Validation of a MC software for the QA of patients treated with modulated intensity photon beams

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Objectives

Nowadays patient specific QA (PSQA) is very important in the RT workflow, especially for patients with highly conformed treatment plans, and it is usually performed prior to patient treatment. Patient QA is fairly time consuming and takes up a lot of time-machine, stealing it from patients' treatments. Moreover, physicist's time is a limited resource.

The innovation proposed within this work is to introduce a new MC software (SciMoCa) in the RT workflow, which can be used as a fast-secondary dose check and an independent plan QA evaluating tool. This method allows to verify only those treatments that do not pass the minimum acceptance criteria.

The aim of the study is to evaluate SciMoCa, testing its performances in term of accuracy, repeatability and calculation time.

Methods

SciMoCa was benchmarked against TPS Monaco and Pinnacle^3 in VMAT techniques, based on MC and CCCS dose calculation algorithm respectively. All three software were commissioned for same 6MV Elekta accelerator using same measurement set.

Fifty patients of six clinical classes (CNS, H&N, breast, lung, prostate and bone metastasis) were randomly selected from clinical database and computed with all algorithms using same calculation parameters. Dose accuracy was studied by assessing isocenter point dose differences while dose distributions were evaluated with statistics of 2D-gamma analysis (%GP), metrics 3% / 3mm - TH10% [1,2].

Software performances were also compared with measurements relying on ArcCHECK device to evaluate dose differences in a homogeneous phantom. Comparison was performed with same setting as before.

A modulation factor, F_m, is introduced to verify whether there is a correlation between complexity of treatment plan and %GP. F_m is defined as the ratio of prescribed MU and dose (cGy) prescribed at isocenter [3].

Results

On average, percentage point dose difference between TPS and SciMoCa is -1.8±1.8% (Monaco) and -0.5±1.1% (Pinnacle^3), **Figure 1**; while for softwares to ionization chamber measurements it is -0.6±1.7%, 0.4±1.4% and 0.8±1.7% for Monaco, Pinnacle3 and SciMoCa, respectively. **Figure 2**.

Comparing SciMoCa dose distributions to those of Monaco and Pinnacle^3, average passing-rates (3%-3mm absolute term), are 94.5±5.4% and 96.5±3.5%, respectively. While for TPSs and SciMoCa to ArcCHECK measurements, passing-rates is 94.0±3.3%, 95.3±2.5% and 93.1±3.2% for Monaco, Pinnacle^3 and SciMoCa, respectively.

The repeatability of the simulated dose is very high, within few ‰. Considering a standard PC (CPU: Intel Core i7-6500U, 2.59GHz; RAM:16GB) the calculation time is in the order of 30 minutes. It decreases as dose computation uncertainty increases and the same happens increasing dose grid resolution.

Plotting %GP against F_m, correlation and determination coefficients (R_P and R^2_{adj} respectively) are close to zero which means there is no identified correlation between the two quantities. **Figure 3**.

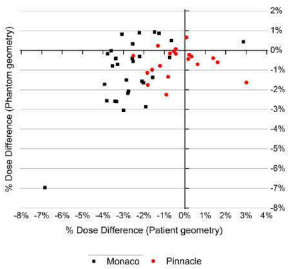

Figure 1. Dose percentage differences between dose computed with TPS (Monaco or Pinnacle^3) and SciMoCa. Percent difference in patient geometry is plotted horizontally on the X axis, while in phantom geometry is plotted vertically on the Y axis. Data points are categorized by treatment planning system.

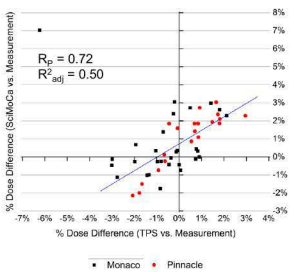

Figure 2. Dose percentage differences between dose calculated with TPS (Monaco or Pinnacle^3) and SciMoCa, and dose measured with ionization chamber in ArcCHECK. TPS vs. measurement percent difference is plotted horizontally on the X axis, while SciMoCa vs. measurement is plotted vertically on the Y axis. Data points are categorized by treatment planning system. R_P = Pearson's correlation coefficient; R^2_{adj} = adjusted determination coefficient.

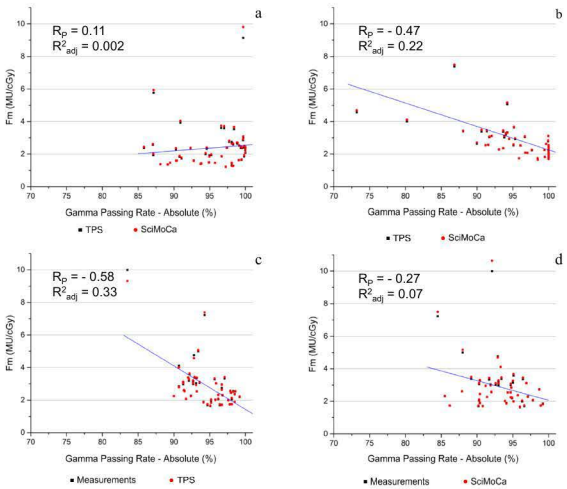

Figure 3. Modulation factor as function of the gamma passing rate for the 4 types of comparison: (a) SciMoCa vs. TPSs – Patient plans; (b) SciMoCa vs. TPSs – Phantom plans; (c) TPSs vs. Measurements; (d) SciMoCa vs. Measurements.

Conclusion

An very good agreement was found between SciMoCa, TPSs (both MC and CCCS dose calculation algorithm) and measurements. This innovation software could be used as a secondary dose check verification system and it could become a fast and positive chance for the PSQA, saving a lot of time both for physics and machine. It could also be useful in adaptive RT for checking the impact of the approved RT-Plan on the daily patient anatomy modifications.

References

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