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

D. Den Boer1, E. Slooten1, G. Wortel1, E. Lammers-Kuijper1, O. Hamming-Vrieze1, C. Van Vliet-Vroegindeweij1, E. Damen3
1Netherlands Cancer Institute, Department of Radiation Oncology, Amsterdam, The Netherlands

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.