Long term stability of kV cone beam CT (CBCT) image quality assurance for IBA Proteus®PLUS proton therapy system

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PURPOSE

Numerous proton therapy systems worldwide started implementing onboard kV cone-beam computed tomography (CBCT) for treatment volume localization and visualization of soft tissues. Intensity modulated proton therapy in conjunction with improved volumetric imaging techniques will help assessing not only target localization but changes in beam path length as well—not to mention the capability of enabling a robust adaptive therapy program. Routine quantitative assessment of various image quality parameters such as geometric accuracy, spatial resolution, uniformity, Hounsfield unit (HU) consistency of various materials, contrast to noise ratio (CNR) etc., are pivotal as CBCT systems are prone to scatter, beam hardening and setup alterations.

METHOD

The CBCT quality assurance program for the IBA Proteus®PLUS system were developed based on AAPM task group 142 & 179 guidelines. Radiological Imaging Technology, Inc. (RIT) software was employed for the analysis and reporting of the CBCT QA data and The Phantom Laboratory (CATPHAN®600) phantom was used to measure these various image quality parameters on a monthly basis.

RESULTS

The CBCT QA baselines used for each treatment rooms were acquired separately over a period using a commonly acquired clinical preset (CatPhanHeadHD protocol-100 kVp, 160 mA, 2.5 mm slice thickness) at our institution. The long term stability (more than 1 year of CBCT QA data) for three proton gantry, kV CBCT systems is presented. Figures 1, 2 & 3 shows the absolute difference of HU constancy for water, polystyrene, LDPE, PMP, air & acrylic inserts. Figures 4, 5 & 6 shows geometric accuracy results and table 1 displays the mean and standard deviations for spatial resolution, CNR and relative uniformity tests for the 3 treatment rooms. The CBCT image quality results for GTR2 treatment room is not optimal and image quality is deteriorating over the last 9 months. Presently its not affecting the accuracy of image guided radiotherapy (IGRT) treatment deliveries. Its currently under investigation with IBA R&D division.

CONCLUSIONS

This study was conducted to evaluate the long term stability of basic image quality parameters for the kV CBCT systems on an IBA proton gantry system based on TG 142 & TG 179 recommendations and vendor suggested tolerance limits.
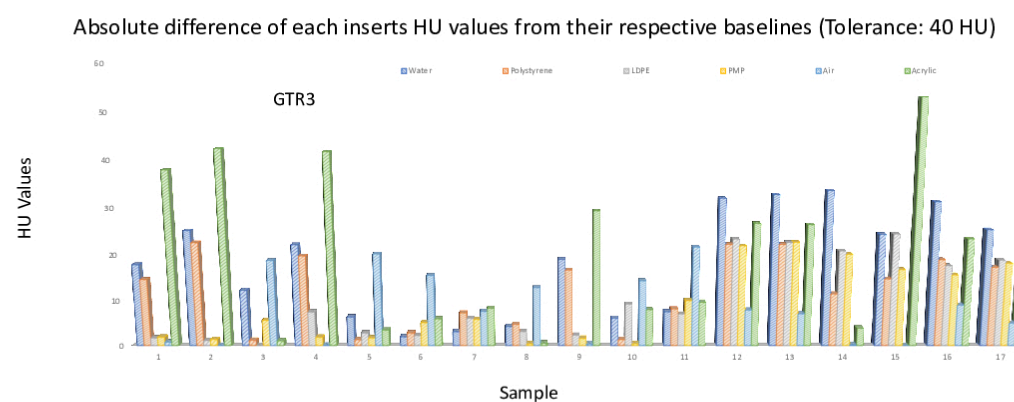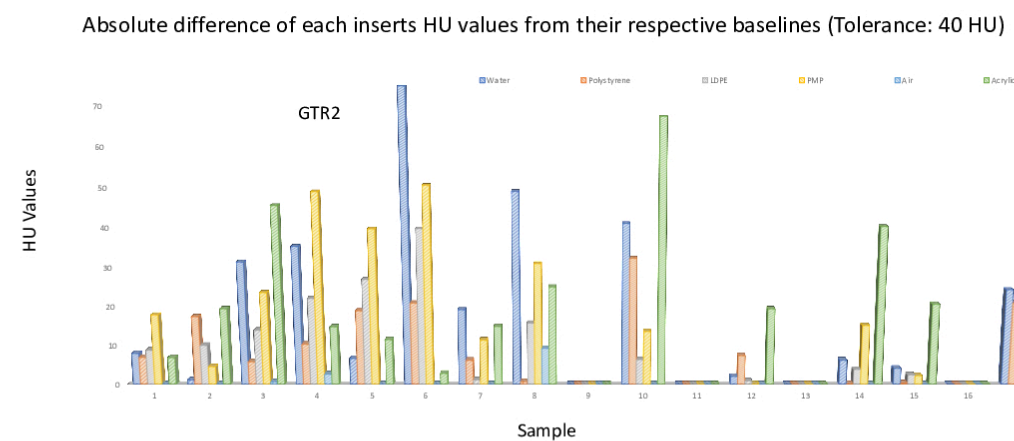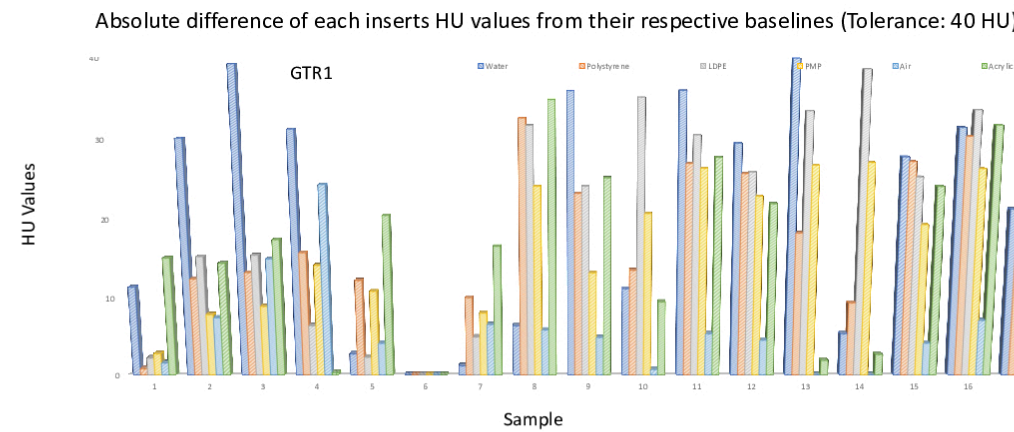
Figures 1, 2 & 3: Absolute difference of HU values of inserts for all 3 treatment rooms on a monthly basis
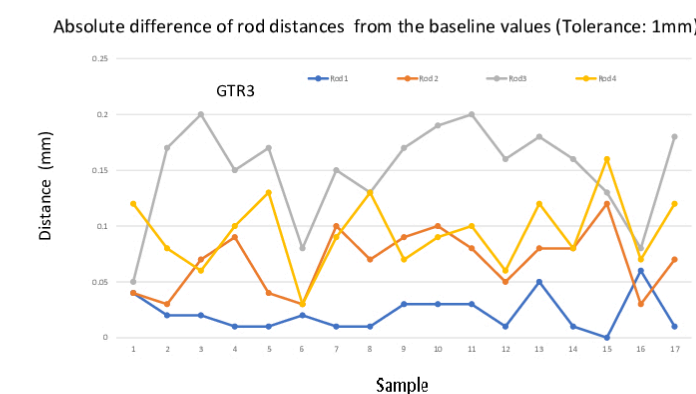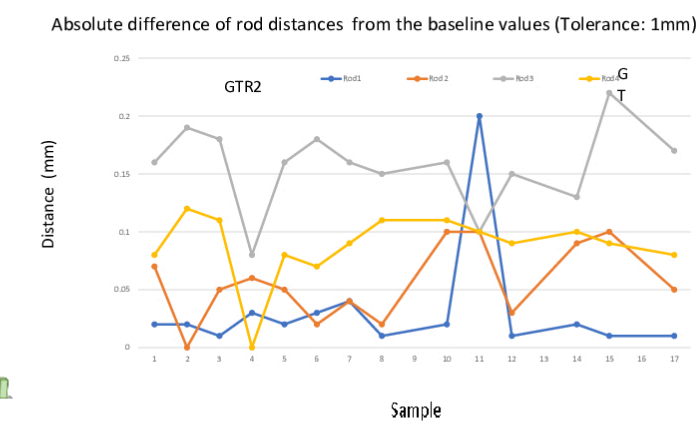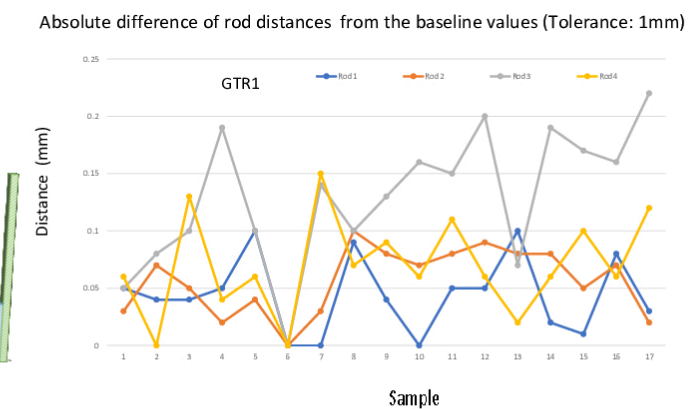
Figures 4, 5 & 6: Absolute difference of distance between each rods for all 3 gantries

Spatial resolution (Tolerance: >6 lp/cm)		
	Mean	Sigma
GTR1	7	0
GTR2	6.86	0.36
GTR3	6.71	0.47
Contrast to noise ratio (Tolerance: >0.1)		
	Mean	Sigma
GTR1	0.26	0.16
GTR2	0.92	0.37
GTR3	0.35	0.12
Uniformity relative to center area (Tolerance: within 50)		
Area	Mean	Sigma
Top (GTR1, GTR2, GTR3)	-5.79, 33, -11.61	14.86, 24.8, 7.44
Right (GTR1, GTR2, GTR3)	-3.8, 42.82, -0.64	8.73, 29.75, 11.31
Left (GTR1, GTR2, GTR3)	-2.24, 45.58, 1.06	8.95, 30.27, 11.07
Bottom (GTR1, GTR2, GTR3)	-1.15, 39.71, -4.41	12.75, 26.19, 8.24

Table 1: Mean and standard deviation results for spatial resolution, contrast to noise ratio and relative uniformity for all the 3 treatment rooms

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