TG-51 Calibration of First Commercial MRI-Guided IMRT System in the Presence of 0.35 Tesla Magnetic Field

S. Murty Goddu, Olga Green and Sasa Mutic, Department of Radiation Oncology, Washington University School of Medicine, St. Louis, MO, USA 63110

Innovation/Impact: ViewRay is the first MRI guided radiation therapy system that is capable of performing real-time imaging and volumetric image guided gating during radiation delivery. The impact of ionization measurements, for calibration, in the presence of magnetic field is unknown and there are no such studies published in the literature.

Introduction:
ViewRay is the first magnetic resonance image (MRI) guided radiation therapy system (figure 1 A) that is capable of real-time MR imaging during radiation delivery that allows real-time gating based on volumetric image information. As this is the first MRI guided RT system, the impact of ionization measurements (for calibration) in the presence of magnetic field is unknown and there is a possibility that standard calibration protocols and tools may not be suitable for dose measurements in the presence of magnetic field. In this study, we have calibrated the pre-clinical ViewRay system at the factory in Cleveland, OH and independently validated the calibration using Thermo-luminescent-detectors from Radiological Physics Center (RPC_TLDs).

Figure 1: Left:ViewRay system being installed at Washington University; Right: A schematic showing three treatment heads between two parallel donut magnets.

Methods: Treatment delivery of the ViewRay (VR) system is via three 15,000Ci Cobalt-60 heads positioned 120° apart and all calibration measurements were done in the presence of 0.35T MF. The treatment heads have a limited range of rotational motion while two of the heads may be positioned at 0°, one head cannot not, and was therefore calibrated at 90°. Two ADCL-calibrated ionization-chambers (Exradin A12, A16) were used for TG-51 calibration. Chambers were positioned at 5-cm depth, (SSD=105cm: VR’s isocenter), and the MLC leaves were shaped to a 10.5x10.5 cm² field size. Percent-depth-dose (PDD) measurements were performed for 5 and 10 cm depths. Individual output of each head was measured using the AAPM-TG51 protocol. Calibration accuracy for each head was subsequently verified by Radiological Physics Center (RPC) TLD measurements.

Results: Measured ion-recombination (P_{ion}) and polarity (P_{pol}) correction factors were less-than 1.002 and 1.006, respectively. Measured PDDs agreed with BJR-25 within ±0.2%. Maximum dose rates for the reference field size at VR’s isocenter for heads 1, 2 and 3 were 1.445±0.005, 1.446±0.107, 1.431±0.006 Gy/minute, respectively. Our calibrations agreed with RPC-TLD measurements within ±1.3%, ±2.6% and ±2.0% for treatment-heads 1, 2 and 3, respectively. At the time of calibration, mean activity of the Co-60 sources was 10,800Ci±0.1%.

Conclusion: This study shows that the TG-51 calibration is feasible in the presence of 0.35T MF and the measurement agreement is within the range of results obtainable for conventional treatment machines. Due to the low strength of the magnetic field, the mean free path of electrons in the ionization chamber volume is too long to have a noticeable curvature, therefore not affecting dose measurements performed with the ionization chambers.