Implementation of a Secondary Dose Calculation System for a Magnetic Resonance Linear Accelerator

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1. Purpose

To report the implementation of the secondary dose calculation software ThinkQA (TQA) v.2.0.0.60 (DOSIsoft) for a magnetic resonance-guided linear accelerator (MR-linac), following the tests of Medical Physics Practice Guideline 5.a, including dose in inhomogeneities and dose profiles.

2. Methods and Materials

Relative Dosimetry

In Monaco v.5.51.11, fields of 2×2, 5×5, 10×10, 15×15, 20×20, and 2×20 cm² were modeled at gantry 0°, at depths of 5 and 10 cm, in an isocentric configuration to obtain dose profiles and field factors.

Dose in Inhomogeneities

In Monaco, the dose was calculated with a 10×10 cm² field and 200 MU in a water-air-water phantom.

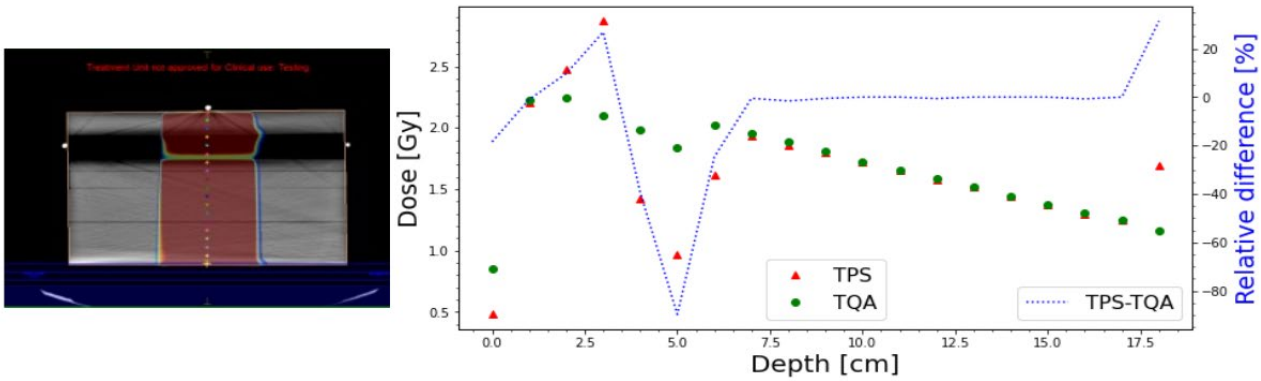


Fig 1. Dose distribution in inhomogeneities.

MLC Transmission

The dose was measured at 5 cm depth using a 10×10 cm² field and 200 MU, with the Exradin® chamber oriented antiparallel to the magnetic field.

Patient-Specific Quality Assurance

Five intensity-modulated radiation therapy (IMRT) plans (anal, abdominal, head & neck, prostate, and lung) were measured following AAPM TG-244 guidelines. The measurements were evaluated using the 3.0%/2.0 mm gamma criterion with the ArcCheck®-MR device (SunNuclear, Melbourne, FL, USA).

Planing system commissioning

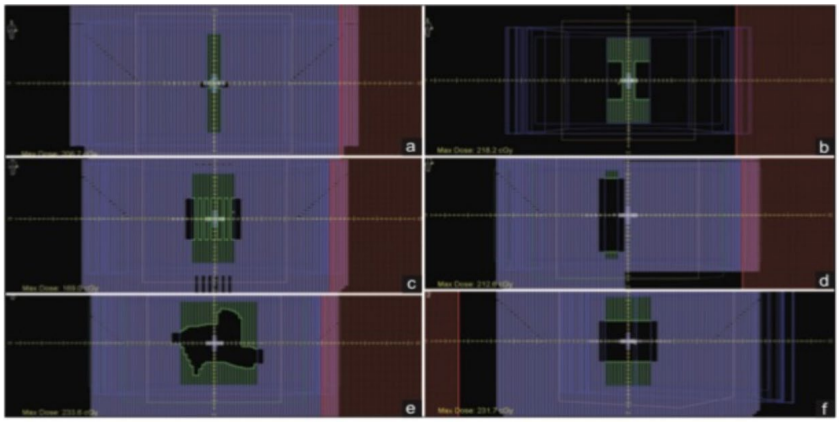
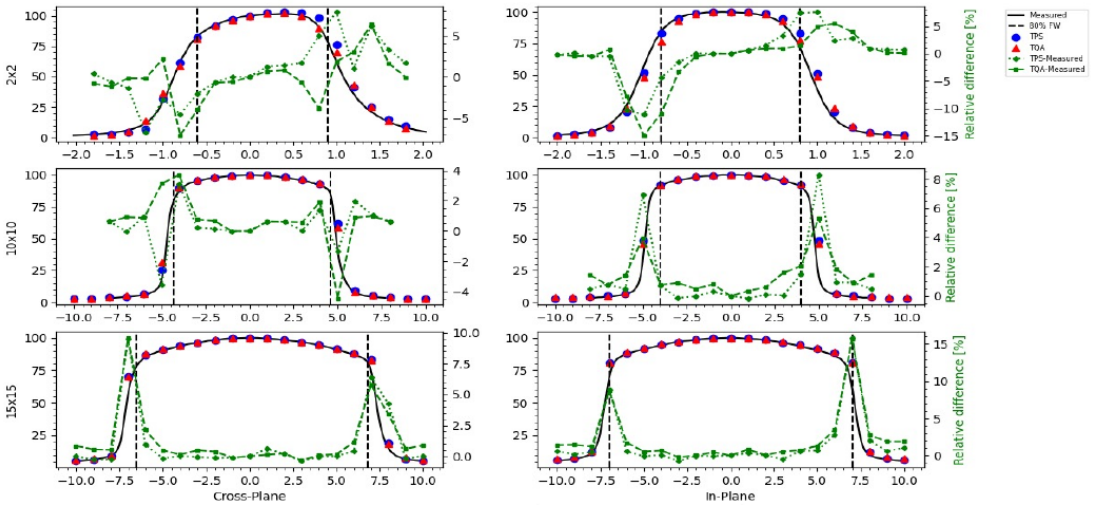


Fig. 2. Fields configuration for the planning system commissioning.

3. Results

Relative Dosimetry

Fig. 3.



Comparison of dosimetric profiles.

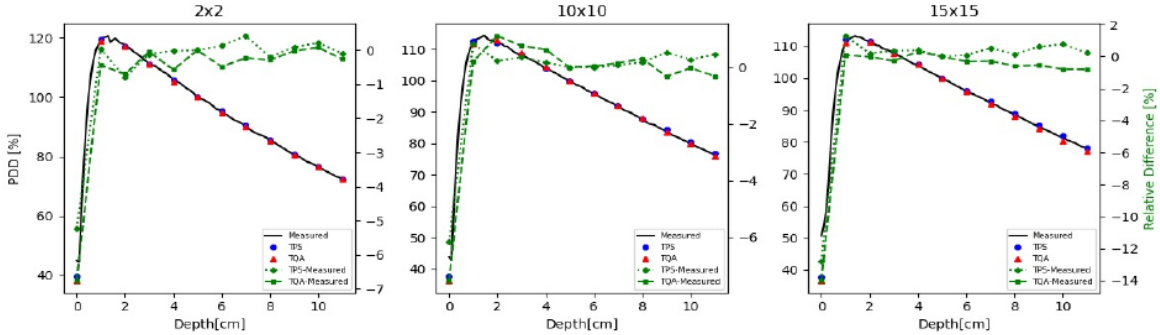


Fig. 4. Comparison of depth dose profiles.

Variations of 3.8% were reported for field factors up to 2×2 cm², comparing measured data and Monaco with TQA.

MLC Transmission

MLC transmission values were 0.25%, 0.60%, and 0.50% for experimental measurements, Monaco, and TQA, respectively.

Patient-Specific Quality Assurance

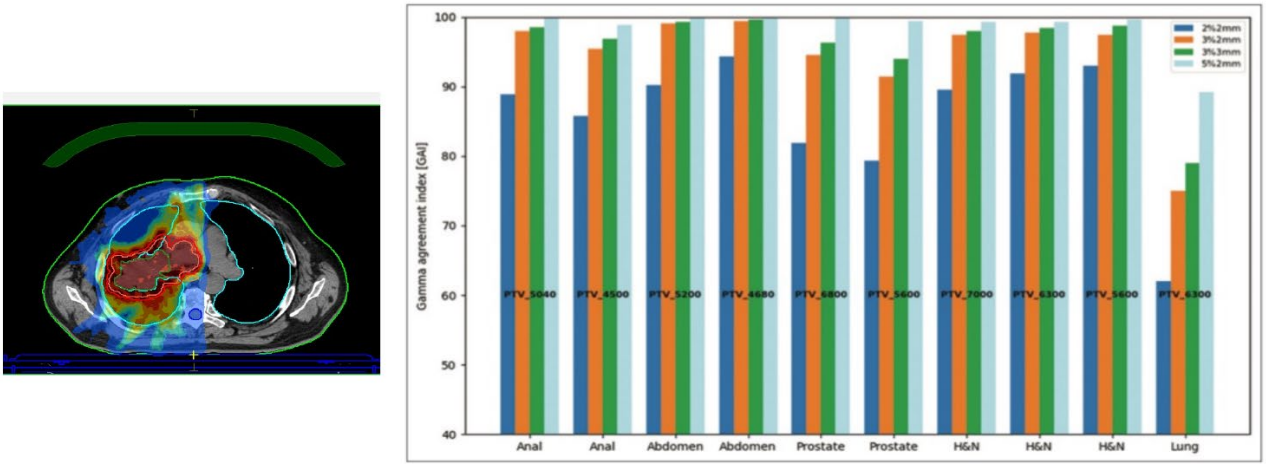


Fig. 5. Gamma index evaluation in clinical plans.

Planing system commissioning

Test	Result
Dose vs. reference calibration condition	0,5%
Small MLC-shaped field	1,0%
Large MLC-shaped field with wide blocking	3,5%
Off-axis MLC-shaped field	-4,0%
Asymmetric field at anticipated minimum SSD	-3,8%
10×10 field with oblique incidence (30°)	-2,1%

Table 1: Results of TQA commissioning.

4. Conclusion

The TQA software was implemented as a secondary dose calculation system for MR-linac and was clinically validated for adaptive treatment workflow using a 3%/2 mm gamma criterion, with 95% as a tolerance limit and 90% as an action limit.