Proposal of a Comprehensive Pre-Treatment QA Procedure in IMRT/VMAT Techniques

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Introduction and objectives

To propose a comprehensive pre-treatment QA procedure, independent of TPS and linac control system, to detect errors related to dose calculation and/or dose delivery in state-of-the-art IMRT/VMAT techniques.

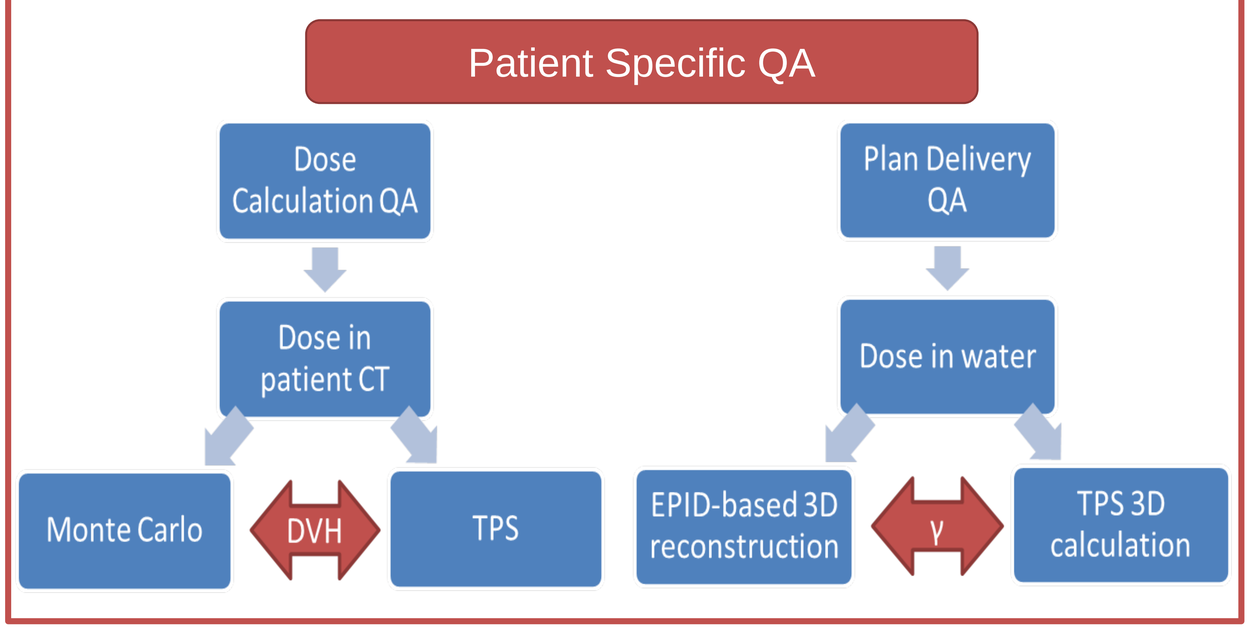
Methods

The proposed pre-treatment QA procedure consists of the subsequent application of two independent methodologies: one relevant to dose calculation QA and the other to dose delivery QA.

The dose delivery QA relies on an in-house developed, plan-specific, 3D dosimetry approach based on EPID technology. The methodology reconstructs a 3D dose distribution in a virtual water phantom based on calibrated and back-projected EPID images. The accuracy of the reconstructed 3D dose distribution has been investigated for deveral complex treatment plans [1]. The sensitivity to geometric and dosimetric errors between the original treatment plan and intentionally modified treatment plans has been assessed in terms of controlled translational shifts of the MLC, rotational shifts of the gantry and over-dosages of the original treatment plan [2].

The dose calculation QA relies on referencing the analytical TPS dose distribution with a more accurate equipment-specific Monte Carlo (MC) dose simulation [3]. DICOM images can be imported in the MC model for precise modeling of patient/phantom geometry (Figure 1). The methodology is under validation against standard dosimetric devices.

The flowchart of the QA procedures is illustrated in the following:



The gamma evaluation with acceptance criteria (3%, 3mm) between the reconstructed EPID-based 3D dose distribution and the TPS calculation resulted in a passing rate of 95% (Figure 2), for a VMAT Head and neck plan

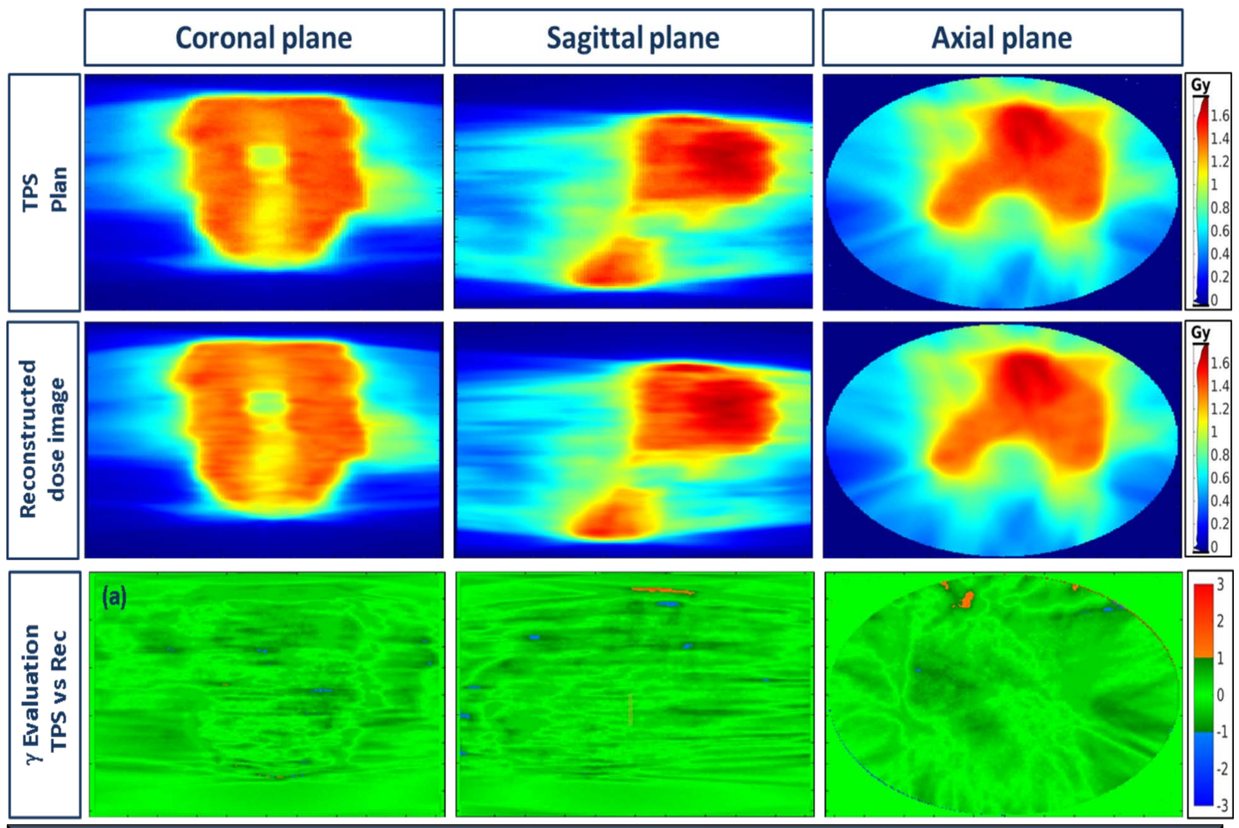


Figure (2) Different views of 3D gamma evaluation between the 3D dose distributions calculated by the TPS and reconstructed 3D dose distributions at the iso-center slice of a VMAT H&N treatment plan.

The dose distribution simulated by the Geant4 model shows similar behavior as the dose measured with the OCTAVIUS® phantom (Figure 3).

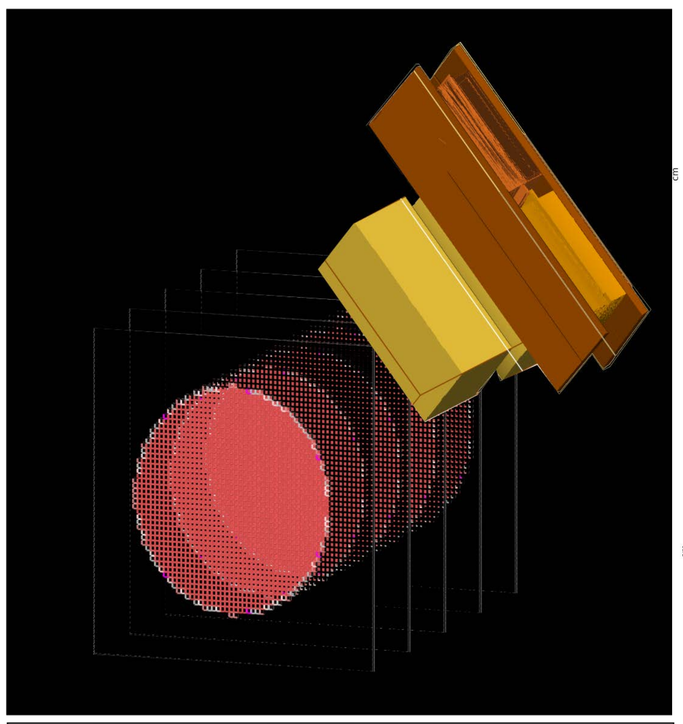


Figure (1) The Geant4 model of an Eleekta Agility® with the OCTAVIUS® phantom, reconstructed based on DICOM images.

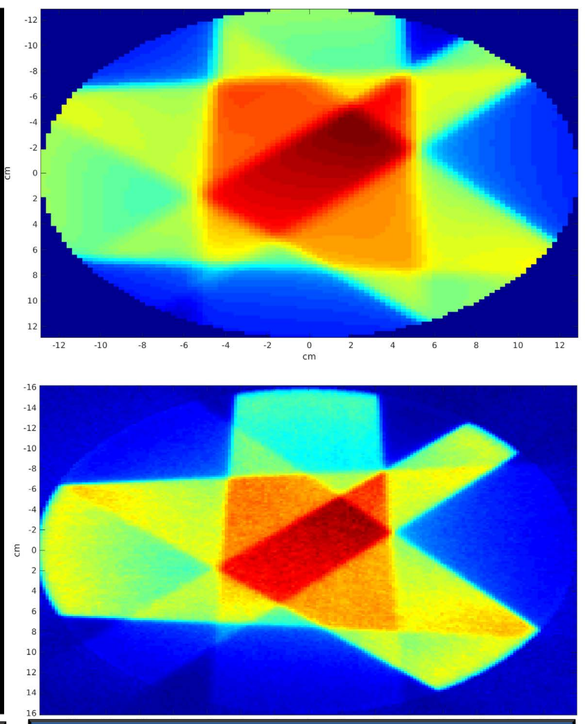


Figure (3) Dose distribution measured by OCTAVIUS® phantom (top), and simulated by the Geant4 model (bottom).

Results

The adequacy of the two presented methodologies for the proposal of a comprehensive pretreatment QA procedure has been demonstrated

Conclusion

The feasibility of a comprehensive patient-specific pre-treatment QA procedure was demonstrated. The EPID-based methodology for plan delivery QA is well developed and validated for complex plans. Moreover, it shows adequate sensitivity to catch geometric and dosimetric errors. The gamma evaluation was able to detect both geometric and dosimetric errors. Further validation of the Monte Carlo model is foreseen.

References

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[3] Kry, Stephen F., et al. "Algorithms used in heterogeneous dose calculations show systematic differences as measured with the Radiological Physics Center's anthropomorphic thorax phantom used for RTOG credentialing." *International Journal of Radiation Oncology* Biology* Physics* 85.1 (2013): e95-e100.