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Evaluation of a MR compatible phantom for patient specific QA

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Introduction:

Most phantoms for patient specific Quality Assurance (QA) are not MR compatible and not MR safe. The Delat4+MR phantom was redesigned to be used in combination with Magnetic Resonance Linear Accelerators (MR-Linac). Here we report extended testing of this phantom and our early clinical experience using the phantom for patient QA.

Materials and Methods:

Since April 2019, a 0.345T MR-Linac (ViewRay, Mountainview, SN228) is clinically operational in the Radiation Oncology department at University Hospital of Zürich. For patient specific QA the Delta4 Phantom+MR (ScandiDos, Sweden) has been tested. With this phantom and a MR compatible Farmer Ionization Chamber (PTW Freiburg, Type TW30013), four tests have been performed. 1. Daily output of the MR-Linac: The output of the machine was measured daily with the Delta4+MR phantom and the chamber in a solid water block. 2. Angular dependency of the phantom: Equally distributed fixed beams with different gantry angles were irradiated on the Delta4+MR phantom and compared with free air measurements of the Farmer Chamber. For the Delta4+MR, the lower beams (gantry angles 135° to 225°) were absorbed additionally by the couch and the fixed compartment of the couch, whereas for the Farmer chamber only the latter was the case. 3. Field size dependence of the phantom: Square fields from 4x4cm² to 20x20cm² were irradiated. Due to the plus arrangement of the 2D arrays of the Delta4+MR phantom, the field size dependency measurements were conducted at a gantry angle of 315°. 4. Patient specific QA: The Delta4+MR phantom was used to asses several patient plans. All the measurements were evaluated with the gamma evaluation method in the Delta4 software (by ScandiDos, Sweden).

Results:

The daily output changes measured with the phantom were within 2%(0.9%) and in good agreement with the chamber measurements(0.6%). The angular dependency of the phantom was small (average gamma passing rates 98% for 3%/3mm and 94% for 2%/2mm criteria) except for the gantry angles 0°,180°, 90 and 270°. This is probably due to the 'plus'detector arrangement of the phantom. Excluding these four angles, the gamma agreement increased to 99.2% for 3%/3mm criteria. The average deviation for angular dependence between Delta4 Phantom+MR and Farmer Chamber was 0.5%. The phantom's gamma passing rate for a field size of 4x4cm² was 100% for 3%/3mm and 92.8% for 2%/2mm criteria and 99.9% for 3%/3mm and 94.9% 2%/2mm for the field size of 20x20cm². The disagreement was similar for all field sizes. Out of the first measured 36 patient plans, only one plan failed the gamma passing criteria of >95% (3%/3mm), the average gamma passing rate was 99.7% for 3%/3mm and 98.2% for 2%/2mm criteria.

Conclusion:

It was shown that the MR compatible phantom is stable over time and shows only a small directional and field size dependence. The Delta4 Phantom+MR can be used for patient specific QA without any major concerns.

Authors: Ms SAFARKHANLO, Yasaman (University of Zurich and UniversitätsSpital Zürich); Mr BAUMGARTL, Michael (UniresitätsSpital Zürich)

Co-authors: EHRBAR, Stefanie (University Hospital Zurich); Dr ZAMBURLINI, Mariangela (UniversitätsSpital Zürich); Mr KRAYENBÜHL, Jérôme (Department of Radiation Oncology, University Hospital Zurich and University

of Zurich, Zurich, Switzerland); Ms CHAMBERLAIN, Madalyne (Radiation Oncology Department, Universitätsspital Zürich, Switzerland); Dr WILKE, Lotte (Universitätsspital Zürich); Dr TANADINI-LANG, Stephanie (Radiation Oncology Department, Universitätsspital Zürich, Switzerland)

Presenter: Ms SAFARKHANLO, Yasaman (University of Zurich and Universitätsspital Zürich)

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