Large-scale Retrospective Monte Carlo Dose Recalculation For Permanent Implant Prostate Brachytherapy

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Introduction

- TG43[1] dose calculation considers patients as infinite water volumes.
- This method is inaccurate at low energies due to heterogeneities.
- TG186[2] proposes material assignment based on organ contours.
- Monte Carlo simulations are gold standard for dose calculations.
- Dosimetric datasets are key to building treatment outcome models.
- An automated Monte Carlo (MC) dose recalculation pipeline was previously validated and tested on a 240-patient cohort[3].

Aim

Retrospectively recalculate the MC dose distributions using the TG186 formalism and investigate dosimetric differences for a cohort of 960 permanent implant prostate brachytherapy patients.

Material/Methods

- Calcifications segmented when present for TG186 material assignment.
- egs_brachy[4] 10^8 photons simulations with track length estimator (STD < 2% in prostate)
- MC pipeline launched on data storage and analysis platform (PARADIM[5]).
- Three simulations compared to TPS TG43 point source dose:
  1. MCTG43: TG43-like conditions at TPS dose grid resolution.
  2. MCTG43CT: TG43-like conditions at CT resolution.
  3. TG186: Patient geometry at CT resolution.

Results

Figure 1 shows expected behaviors such as the differences between TG43 line and point source approximations (light blue), the variability in grid-based DVH algorithms (dark blue), and the differences between TG43 and TG186 (orange)[3]. Finally, significant differences are seen between clinical data and TG186 simulations (green).

Figure 2 shows a general decrease of 2.57% per % of calcification in the prostate. This decrease agrees with the 2.51% from previous works[6] while reaching a better correlation (R^2 of 0.925 vs 0.84[6]).

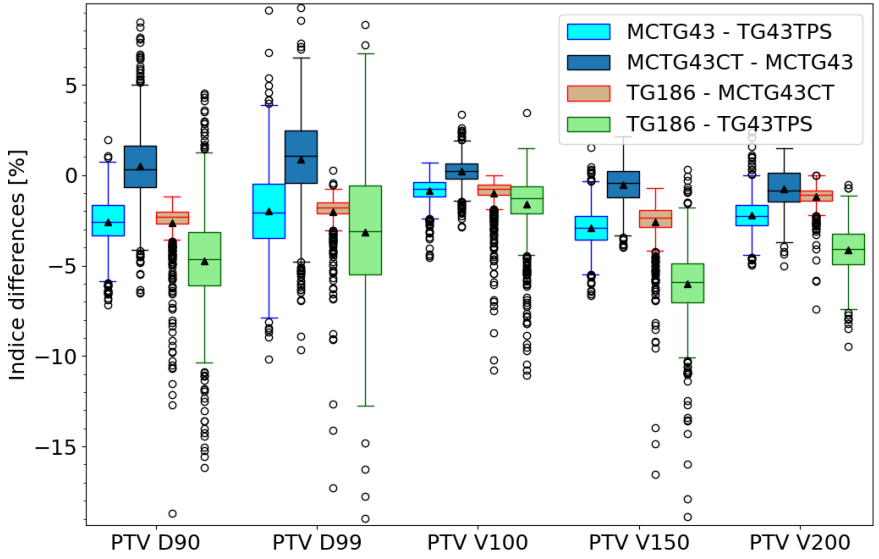

Figure 1. Dosimetric indices comparison for the PTV (prostate) between the TPS dose distribution (TG43TPS) and the three types of MC simulations (MCTG43, MCTG43CT, and TG186)*.

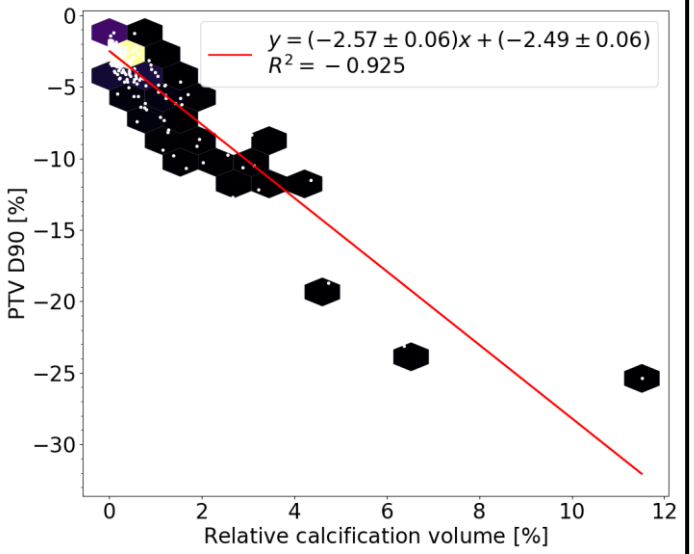

Figure 2. PTV D90 differences between the MCTG43CT and TG186 MC simulations as a function of relative calcification volume

*Using PARADIM, the pipeline was launched simultaneously on 20 patients. Each patient took on average 25 minutes; a total of 60 hours for the three MC simulations on all 960 patients.

Conclusion

The produced MC dose dataset with three MC simulations for 960 patients constitutes a key resource for future dosimetric studies. Such studies would correlate accurate delivered dose to the treatment outcome.

References

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