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6th MR in RT Symposium 2018

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PRESENTATION TITLE

Heterogeneous and homogeneous 3D dosimeters for MR-IGRT systems

AUTHOR(S)

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ABSTRACT

Please type in your abstract up to a MAXIMUM of 500 words. Figures may be included.

Purpose: To demonstrate the quantitative abilities of novel reusable and non-reusable MR-visible gel dosimeters incorporating nonhomogeneous components to mimic anatomic heterogeneity for MR-IGRT. Due to the presence of a strong magnetic field in MR-IGRT systems, conventional point and planar measurement devices may no longer be sufficient for QA of multi-beam radiation delivery to anatomies containing air cavities and other structures.

Materials & Methods: Reusable heterogeneous anthropomorphic and non-reusable homogeneous large volume gel phantoms were irradiated with simple 3D and more complex step-and-shoot TG119 IMRT plans in a pre-clinical 1.5 T – 7 MV MR-linac (Elekta AB, Stockholm, Sweden). Each dosimeter was imaged with T1-weighted MR sequences in the MR-linac immediately prior to and post irradiation for dose analysis. Heterogeneous gels were irradiated inside a water-filled IROC-Houston IMRT Head and Neck phantom with five 3D plans, ranging from delivery of one to seven beams. Heterogeneity was incorporated with four different components: 1.3 cm diameter solution, 1.3 cm diameter gel, 1.3 cm diameter air cavity, and 3 cm diameter air cavity. Homogeneous gels were created in a cylindrical 2-liter container and were irradiated with five TG119 plans: AP PA, MultiTarget, Prostate, Head/Neck, and C-Shape. Plans were generated using research Monaco TPS (version 5.19.02), and 3D Slicer was used to perform 3D gamma comparison between the planned and measured doses (calculated from the MR images of the gels). Figure 1 summarizes the overall workflow in the MR-linac: fusion of the CT and daily MRI for plan adaptation, delivery of the plan, acquisition of post-irradiation MRI, scaling of the MRI of the gel to delivered dose, comparison of delivered dose to planned dose using gamma analysis.

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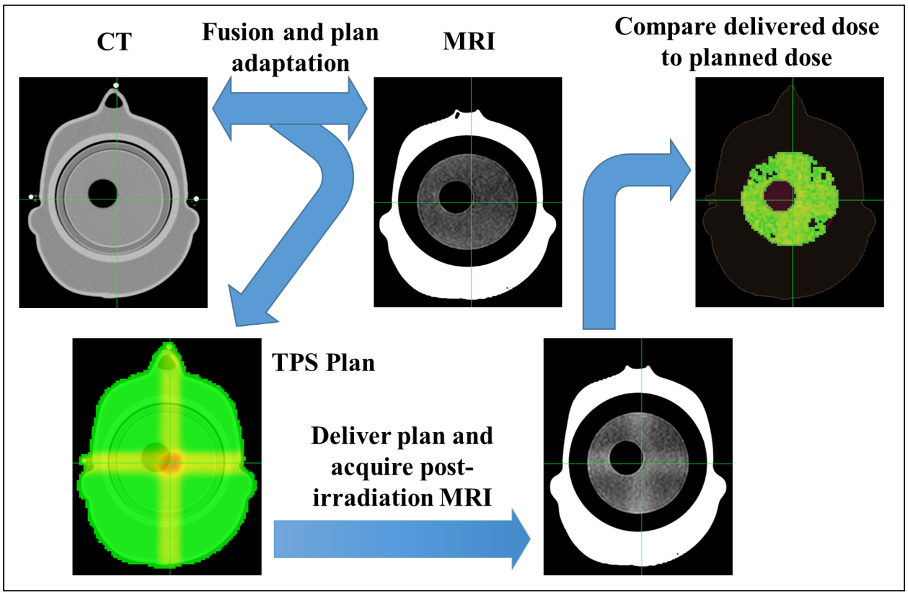

Figure 1: Overall MR-linac gel workflow. First, make a reference TPS plan from the CT. Next, fuse the daily MRI with the CT and make an adapted plan. Next, deliver this plan and obtain a post-irradiation MRI. Scale the acquired MRI of the gel linearly to a relative dose. Finally, compare the relative delivered dose with the planned dose.

Results: Using gamma criteria of 7%/4mm (IROC-Houston's constraints for the Head and Neck phantom), the heterogeneous phantoms had gamma pass rates ranging from 92.74-99.14% (lowest pass rate for 1.3 cm gel insert and 3 beams and highest pass rate for 1.3 cm air insert and 3 beams). Using gamma criteria of 5%/3mm, the heterogeneous phantoms had gamma pass rates ranging from 77.63-87.68% (lowest for 1.3 cm gel insert and 7 beams and highest for 1.3 cm gel insert and 1 beam). Using gamma criteria of 3%/3mm, the heterogeneous phantoms had gamma pass rates ranging from 51.06-76.63% (lowest for 1.3 cm gel insert and 3 beams and highest for 1.3 cm solution insert and 1 beam). Using gamma criteria of 7%/4mm, the homogeneous phantoms had gamma pass rates of 99.06% (AP PA), 96.73% (MultiTarget), 97.94% (Prostate), 94.28% (Head/Neck), and 94.79% (C-Shape).

Conclusions: The calculated volumetric doses from the heterogeneous phantoms were comparable, regardless of the heterogeneous component (ranging from gel to air). The gamma pass rates for the homogeneous phantoms were within 5% of the pass rate for the simple AP PA plan. Future work will involve improving the MR image quality for tighter gamma criteria suitability. Since these dosimeters demonstrate MR contrast post-irradiation, they can be used for patient workflow testing in MR-IGRT systems both for training and for comparison with TPS calculated doses.