Using Varian Eclipse as An Independent MU Check for MRI-Guided Radiation Therapy

J. Yang, P. Zhang, N. Tyagi, P. Godoy Scripes, J. Mechalakos, A. Li, D. Lovelock, S. Lim
Memorial Sloan-Kettering Cancer Center, New York, NY

JULY 12–16 2020 VIRTUAL JOINT AAPM | COMP MEETING
EASTERN TIME [GMT-4]

INTRODUCTION

MRI-guided radiation therapy is increasingly being adopted in clinics for image guided radiotherapy because of the MRI's advantage in identifying target accurately. Online plan adaptation is required for the new MR image set acquired during a treatment session. For patient specific QA including independent MU check for online adapted plans, a general commercial solution is not yet available.

AIM

To investigate the feasibility of adopting a commercial treatment planning system (TPS) , specifically, Varian Eclipse TPS (ETPS), as an independent MU check for both offline reference and online adaptive plans generated by Elekta Monaco TPS (MTPS).

METHOD

- Build beam and multi-leaf collimator (MLC) model in ETPS
  - Use 7MV FFF 1.5T Elekta Unity MR Linac in MTPS as reference
  - AAA algorithm used for dose calculation in ETPS
  - The dose profiles and depth curves adjusted to match the dose from MTPS without magnetic field
  - Plans automatically adjusted for different SADs
    - 143cm for MTPS and 100cm for ETPS
  - MLC dosimetric leaf gap in ETPS determined by matching dose distribution between ETPS and MTPS of IMRT plan generated by MTPS
- Clinical work flow for online adaptive plan IMU check (Fig. 1)
  - Dicom export from MTPS when plan is ready
  - RTPlan adjusted in the Dicom Listener and pushed to ETPS
    - SAD changed to 100cm from 143cm
    - Beam isocenter shifted to new SAD but beam geometry is preserved
    - Jaws and MLC leaf positions scaled to new SAD
  - Dose calculated in ETPS
  - Run our in-house Eclipse Plugin (Fig. 2) to analyze gamma
    - Gamma analyse performed for each beam at a plane perpendicular to the beam CAX. The plane can be shifted so that the center of mass of the PTV is on the plane
    - The Unity couch as well as posterior magnetic coil in MRL corrected for proper attenuation
    - Magnetic effect modelled by lateral shift of 2mm

METHOD -CONTINUED

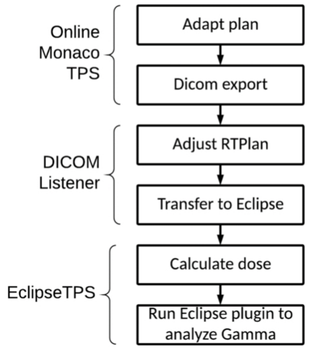

Figure 1. Workflow of IMU check for online adaptive plans

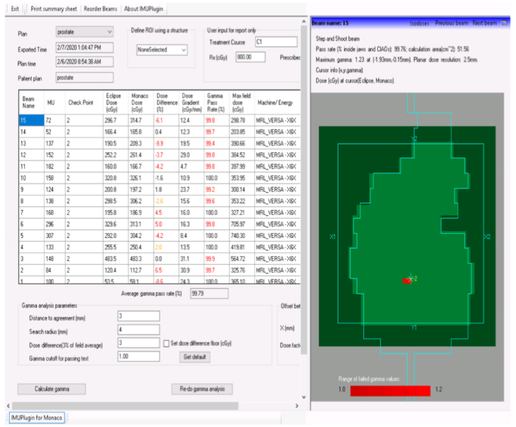

Figure 2. Our Eclipse plug-in program: Gamma pass rates for all beams are shown in the table on the left panel. And Gamma map of the selected beam is shown on the right panel.

RESULTS

Five test prostate cases and three liver cases have been studied. All cases have the reference plan done. Only four adaptive plans for the prostate cases are available for this study. One is adapt-to-position and three are adapt-to-shape plans with the MR images. For prostate cases (9 plans) the average gamma (4%, 4mm) pass rate for a plan is between 99.2% to 100%. The lowest pass rate for all individual beams is 98.4% (Fig. 3). There is no difference observed between the reference plans and the adaptive plans. For the liver cases, the average gamma (4%, 4mm) pass rate for a plan is from 98.6% to 99.9% with the lowest pass rate for a beam at 96.2% (Fig. 5). The average pass rate for gamma (3%, 3mm) is above 95% for all plans. The gamma (3%, 3mm) pass rate for all individual beams are shown in Fig.4 and Fig. 6 for prostate and liver plans, respectively. For prostate the average pass rate only decreases 0.6-1.6% compared to the average with gamma (4%, 4mm). For liver cases the average pass rate decreases 1.4-3.3%. This is because the air cavity can be close to a target for the liver cases, as the magnetic effect on air-tissue interface is not modelled in ETPS calculation. One beam in a liver case has 85.4% because of the air cavity just on the edge of the target on the evaluated plane.

The calculation time for a CT based plan in Eclipse is usually within 1-2 minutes. The calculation time for an MR based plan in Eclipse can take longer because Eclipse needs to process assigned electron density for each voxel for all structures. Reducing the number of unnecessary structures imported into Eclipse can thus reduce dose calculation time. In this study all process times are within 4-5 minutes.

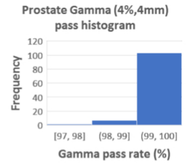

Figure 3. Gamma (4%, 4mm) pass rate histogram for prostate plans

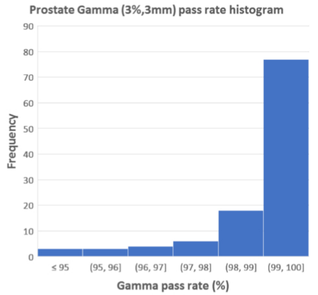

Figure 4. Gamma (3%, 3mm) pass rate histogram for prostate plans

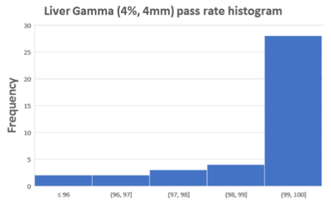

Figure 5. Gamma(4%,4mm) pass rate histogram for liver plans

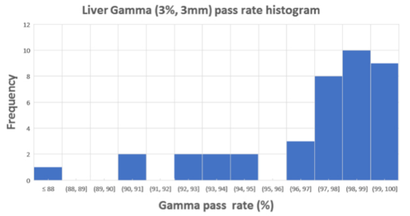

Figure 6. Gamma(3%,3mm) pass rate histogram for liver plans

CONCLUSIONS

Eclipse TPS can provide an efficient way to perform IMU check for Monaco offline reference and online adaptive plans.

REFERENCES

1. Raaymakers B W et al. Integrating a MRI scanner with a 6 MV radiotherapy accelerator: dose deposition in a transverse magnetic field. Phys. Med. Biol. 49 (2004) 4109-4118.
2. Chen G-P et al, Technical note: Development and performance of a software tool for quality aasurance of online replanning with a conventional Linac or MR-Linac. Med. Phys. 43(2016) 1713-1719

CONTACT INFORMATION

yangj1@mskcc.org