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Digital Poster 435 | Experimental dosimetric verification of the intra-fraction drift correction on the 1.5 T MR-linac

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Purpose/Objective:
MRI-guided online adaptive treatments enable better targeting of the tumor. However, to correct the intra-fraction motion there is a need for intra-fraction adaptation methods. A new motion management functionality, an intra fraction drift correction (IDC) was introduced for the 1.5 T Unity MR-linac (Elekta AB, Stockholm, Sweden). This functionality images the position of the tumor in real-time using cine MR-scans. The treatment plan can then be adapted within a minute by repositioning the segments when the tumor location shifts beyond a pre-defined limit [1]. The goal of this research is to experimentally verify the IDC using film, scintillation, and diode dosimetry.

Material/Methods:
To experimentally verify the IDC procedure, its dosimetric and geometric accuracy was verified using EBT3 film and Plastic Scintillation Dosimeters (PSDs) (Medscint, Quebec City, Canada). The Delta4 Phantom+ MR (ScandiDos AB, Uppsala , Sweden) was used as a QA procedure of the delivered beams during the EBT3 film measurements.
A radiotherapy treatment was mimicked whereby the QUASAR MRI4D motion phantom (IBA QUASAR, London ON, Canada) shifted in the middle of the treatment. First, a treatment plan based on a clinical lung SBRT template was

created. The phantom contains a cylinder with EBT3 film or a cassette with eight integrated PSDs for dose measurements. In the middle of the treatment, the cylinder was shifted 1 cm in inferior direction. Cine MR-scans (6Hz, interleaved coronal / sagittal) were recorded and the CCM software identified a shift in the defined tracking structure and the segments were repositioned, denoted as the IDC plan, illustrated in Figure 1. The remaining beams were delivered with the new IDC plan.

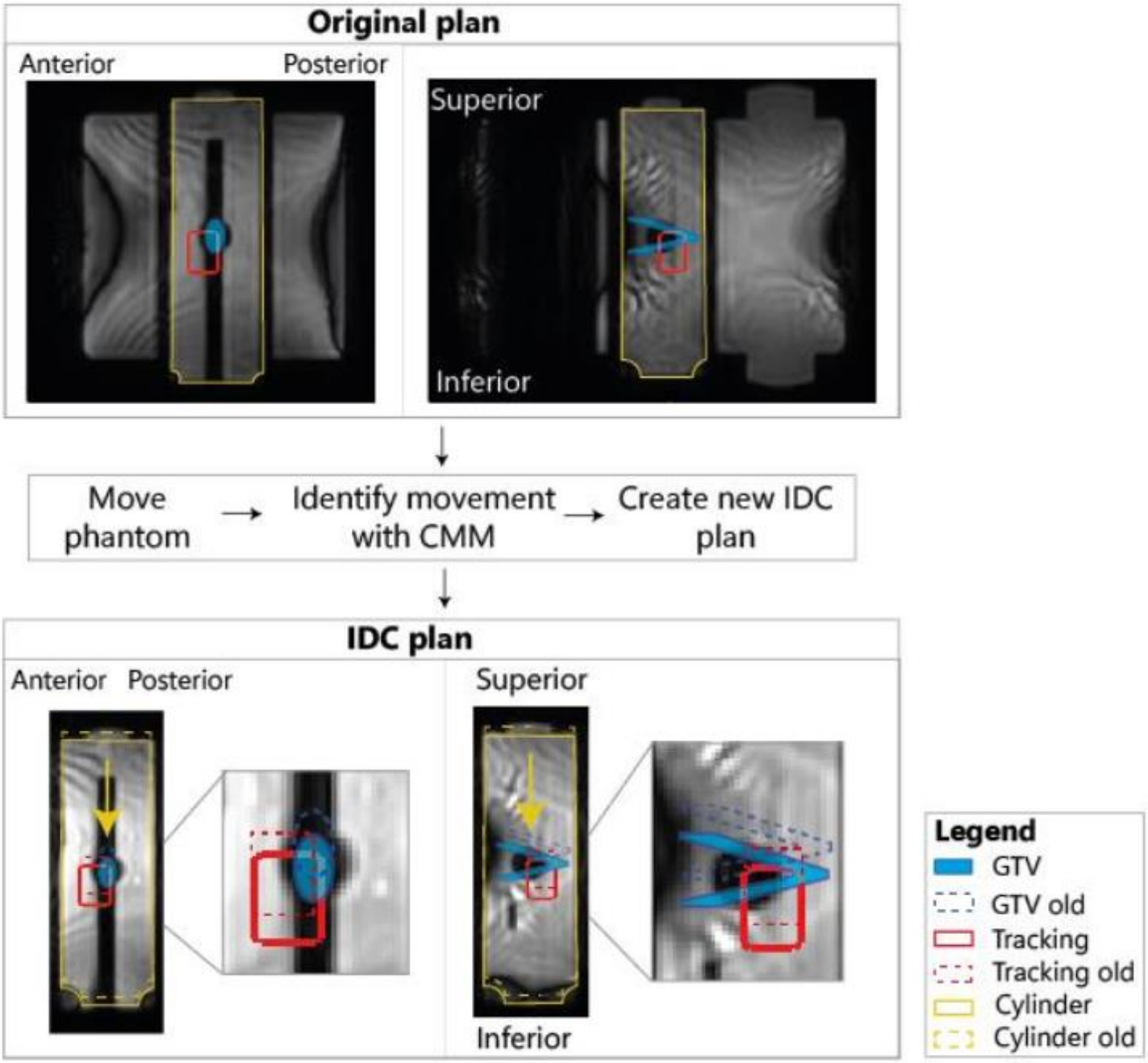

Figure 1. Comprehensive motion management (CMM) software used during the experimental validation of the Intra-fraction Drift Correction (IDC) using EBT3 film.

For the film measurements a V-shaped GTV, shown in Figure 1, was used, to facilitate registration of the film to the calculated dose. A treatment of 14 beams was used with a prescription dose of 8 Gy. The absolute measured and calculated dose was compared, investigating dose deviations and γ passing rates (2%/2mm). The total calculated dose was created by summing the dose of the first half of the treatment (original plan) and the second half of the treatment (IDC plan) shifted by 1 cm.

For the PSD measurements a treatment of 13 beams was used with a prescription dose of 7.5 Gy. The GTV was defined

as a sphere with 3 cm diameter. The measured doses were compared between the original plan and the IDC workflow.

The Delta4 Phantom+ MR was used as a QA procedure of the delivered individual beams and the total delivered IDC workflow of the EBT3 film measurements, illustrated in Figure 2. For the total IDC workflow, the Delta4 remained in the original position for the first seven beams and for the final seven beams the phantom was shifted by 1 cm. The total calculated dose was created by summing the dose of the first seven beams on the original plan and the shifted seven beams which were interpolated by 1 cm on the IDC plan. Measured and calculated doses were compared using γ passing rates (3%/3mm).

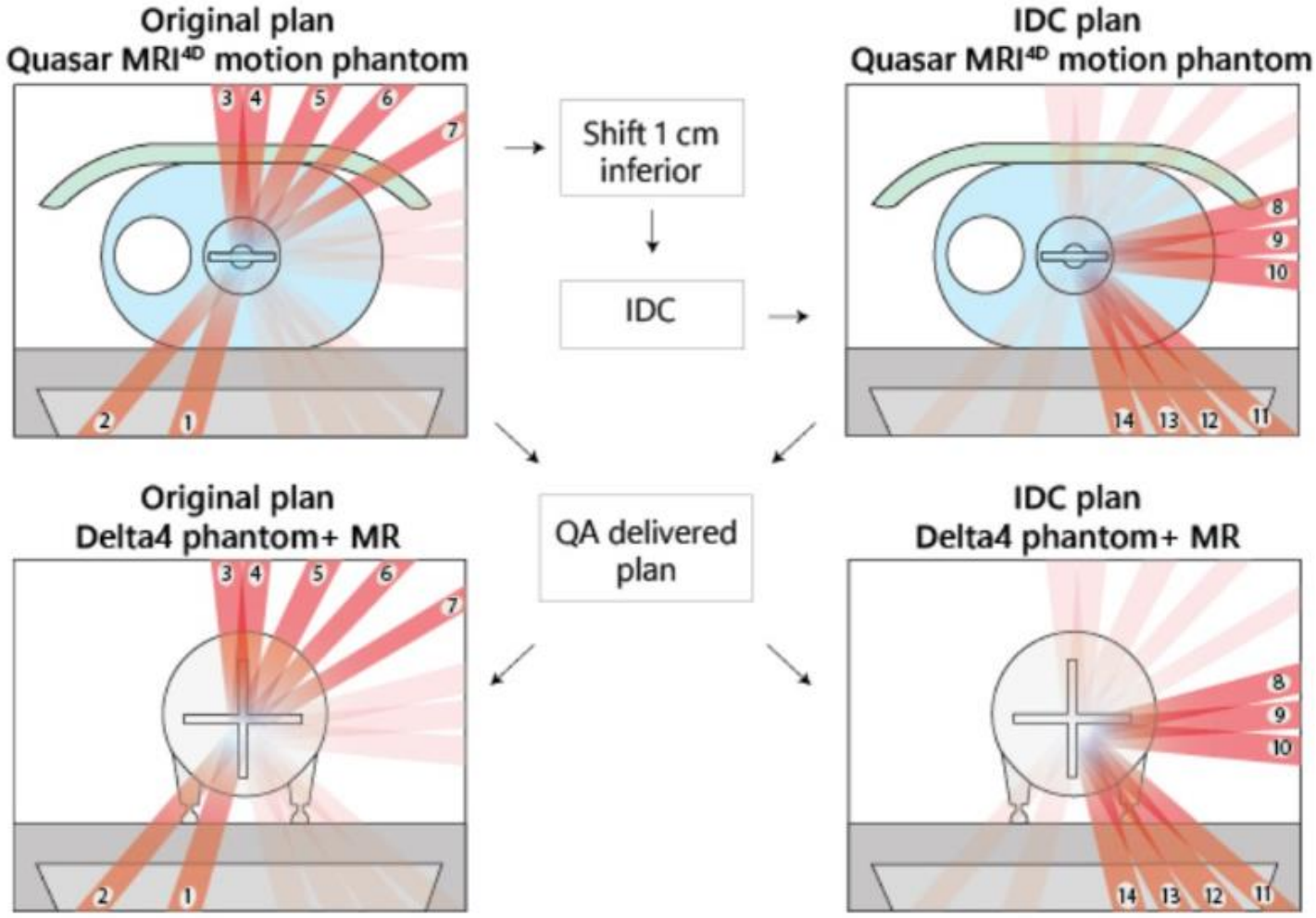

Figure 2. Workflow of the IDC treatment using EBT3 on the QUASAR MRI4D motion phantom including a QA dosimetric verification on the Delta4 phantom+ MR.

Results:
The experimental verification of the IDC showed a good agreement between the total measured and calculated treatments, using EBT3 film. The global γ passing rates were 99.6% and 99.1%, for threshold doses of 10% and 80% of the maximum dose. The mean dose differences were -0.3% ± 1.2% and 0.1% ± 1.1%, for threshold doses of 10% and 80% of the maximum dose. The PSD in the high dose region showed a dose difference between original and IDC workflow measurements of 0.1%. The other PSDs showed larger dose differences between the measurements on the high dose gradients with dose difference of 0.0% ± 9.1%. The individual beams on the Delta4 phantom showed a good agreement between measured and calculated doses, with a mean γ passing rate of 95.4% ± 7.0%. The total delivered dose of the IDC workflow showed a γ passing rate of 99.6%.

Conclusion:
A good agreement between the total measured and calculated IDC treatments were shown with high γ passing rates

and small dose deviations illustrated with film. A good agreement between the original and the IDC workflow were shown in the high dose region with scintillation dosimetry and larger deviations were shown in the higher gradient regions susceptible to positioning uncertainty. The individual beams and the total IDC workflow on the Delta4 showed a good agreement between measured and calculated doses. The IDC is a valuable functionality for fast intra-fraction adaptations and this research verifies the geometric and dosimetric accuracy of the IDC process.

Keywords: MR-linac, intra-fraction drift correction

[1] Fast, Martin, et al. "Tumor trailing for liver SBRT on the MR-Linac." International Journal of Radiation Oncology Biology* Physics 103.2 (2019): 468-478*