Quantification of TG 119 in the VMAT Era

JE Roring, K Rasmussen, S Stathakis, D Saenz, N Kirby, and N Papanikolaou,
Department of Radiation Oncology, The University of Texas Health Science Center at San Antonio, Texas

Mays Cancer Center
UT Health San Antonio MD Anderson Cancer Center

Purpose

TG – 119 provides a set of IMRT commissioning tests to assist with inter-clinic quality standards in Intensity Modulated Radiation Therapy. Outcomes from TG –119 were based on Step and Shoot IMRT plans using only 6 MV beams. Modern IMRT has evolved toward Volumetric Modulated Arc Therapy and can incorporate a wide range of energies. The purpose of this work is to compare plans between the established data using multiple energies with both IMRT and VMAT.

Methods

The plans were created on the Pinnacle^3 treatment planning system using a Varian Novalis Tx linear accelerator model. All plans meet the dose constraints as designated within TG – 119 with exception of the "hard" C-shape plan. This plan contains parameters too difficult (and not intended) to meet but is used as an example of a model pushed to the limit of its capability. The IMRT plan beams imitated those described by TG – 119. The VMAT plans were created using one or two full arcs with varying collimator angles. A grid of 0.2 cm was used to calculate dose and a treatment couch imitation contour was applied in the planning. Treatments were recalculated to be delivered to the PTW Octavius4D phantom for measurement. Octavius measurements were calibrated by taking an expected dose measurement of a 10x10 field to 2 Gy to a point. This reduced error caused by machine output, pressure, temperature, etc. The measured dose was compared to the planned dose from Pinnacle using PTW Verisoft. Gamma passing rate was determined using a limit of 3% and 3 mm. The 3% relation was derived from 90% of the maximum dose as measured by the Octavius 1500 array. An additional analysis threshold of a minimum of 10% of the maximum dose measured was applied to the gamma analysis. Verisoft was then able to calculate the gamma passing rate (%) of the entire 3D space of the phantom.

	3D Gamma Passing Rate			
Plan	6 MV IMRT	6 MV VMAT	10 MV IMRT	10 MV VMAT
MultiTarget	99.6%	99.6%	99.7%	99.5%
Prostate	97.8%	99.0%	99.3%	99.6%
Head and Neck	99.4%	94.9%	98.4%	97.3%
C-Shape Easy	99.4%	98.2%	98.4%	97.3%
C-Shape Hard	99.8%	97.8%	99.7%	97.4%

Table 1: Total gamma passing rate (3%/3mm) for each plan as determined from PTW Verisoft. Each plan was measured on the Octavius 1500 4D array.

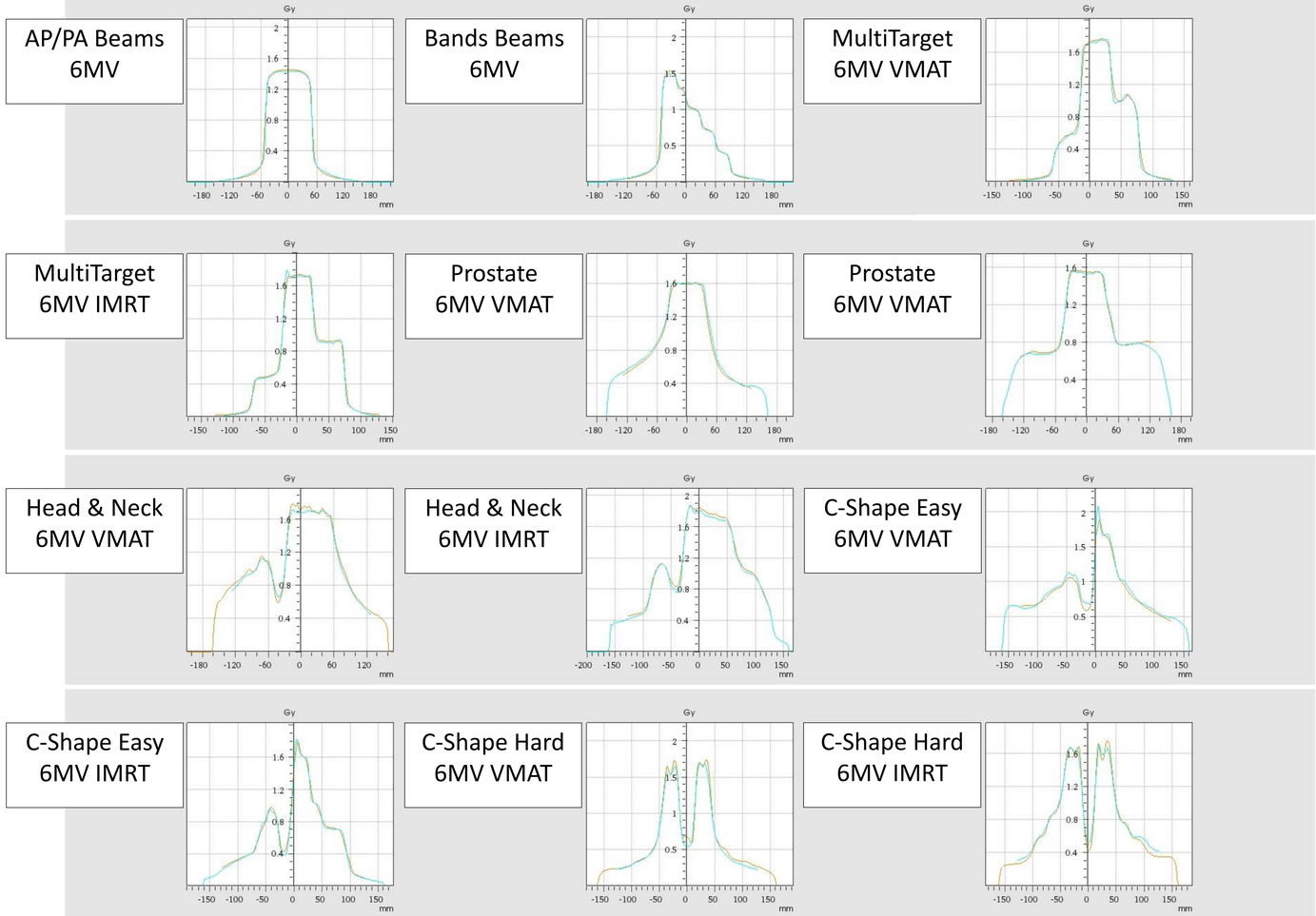
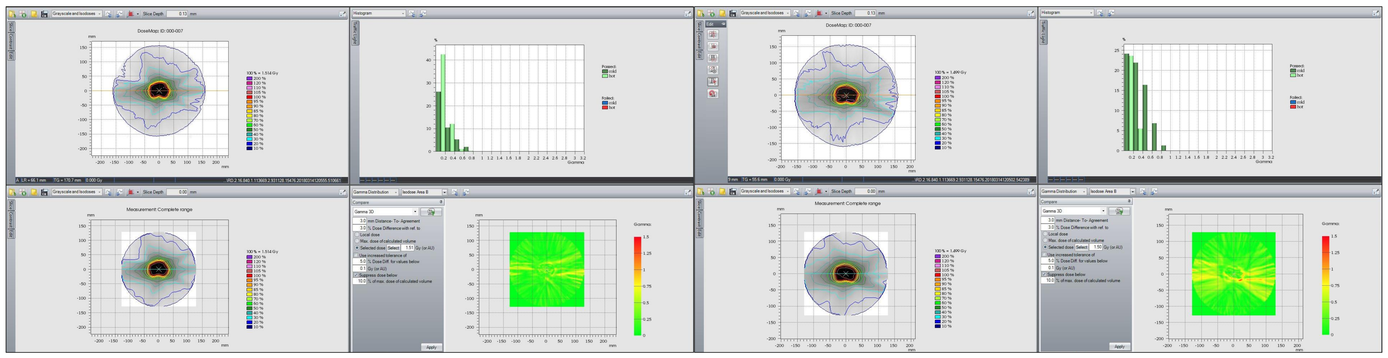


Figure 1: Dose profiles from various studies as determined from PTW Verisoft. Blue: Octavius 1500 4D measurement. Orange: Expected dose from plan calculated in Pinnacle^3 planning software.



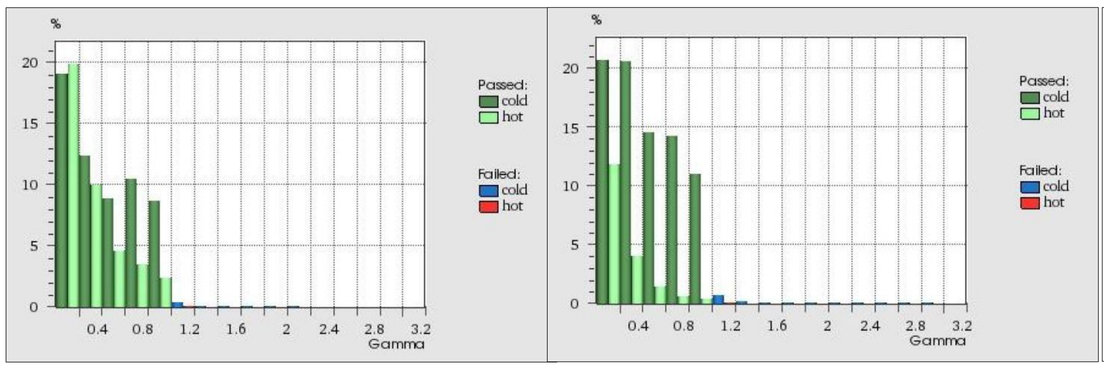


Figure 2 (above): Verisoft 3D single slice analysis of 10 MV (left) and 6 MV (right) prostate arc plans

Figure 3 (left): Total 3D volume gamma histogram of the 10 MV (left) and 6 MV (right) prostate arc plans

Results

While all plans were able to meet the criteria within TG – 119, in general, VMAT plans within Pinnacle^3 allowed for more homogeneous distribution within the target (smaller cold and hot spots) and reduced overall dose to organs at risk. This difference is most readily seen in the average dose of the organ in question. The average passing rate of all energies and plans was 98.6%. Thus, overall agreement between the model and the measured dose was high.

Conclusion

VMAT plans produced similar desired treatment results to IMRT plans with gamma passing at a comparable rate. 6 and 10 MV were able to create similar plans for the phantom tested and show no significant difference in gamma passing rate. It is important to verify that VMAT accuracy is as acceptable as that of previous IMRT plans. This work allows for the development of more accurate IMRT delivery and verification of current quality assurance standards within the clinic. Future analysis could include application of TG – 218 with tighter dose constraints.

Contact: roring@livemail.uthscsa.edu