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Robustness to set-up errors for treatment plans for superficial tumors in head and neck radiotherapy

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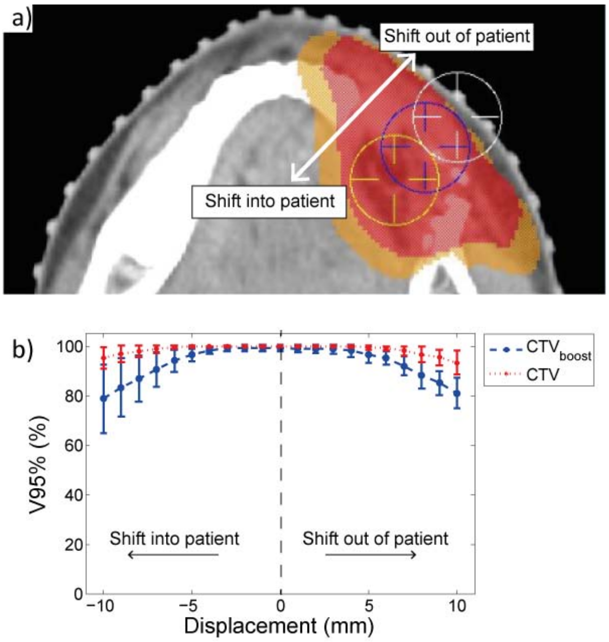
Purpose or Objective: Clinical target volumes (CTV) in the head and neck region are typically located just beneath the skin. Therefore, planning target volumes (PTV) will be outside the body contour. Moreover, for IMRT and VMAT treatment plans the build-up region is excluded from the PTV in the treatment planning system and optimization is done on the remaining part of the PTV (in our institute excluding the PTV outside the patient and a margin of 4 mm beneath the skin). This study evaluates the robustness of such treatment plans to set-up errors.

Material and Methods: Seven head-and-neck treatment plans were evaluated (VMAT, SIB with 54.25 Gy to the CTV and 70 Gy to the CTVboost in 35 fractions, CTV to PTV margins were 3 mm, Pinnacle Treatment Planning system). To investigate the effect of set-up errors on CTV coverage, a patient-shift on the treatment table is simulated as a shift of the isocenter. The isocenters were shifted in steps of 1 mm up to 10 mm for each of these treatment plans, in both directions ("into the patient" and "out of the patient", see Figure 1a; direction chosen in such a way that shifts out of the patients have the most effect). Subsequently, it was evaluated up till which step in mm the DVHs of the simulated (shifted) treatment plans were clinically acceptable (V95% > 99%).

Results: The effects of the shifts on the V95% of both the CTVboost and the CTV can be seen in Figure 1b. For the CTVboost regions (indicated by the blue line), it was found that the V95% was still 99% up to a shift of 3 mm (irrespective of the direction, into or out of the patient). For the elective region the V95% is still high enough (above 99%) up to a shift of 6-7 mm (6 mm into the patient, 7 mm out of the patient).

Figure 1 a) Effect of set-up error is simulated by shifting the original isocenter used for the delivered treatment plan (indicated by blue crosshairs) in the direction out of or into the patient (as indicated by the white arrow). The displacement of 10 mm into the patient is indicated by the yellow crosshairs, 10 mm in the direction out of the patient by the white crosshairs. CTVboost and CTV are indicated by red and orange colorwash respectively. b) The V95% values of the CTVboost and CTV due to the shifts of the isocenter.



Conclusion: This work shows that treatment planning in the head and neck region with a CTV to PTV margin of 3 mm and subsequent subtraction of a build-up region of 4 mm results in adequate CTV coverage up till setup errors of 3 mm. Since in clinical practice setup errors are well below 3 mm, this is a safe strategy.

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VMAT FFF irradiation in deep inspiration breath hold

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Purpose or Objective : Radiotherapy treatment on a lung moving tumor requires much caution. Among various treatments possibilities, the patient can be irradiated in deep inspiration breath hold during VMAT delivery. The purpose of this study was to investigate the feasibility of such irradiation. First, dosimetric effects of beam interruptions on VMAT delivery were determined. Then we studied the way to optimize dosimetry with multiple sub-arcs permitting breath hold. Finally another way to irradiate has been adjusted for a faster treatment while keeping VMAT advantages. We need to use a flattening filer free beam (FFF) to keep the irradiation time as low as possible.

Material and Methods: Dosimetric effect of beam interruptions delivery was studied depending on modulation, beam off numbers, dose rate and accelerator (TrueBeam, Clinac 2100C/S). We compared: absolute and relative dose and MLC Dyna/Trajectory Log files. Two rotations of 194° (clockwise/counterclockwise) were divided until 6 segments. Theirs overlapping or spacing have been compared (Eclipse). Dosimetric FFF plans with sub-arcs method was studied for 2 rotations of 360° depending energy, dose rate, segments numbers and treatment time.

Results: The maximal dose variation with beam interruptions was equal to 0.23%. TrueBeam Logfile showed that 10% of the control points have a difference higher than 0.05 mm between real and planning positions versus 70% with Clinac. The PTV volume receiving 95% of the prescribed dose V95% was equal to 99,35% with two arcs of 194° and 92,35% with one arc. When irradiation was performed with 6 segments spacing of 20°, V95% reach 98,08% with a dose reduction for the organs at risk (spinals cords: 2,2 Gy against 2,6 Gy). The sub-arcs method provided 6 arcs of 12 seconds compared to the standard 2 arcs of 40 seconds. Using FFF beams, the planning dosimetry was close to the standard treatment (Volume factor of injury cover equal 0.96 against 0.95) with a better OAR protection (spinals cords: Dmax=18,51 Gy with X6FF/2arcs, 11,75% with X10-FFF/6 arcs). For one rotation of 360°, the standard treatment needs 131 seconds versus three arcs of 12 seconds with FFF and sub-arcs.

Conclusion: We observed no significant dosimetric effect caused by beam interruptions. In order to have a shorter and a safer irradiation, the gantry rotation can be divided in several segments of 20° spacing. The dose distribution difference is insignificant and the OAR are better protected. The use of FFF and segmentation allows reducing the irradiation time by six.

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Feasibility of an "off-target isocenter" technique for cranial intensity-modulated radiosurgery

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Purpose or Objective: To evaluate the dosimetric effect of placing the isocenter away from the planning target volume on intensity-modulated radiosurgery (IMRS) plans to treat brain lesions.

Material and Methods: Fifteen patients, who received cranial IMRS at our institution, were randomly selected. Each patient