Influence of planning target volume definition on skin dose for head and neck patients treated with inverse planned IMRT

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Abstract— **The location of the planning target volume (PTV) for head and neck patients can be an issue in terms of skin dose when using inverse planned intensity modulated radiation therapy (IMRT) systems due to the optimization process. Our work evaluates how the PTV proximity to the skin surface affects the surface dose when using IMRT. An anthropomorphic phantom underwent a CT simulation positioned as a typical patient with thermoplastic mask immobilization. Organs at risk and a CTV including the lymph nodes were drawn. The PTV1, PTV2, PTV3, were created by varying their distance to the surface by 10 mm, 5 mm and 0 mm, respectively. An individual IMRT plan was created for each PTV using 7 coplanar fields and a 6 MV photon beam. Thermoluminescent dosimeters (TLD) and micro metal-oxide-semiconductor field-effect transistors (MOSFET) were placed in 12 different positions on the phantom's head, neck and supra-clavicular surface and 3 reference positions inside the CTV. The measurements showed that for all measured points there was an increase in surface dose of between 18 to 99% when comparing the surface dose measured for the PTV2 and PTV3 to the PTV1 plans. The surface dose increase was largest when comparing the PTV1 plans to the PTV3 plans. Plotting the surface dose measurements for plans with the PTV1 versus PTV2 and PTV3 yielded a linear relationship in both cases (R = 0.93217, p < 0.0001 and R = 0.89191, P < 0.0001, respectively). The slope of each curve is directly proportional to the increase in surface dose for each PTV situation. The linear relationship is indicative that the increase in surface dose is not a function of measurement location or shape of PTV, but only a function of PTV depth from the skin.**

Keywords— **Surface dose, PTV definition, IMRT.**

I. INTRODUCTION

Inverse planned IMRT allows for the simultaneous treatment of multiple targets to different doses with highly conformal distributions that maximize healthy tissue sparing. The superficial location of target structures defined for the treatment of head and neck tumors can raise some problems unique to inverse planned IMRT. Typically for these patients, target definition follows the ICRU reports 50 [1] and 62 [2] conventions for GTV, CTV, and PTV. In the case of head and neck patients the location of lymph nodes defined as part of the CTV may result in a PTV which encroaches the patient's skin [3]. The optimizing algorithm may overcompensate for lack of scattering material near the surface by increasing dramatically the beam intensity aimed at those locations, and thereby possibly increasing the surface dose. Several works have addressed this issue [4, 5]. This work evaluates the skin dose as a function of PTV proximity to the surface.

II. METHODS AND MATERIALS

An anthropomorphic phantom (Rando) underwent a CT simulation positioned as a typical patient with thermoplastic mask immobilization. Organs at risk and a CTV including the lymph nodes were drawn. The PTV_1, PTV_2, PTV_3, were created by varying their distance to the surface by 10 mm, 5 mm and 0 mm, respectively. An individual IMRT plan was created for each PTV using 7 coplanar fields and a 6 MV photon beam using CORVUS treatment planning system. To evaluate the dose to Rando' surface we used thermoluminescent dosimeters (TLD) and micro metal-oxide-semiconductor field-effect transistors (MOSFET) placed in 12 different positions on the phantom's head, neck and supra-clavicular surface and 3 reference positions inside the CTV. The anthropomorphic phantom was irradiated with a 6 MV photon beam from a Varian Clinac 6EX.

III. RESULTS AND DISCUSSION

The effective depth of measurement (d_{eff}) was determined for each detector and PDDs corrections (relative to 70 μm) were applied on them. The d_{eff} for the TLDs and MOSFETs were 135 μm and 353 μm, respectively. The uncertainty associate to the detectors was about 5%.

The measurements showed that for all measured points there was an increase in surface dose of between 18 to 99% when comparing the surface dose measured for the PTV_2 and PTV_3 to the PTV_1 plans. The surface dose increase was largest when comparing the PTV_1 plans to the PTV_3 plans. Plotting the surface dose measurements for plans with the PTV_1 versus PTV_2 and PTV_3 yielded a linear relationship in both cases (R = 0.93217, p = 0.0001 and R = 0.89191, p = 0.0001, respectively) showed in the Figures 1 and 2 respectively. The slope of each curve is directly proportional to the increase in surface dose for each PTV situation.

The average surface dose for the IMRT plans in the neck region was measured to be 59%, 78% and 92% of the prescription dose for the PTV_1, PTV_2, and PTV_3 plans respectively, and likewise, 46%, 56% and 74% in the supra-clavicular region. Table 1 shows the percentage of the surface dose for each position of the neck and supra-clavicular region measured with both dosimeters and normalized to the prescription dose located inside Rando's neck.

Table 1 Percentage of surface dose on points located on Rando's neck and supra-clavicular region normalized to the prescription point inside Rando's neck.

Measurement position on Rando	PTV_1 (%)	PTV_2 (%)	PTV_3 (%)
Right side of the neck surface	62	90	95
Center of the neck surface	53	69	91
Left side of the neck surface	61	75	91
Mean % dose of neck surface	59	78	92
Point 1 of the supra-clavicular surface	47	62	80
Point 2 of the supra-clavicular surface	44	59	74
Point 3 of the supra-clavicular surface	46	48	67
Mean % dose of supra-clavicular surface	46	56	74
Point of dose normalization inside Rando's neck	100 (1.63 Gy)	100 (1.63Gy)	100 (1.63 Gy)

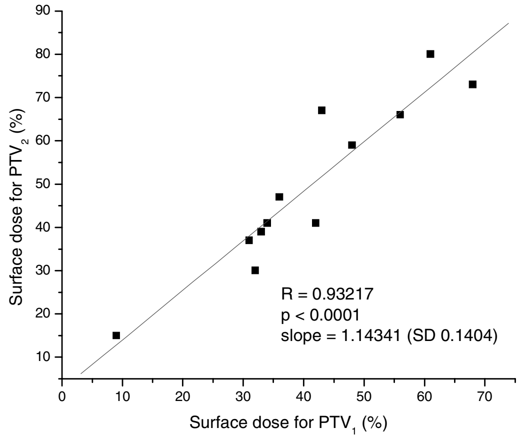

Fig. 1 Percentage of the surface dose measurements for plans with PTV_1 and PTV_2. The TLDs and MOSFETs were placed in 12 different positions on the Rando's head, neck and supra-clavicular region. The average surface dose for each position was normalized to the prescription dose located inside Rando's neck.

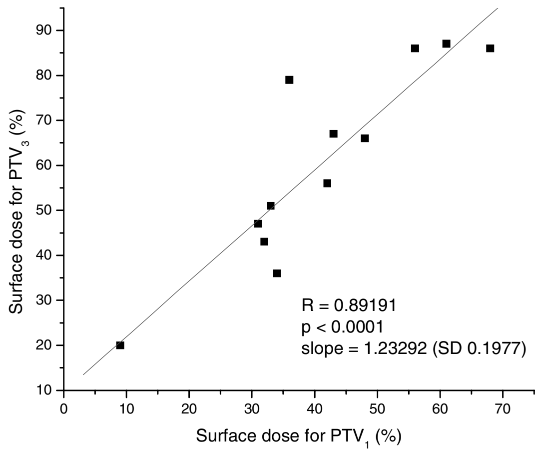

Fig. 2 Percentage of the surface dose measurements for plans with PTV_1 and PTV_3. The TLDs and MOSFETs were placed in 12 different positions on the Rando's head, neck and supra-clavicular region. The average surface dose for each position was normalized to the prescription dose located inside Rando's neck.

IV. Conclusions

For the IMRT plans the surface dose increased as a function of PTV proximity to the surface. The linear relationship between the surface dose measurements for plans with the PTV_1 versus PTV_2 and PTV_3 is indicative that the increase in surface dose is not a function of measurement location or shape of PTV, but only a function of PTV depth from the skin.

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