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PRESENTATION TITLE

R-IDEAL 0 simulation study: Investigation of the potential dosimetric benefits of treating lymph node oligometastases on the 1.5T MR-linac

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ABSTRACT

Purpose:
Superior soft tissue contrast provided by MR-images on the 1.5T MR-linac improves target visibility and may allow the use of smaller margins and incorporation of daily patient anatomy. This opens up opportunities for dose escalation and hypofractionation towards a higher biologically equivalent dose (BED) associated with improved local tumour control. The aim of this R-IDEAL 0[1] simulation study is to investigate the potential benefit of treating lymph node oligometastases on the 1.5T MR-linac.

Materials & Methods:
For this simulation study, pelvic and para-aortic pathological lymph nodes were included from 7 female patients with locally advanced cervical cancer. All treatment planning work in this study was performed using Monaco TPS research version 5.19.03d by Elekta AB (Stockholm, Sweden) using the MR-linac 7MV FFF beam model and presence of a 1.5T magnetic field in superior-inferior patient direction. Delineations were performed by an expert radiation oncologist.

First the dosimetric impact of planning target volume (PTV) margin reduction by treatment on the MR-linac was quantified using two treatment plans with an isotropic margin of 8mm (PTV margin for lymph nodes poorly visible on CBCT) and 3mm (well visible) for 33 lymph node oligometastases.

Secondly, the potential benefit of online replanning for SBRT of lymph node oligometastases on the 1.5T MR-linac compared to online position correction as used in current clinical practice was investigated (N=17). Pre-treatment plans with both a 3mm and 8mm PTV margin were calculated on daily anatomy after recontouring and placing the isocenter to the center of the PTV, To simulate online replanning, completely new treatment plans were generated based on the daily anatomy.

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Finally, the feasibility of dose escalation and hypofractionation was investigated for treatment on the 1.5T MR-linac. Three treatment plans were created for each of 17 lymph nodes with a prescribed dose of 5x7Gy, 3x12Gy and 1x24Gy using a 3mm isotropic PTV margin. Additionally a 1x24Gy plan was created using a 2mm isotropic PTV margin.

Table 1. Clinical dose criteria for lymph node oligometastases SBRT as used in the evaluation of the treatment plans based on the UK SABR consortium guidelines 2016. Dose criteria for 3 and 1 fraction(s) were calculated using the linear-quadratic (LQ) model with $\alpha/\beta=3$. Applying the LQ model for fraction doses >15Gy is associated with higher uncertainties.

Structure	5x7Gy	3x12Gy	1x24Gy
PTV	$V_{100\%}$ > 95%	$V_{100\%}$ > 95%	$V_{100\%}$ > 95%
	D_{max} < 135%	D_{max} < 135%	D_{max} < 135%
Bladder	$D_{0.5cc}$ < 38Gy	$D_{0.5cc}$ < 30.6Gy	$D_{0.1cc}$ < 18.6Gy
	D_{15cc} < 18.3Gy	D_{15cc} < 15.0Gy	D_{10cc} < 9.7Gy
Bowel, Rectum, Sigmoid	$D_{0.5cc}$ < 35Gy	$D_{0.5cc}$ < 28.2Gy	$D_{0.1cc}$ < 17.2Gy
	D_{10cc} < 25Gy	D_{10cc} < 20.4Gy	D_{5cc} < 12.7Gy

For all three experiments, evaluation was performed using dose criteria (Table 1) and by comparison of DVH parameters.

Results: Reducing the PTV margin from 8mm to 3mm shows significant dosimetric benefits. With margin reduction, the amount of cases in which concessions to the target coverage had to be made was reduced from 7/33 to 2/33. A comparison of DVH parameters between pre-treatment plans calculated on the recontoured daily MRI anatomy and online replanning shows that online replanning reduces the amount of unplanned violations of dose criteria (Figure 1). Hypo-fractionated and dose-escalated schemes seem to be feasible (Figure 2). In almost all cases with violations, the PTV overlapped with an OAR.

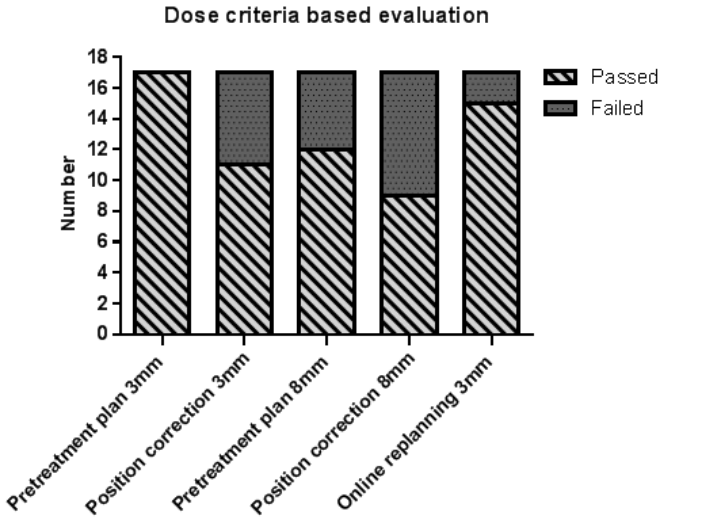

Figure 1. Number of plans (N=17) that met all dose criteria based on the UK SABR consortium guidelines and a prescribed dose of $V_{100\%}$ < 95%.

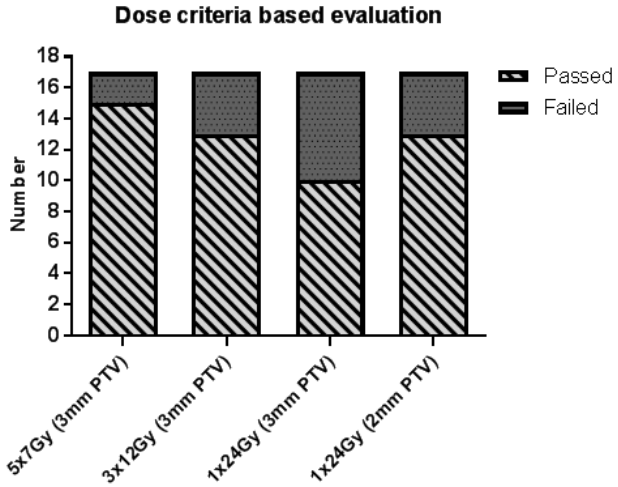

Figure 2. Number of plans (N=17) that met all dose criteria based on the UK SABR consortium guidelines and a prescribed dose of $V_{100\%}$ < 95%.

Conclusions:
This R-IDEAL 0 simulation study indicates a potential benefit of treating lymph node oligometastases on the 1.5 MR-linac. Improved sparing of surrounding OARs could be achieved by reduction of the PTV margin for poorly visibly lymph nodes as well as online replanning, which also yields better coverage of the PTV. Dose escalation, which is believed to further increase local control rates, and hypofractionation will become feasible.

[1] Verkooijen et al. R-IDEAL: A Framework for Systematic Clinical Evaluation of Technical Innovations in Radiation Oncology. Front Oncol 2017.