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Impact of interfractional deformable image registration variations for proton therapy of lung cancer treatments

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Introduction: With proton therapy, high dose conformity to the target can be achieved while sparing normal tissues, which makes it especially suitable for non-small cell lung cancer (NSCLC) patients. On the other hand, the proton dose is sensitive to density changes in the beam path and the anatomy of NSCLC patients often changes between fractions (fast tumor growth/shrinkage, weight changes). To evaluate the effect of these changes on the dose distribution, it is necessary to deform the recalculated dose distributions on regularly acquired repeated images via deformable image registration (DIR) to match the planning CT. However, uncertainties in DIR lead to differences in the dose distribution warped back to the planning CT, which can influence any further clinical decision. In this study, we aim to evaluate the dosimetric uncertainty introduced by DIR, and to compare its magnitude to the differences caused by anatomical changes.
Materials and Methods: For 7 NSCLC patients we designed proton treatment plans with 60 Gy-RBE to the PTV. We recalculated the dose on 9 repeated breath-hold CTs at different time points during treatment and warped these doses back to the planning breath-hold CT for accumulation with 6 clinically used DIR algorithms (see Figure1). Differences in PTV V95 were evaluated.
Results: Example accumulated dose distributions warped with different DIRs are shown in Figure1. Large dose differences caused by anatomical changes were also seen in the deformed doses. By choosing different DIRs, differences up to 20% in PTV V95 can be observed.
Conclusions: Dose differences caused by anatomical changes are generally larger than those caused by the use of DIR algorithm. However, DIR variations should be considered when taking clinical decisions.

Figure 1:Initial plan dose, accumulated doses warped with different DIRs and DVH of PTV, CTV and ipsilateral lung. The solid line is the initial planned dose. The band shows the variations between accumulated doses with different DIRs

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