Efficient quality assurance method for multi-lesion stereotactic radiosurgery treatment with a single isocenter

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INTRODUCTION

Since multiple imaging systems are utilized for patient positioning and monitoring for IGRT frameless SRS, validation of isocenter congruence of all imaging modalities is essential for accurate treatment delivery[1-3]. Additionally, for multi-lesion SRS treatments with a single isocenter, delivery errors can be magnified compared to multiple isocenter delivery[4-6]. Therefore, evaluating coincidence of the mechanical and radiation field at off-isocenter becomes crucial for multi-lesion with single isocenter SRS treatment. We propose an efficient quality assurance (QA) method to evaluate both imaging isocenter coincidence and off-isocenter coincidence using a commercial phantom with a single setup.

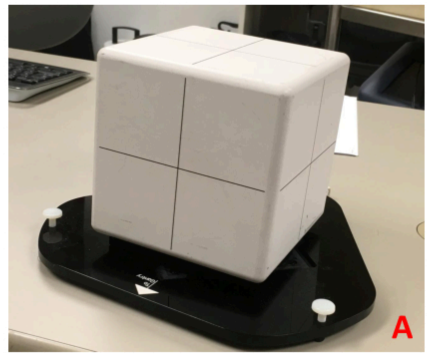
AIM

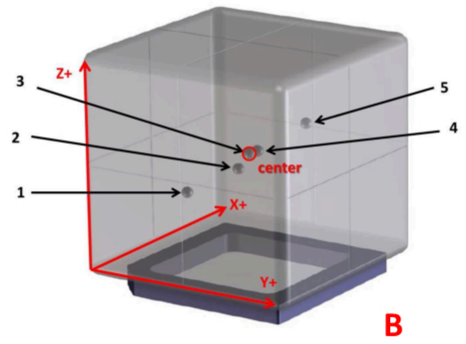
To develop an efficient quality assurance (QA) method to verify isocenter congruence between 3D surface imaging system (3DSI), MV and kV imaging and the radiation isocenter. In addition, radiation isocenter walkouts both at on- and off-isocenter locations are evaluated using single phantom setup.

METHOD

- Phantom: Optical Surface Monitoring System (OSMS, Varian, CA) IsoCube phantom (VisionRT, UK) with 5 BBs embedded at different locations (figure 1 A & B). The dimension of the central BB and 4 additional BB's offset are listed in figure 1.C
- Eight image sets obtained on our stereotactic linac are used for this study. All the image data are acquired using a single XML code in the TrueBeam developer mode (Varian, CA) without user interruption.
- The isocenter of 3DSI is aligned to the radiation isocenter by performing AlignRT MV isocenter calibration (VisionRT, UK) using the IsoCube phantom.
- Then orthogonal MV and kV images at four gantry angles, and Winston-Lutz (WL) test images of all five BBs and also focused only on the central BB are automatically acquired.
- The isocenter shifts of 3DSI, MV and kV images from the radiation isocenter are calculated using the AlignRT software. One MV image example is shown in figure 1.D
- The radiation isocenter walkout is determined using the RIT software (Radiological Imaging Technology, CO).
- Radiation isocenter walkouts for the off-isocenter BB's are determined using an algorithm developed in Matlab (Mathworks, MA). This algorithm analyzes the locations of the BBs in each MV image, and then determines deviations between the expected and measured positions.

METHOD (Cont'd)





BBs	X (mm)	Y (mm)	Z (mm)
1	-10.0	-25.0	-30.0
2	+10.0	-15.0	-15.0
3	0.0	0.0	0.0
4	-20.0	+20.0	+10.0
5	+20.0	+35.0	+20.0

C

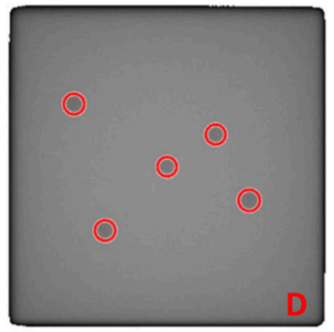


Figure 1: A: OSMS IsoCube phantom used for the study. B: Arrangements of five BBs with numbering are shown. C: The table with the BB locations in mm relative to the central BB. BB1 & BB5 are > 4 cm away from the center. D: MV image of the phantom at gantry 180° with automatically detected BB locations

RESULTS

- The maximum 3D isocenter shifts of MV, kV, and 3DSI from the radiation isocenter are 0.3, 0.4, and 0.4 mm respectively.
- The mean and standard isocenter shifts from the radiation isocenter for each imaging modality:
  - MV: 0.1±0.1 mm
  - kV: 0.2±0.1 mm
  - 3DSI: 0.2±0.1 mm
- The mean and standard deviation of radiation isocenter walkouts for the central BB is 0.2±0.1 mm in 3D. The largest deviation is close to 0.3mm in 3D.
- The off-isocenter BB's are between 0.2±0.5 mm – 0.4±0.4 mm with a maximum of 1.1mm for the most offset BB.

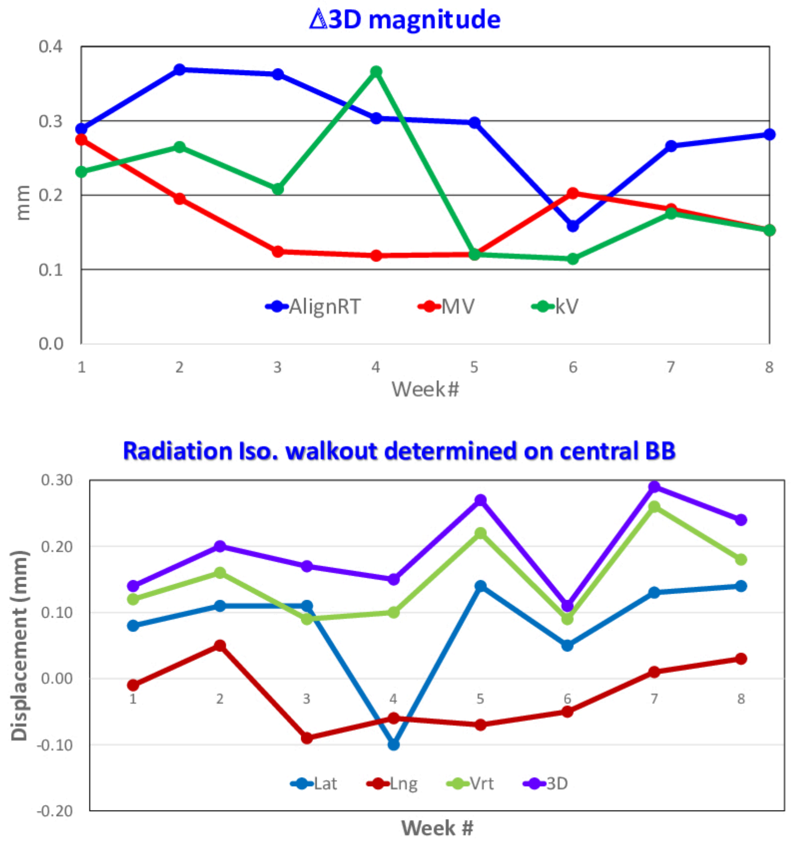


Figure 2: 3D Isocenter shifts of 3DSI (AlignRT), MV, and kV with respect to the radiation isocenter for eight sets of data acquired on our SRS machine (TOP). Radiation isocenter walkouts determined on the central BB in LAT, LNG, VRT and 3D using 12 images for WL tests (BOTTOM)

	LAT (mm)	LNG (mm)	VRT (mm)	3D (mm)
BB1	0.11±0.48	-0.34±0.31	-0.04±0.32	0.36±0.34
BB2	0.16±0.48	-0.29±0.34	-0.01±0.39	0.33±0.39
BB3	0.28±0.52	-0.24±0.32	-0.03±0.35	0.37±0.45
BB4	0.13±0.53	-0.18±0.36	0.00±0.42	0.22±0.45
BB5	0.17±0.46	-0.24±0.35	0.07±0.36	0.30±0.39

Table 1: Mean± standard deviation of the 3D radiation isocenter walkouts on five BB shown in figure 1. The walkouts were determined using an algorithm developed in Matlab. The largest walkout is 1.1mm for BB1.

CONCLUSIONS

- We developed an on- and off-isocenter WL test to evaluate the accuracy of single iscoenter delivery for multi-lesions SRS.
- This method assesses isocenter shifts of MV, kV, 3DSI and off-isocenter from the radiation isocenter, and isocenter walkout with a single phantom setup
- This QA can be implemented to verify the consistency of linac performance prior to treating multi-lesion SRS with a single isocenter
- Ongoing work to evaluate couch rotation isocenter and incorporate into analysis. Important for dynamic couch treatments (4π delivery)
- Further development: Full automation of the whole process using single software without manual data transfer

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