Comparison between XVMC Monte Carlo and Eclipse AAA Dose Calculations for Rapidarc Plans

Wolfram Laub

Department of Radiation Medicine, Oregon Health and Science University, Portland, Oregon

Purpose

Rapidarc is emerging technology that continues to be adapted by clinics around the country and around the world at a fast pace. Despite this, we still have limited knowledge about the accuracy of the dose calculation and delivery of Rapidarc plans. Rapidarc dose calculation can be challenging, because individual control points of arcs often show multiple small islands of open areas. In addition, a high percentage of the segment is often blocked by the multi-leaf collimator (MLC) of the linear accelerator (see Fig. 1). In this study we investigate the dose calculation accuracy of the Eclipse AAA dose calculation algorithm for Rapidarc treatment plans by means of recalculating Rapidarc plans with the fast Monte Carlo code XVMV[1, 2].

Methods and Materials

The fast Monte Carlo code XVMC was commissioned for a Trilogy linear accelerator (Varian, Palo Alto) with a 6x photon beam. Because profile and PDD data comparisons between the “gold beam” data and our measured data showed good agreement, the AAA algorithm in Eclipse (Varian, Palo Alto) was commissioned with the “gold beam” dataset. Dose calculation tests with XVMC in solid water demonstrated the high accuracy of the beam model for different field sizes compared to measurements and calculations with the AAA algorithm. Dose calculations for conventional treatment plans in the absence of large areas of high or low density inhomogeneities for 3D conformal treatment plans, like 4-field pelvis plans, also demonstrated a high level of agreement between the XVMC dose calculation method and the clinically commissioned AAA algorithm. Clinical Rapidarc treatment plans of mostly prostate and H&N cases were imported into the research treatment planning system Hyperion and recalculated with XVMC.

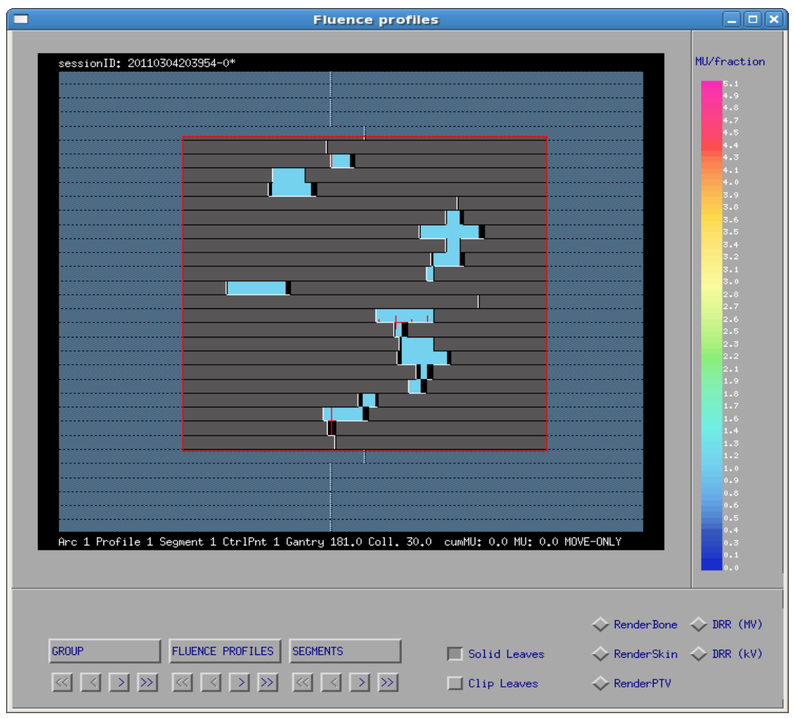
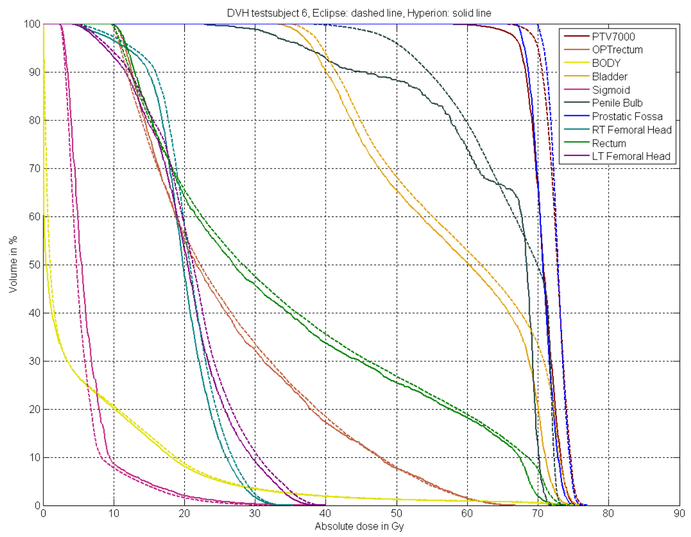


Fig 1: Segment of one control point of a Rapidarc plan. The red lines represent the position of the jaws, the grey lines the position of the MLCs. Areas in cyan are open areas.

Results & Conclusion

Comparison between AAA and XVMC dose calculations of Rapidarc plans show differences in the presence of inhomogeneities as they have already been discussed in a variety of publications comparing AAA or Collapsed Cone calculations with Monte Carlo results. The overall absolute dose in the PTV can be different by several Gray (see Fig. 2). These differences increase for higher doses. A typical prostate or H&N plan will show a dose difference of 2-4 Gy in the PTV between the XVMC dose calculation and AAA calculations. This indicates that in addition to the well known limitations of AAA or Collapsed Cone algorithms with respect to how they handle and correct for lateral electron scatter and electron disequilibrium, the accuracy of absolute dose calculations may also be limited in Rapidarc treatment planning. This can be explained with the extremely small islands of dose and the high percentage of area blocked by the MLCs as it can often be observed for individual control points of Rapidarc treatment plans. As a result, even the smallest inaccuracy in how output factors are applied for individual control points can accumulate during rotations to inaccuracies of several Gray in the absolute dose of the PTV in the plan calculations.



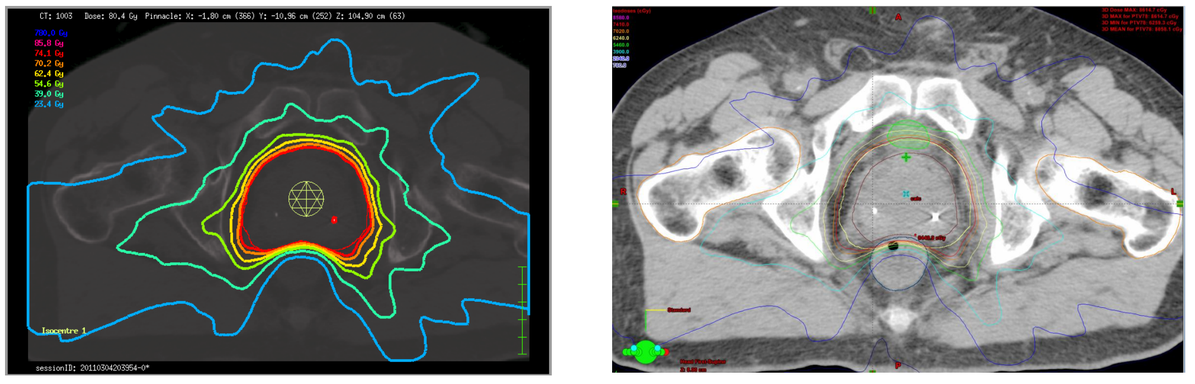


Fig 2: Comparison between DVH (top) and isodose lines (bottom) between the Eclipse AAA calculation (right) and the XVMC calculation in Hyperion (left). Dose in Eclipse was prescribed to 70.2 Gy to 95% of the PTV. In Hyperion only 76 Gy is given to 95% of the PTV. Both plans were calculated with identical monitor units (MUs).

References

[1]Matthias Fippel: “Fast Monte Carlo dose calculation for photon beams based on the VMC electron algorithm”, Med. Phys. 26 .8., (1999)

[2]Iwan Kawrakow and Matthias Fippel, “Investigation of variance reduction techniques for Monte Carlo photon dose calculation using XVMC”, Phys. Med. Biol. 45 2163–83 (2000).

Presented at the 2011 AAPM Annual Meeting, Vancouver, Canada, July 31- Aug 4, 2011