

Dosimetric impact on fiducial array distortion for tracking in robotic radiosurgery: a phantom study

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Introduction: The Cyberknife system uses a parameter known as rigid body error (RBE) to determine differences in the distances between fiducial pairs as measured during the treatment and the planning. If RBE thresholds are out of tolerance, treatment interruptions are triggered and according to the manufacturer, tracking accuracy might be affected. The objective of this work is to create a new 3D printed phantom capable of inducing fiducial errors, mimicking fiducial array distortions, and measuring the dose differences caused by RBEs.

Materials and Methods: A Cyberknife model M6 was used in this study. The phantom contained three embedded fiducials, 2 fixed (F2, F3) and one moveable (F1). Two plans were built using two targets, T1 and T2 located at 2,5 cm and 6,5 cm respectively from fiducial center of mass (COM). Plans were delivered firstly without induced errors. Subsequently, errors of 2 mm, 4 mm and 6 mm were applied in F1. Two semiflex A1SL ionization chambers, C1 and C2 were used to measure the dose at targets T1 and T2 respectively. RBEs values and dose differences were registered and reported accordingly. Figure 1 illustrate the axial (left) and coronal (right) for the plan created for T1. The purple and blue line represents isodoses for 8Gy and 2Gy respectively.

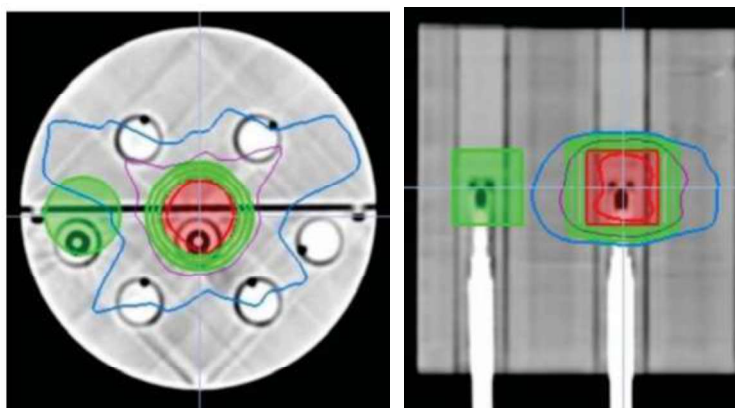


Figure 1 - axial (left) and coronal (right) for the plan created for T1

Results and Discussion: Dose differences were seen to be greater as RBE gets wider and for targets farther from fiducial COM. Displacing F1 by only 2mm, corresponding to an RBE of 1,8 mm in this study, led to an absolute dose difference of 7% for T2. When displacing F1 by 6mm, yielding an RBE of 4,6 mm, the measured absolute dose differences reached up to 23% in the high gradient region for T2. Conversely for T1 the impact was maintained below 5%, mitigated by the proximity with COM.

Conclusions: RBE has been shown to be a powerful indicator of fiducial array deformation. Performing these analyses is paramount for a better understanding of fiducial tracking accuracy in Cyberknife and confirms manufacturer recommendations.