slice of the phantom has holes which are plugged with bone-equivalent, soft-tissue-equivalent or lung-equivalent pins which can be replaced by TLD holder pins.[20] The images of the Rando phantom were transported to TiGRT TPS version 1.2 (LinaTech, Sunnyvale, CA, USA). According to user's manual of TiGRT TPS, the TPS uses a three dimensional photon dose calculation algorithm based on full scatter convolution (FSC), developed to facilitate accurate and fast calculations. According to the manual, this algorithm separates the absorbed dose (D) in a given point into the primary dose (D_p) and the scatter dose (D_s):

$$D = D_p + D_s \tag{1}$$

The primary dose D_p $(\vec{r})$ is obtained based on the convolution algorithm, using the following formula:

$$D_p(\vec{r}) = \iiint \phi_p(\vec{r}')k_p(\vec{r} - \vec{r}')dV' \tag{2}$$

where $\phi_p(\vec{r}')$ is photon fluence at the surface of a ray passing through the surface to point $\vec{r}'$ and $k_p(\vec{r} - \vec{r}')$ denotes the electron transport kernel, explaining the dose distribution around the primary interaction site of the photon. This demonstrates that the electron transport modeling by this algorithm has been taken into account, and the electron dose deposition kernel can be scaled for heterogeneities such as lung, bone and air cavities. Finally, V' states the differential calculation volume at point $\vec{r}'$. The scatter dose $D_s(\vec{r}')$ is derived from the following convolution equation:

$$D_s(\vec{r}) = \iiint \phi_p(\vec{r}')k_s(\vec{r} - \vec{r}')dV' \tag{3}$$

In FSC algorithm, multiple scattering of photons is discarded and $k_s(\vec{r} - \vec{r}')$ is the first scatter fluence kernel. This kernel can be derived from the electron transport kernel.

In this study, two lateral parallel opposed fields were planned, in which one of them was wedge field and another was open field. A source axis distance technique was applied to deliver 200 cGy dose to the selected point (the center slice No. 5 of the RANDO phantom). The treatment fields covered the slices of No. 2–7 of the RANDO phantom. The irradiated area on the RANDO phantom is shown in Fig. 1. Before irradiation, the thermoluminescent detector-100 (TLD-100) chips were placed in special points of the RANDO phantom. The RANDO phantom was irradiated based on the treatment plan with 6 MV X-rays emitted from a Siemens Primus accelerator (Siemens AG, Erlangen, Germany). Doses received by the

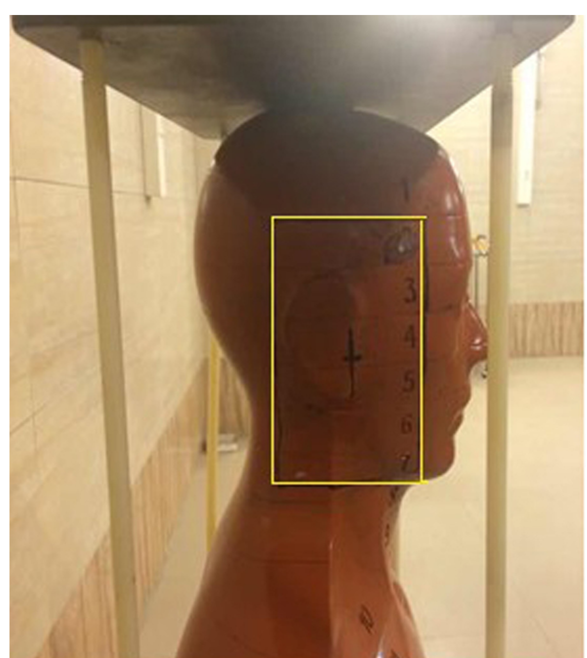

Fig. 1 – Irradiated area on the RANDO phantom.