Session title

Track **Abstract submission: Physics**

Topic **Physics track: Adaptive radiotherapy and inter-fraction motion management**

Presentation preference **Oral presentation**

Abstract title **Plan-library supported automated replanning for online-adaptive IMPT of cervical cancer**

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Purpose or Objective

Intensity-modulated proton therapy (IMPT) is very sensitive to small daily density variations along the pencil beam paths and variations in target and OAR shapes. This makes IMPT for sites with large inter-fraction target deformations extra challenging, such as in the treatment of cervical cancer. Online replanning is an option to achieve adequate target dose in each fraction. This study evaluates a novel approach employing a pre-treatment established plan-library as prior information in automated online replanning for IMPT of cervical cancer.

Material and Methods

CT data of 5 cervical cancer patients was available, comprising of a full and empty-bladder CT and 3-4 repeat CTs. Prescribed dose for the primary tumor and pelvic ±para-aortic lymph nodes was 45 Gy. Pre-treatment plan-libraries were created to provide prior spot distributions for replanning on the repeat CTs. One consisted of two treatment plans based on the full and empty-bladder CT +8 mm margin and the other of one treatment plan encompassing all target deformation observed in the full and empty-bladder CT +10 mm margin, i.e. a large ITV. In case of the 2-plan-library the daily bladder volume was used to select the prior plan for replanning.

The reoptimization method starts with a spot-position (Bragg peak) restoration from the selected prior plan by adjusting the energy of each pencil beam to the water equivalent path length in the repeat CT. To further compensate for deformations, new spots are added. The reference point method (RPM) is then used to optimize the spot weights. The RPM has been automatically tuned on benchmark plans of 4 CTs (i.e. optimized from scratch without time constraints) and results in a reoptimized Pareto optimal plan for the new anatomy, with similar trade-offs as in the benchmark plan. Replanning was performed for each repeat CT using tight margins of 5/2 mm (primary tumor/nodes), only meant to account for intra-fraction motion. The prior and reoptimized plans were evaluated on the repeat CTs using the 5/2 mm-PTVs and compared to benchmark plans on the repeat CTs.

Results

Evaluating the prior plans on the repeat CTs without replanning resulted in $V_{95\%}$<95% in most CTs, with values down to 50% (see Fig 1). For both plan-library approaches, reoptimization increased the number of repeat CTs with adequate coverage (PTV $V_{95\%}$≥95% and $V_{107\%}$≤2%) from 2/19 to 19/19 CTs. Fig 2 shows the differences between the reoptimized and benchmark plans on the repeat CTs using the ITV or 2-plan-library as prior. Median improvements are seen up to 4.5%-point for bladder V_{30Gy} when using the 2-plan-library instead of the ITV plan, with

outliers up to 13.8%-point. Reoptimization took 3.6 min on average.

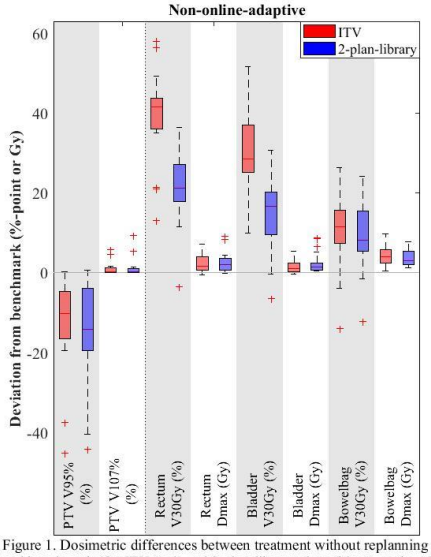

Figure 1. Dosimetric differences between treatment without replanning and benchmark (for ITV (red) and 2-plan-library plans (blue)) on the 19 repeat CTs. Differences closer to 0 correspond to better results.

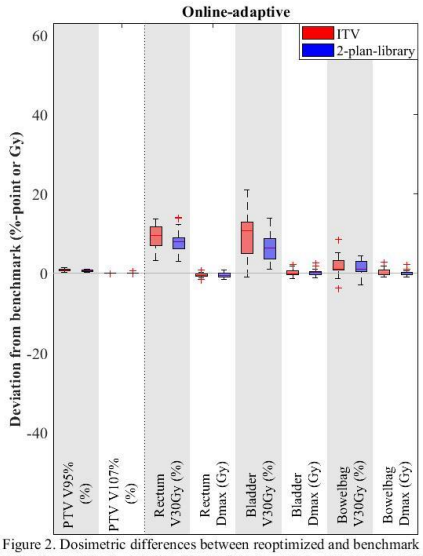

Figure 2. Dosimetric differences between reoptimized and benchmark using the ITV (red) or 2-plan-library (blue) as prior, on the 19 repeat CTs . Differences closer to 0 correspond to better results.

Conclusion

With fully automated replanning, adequate target coverage was restored for all CTs, as well as decreased OAR doses. The use of a 2-plan-library yielded lower OAR doses than a single ITV prior plan. With an average time of 3.6 minutes, this method is an important step towards online-adaptive IMPT in cervical cancer.

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Keyword **Particle therapy**