1. Chang, S. et al. Introduce a rotational robust optimization framework for spot-scanning proton arc (SPArc) therapy. Phys. Med. Biol. 68, (2022).

2. Ding, X. et al. Spot-Scanning Proton Arc (SPArc) Therapy: The First Robust and Delivery-Efficient Spot-Scanning Proton Arc Therapy. Int. J. Radiat. Oncol. Biol. Phys. 96, 1107–1116 (2016).

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

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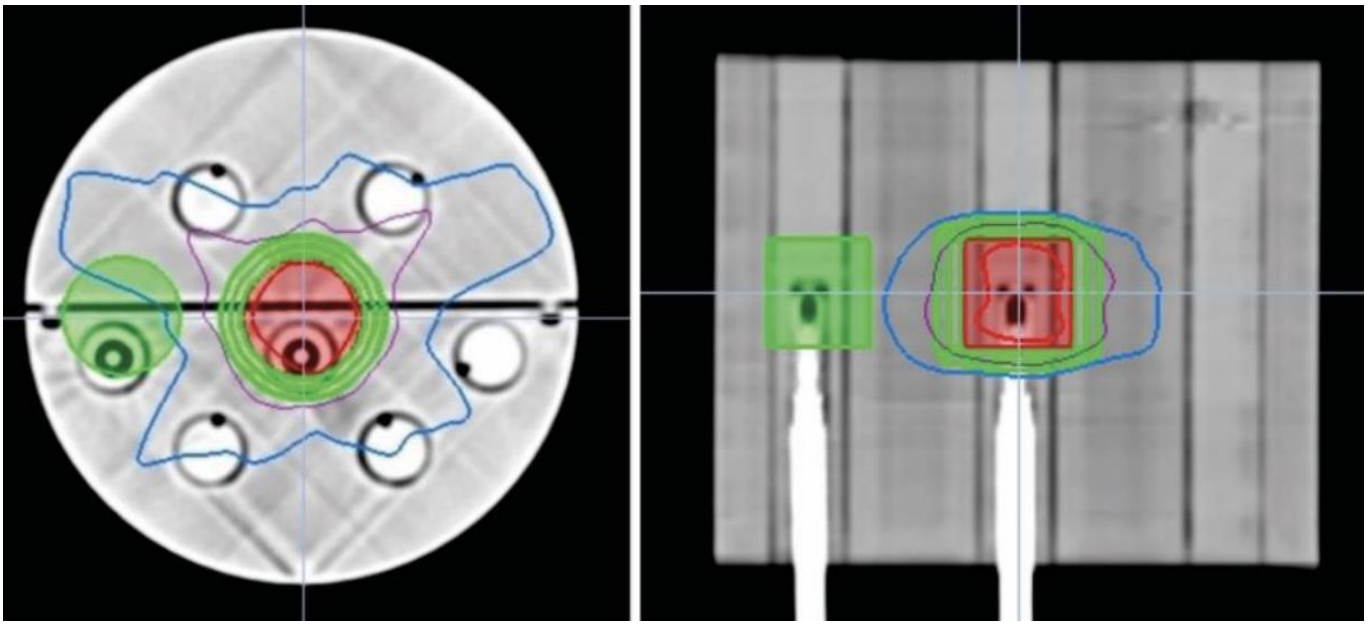
Purpose/Objective:

Target tracking through online image guidance became an inherent part of the diffused usage of new hypofractionated regimens. Tissue implanted fiducial markers is one of the available options widely used as a surrogate for intrafraction target motion. The Cyberknife system uses a fiducial extraction algorithm capable of tracking the fiducial array center of mass (COM) allowing a thorough evaluation of fiducial positioning. In order to flag any array distortions, caused by organ deformation or fiducial migration, a parameter known as rigid body (RB), determines differences in the distances between fiducial pairs as measured during the treatment and the planning. If RB thresholds are out of tolerance, treatment interruptions are triggered and according to the manufacturer, tracking accuracy might be affected. Despite manufacturer recommendations, dose differences caused by rigid body errors (RBE), and whether the distance of targets from fiducial COM maximize this effect are not fully known. Therefore, 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.

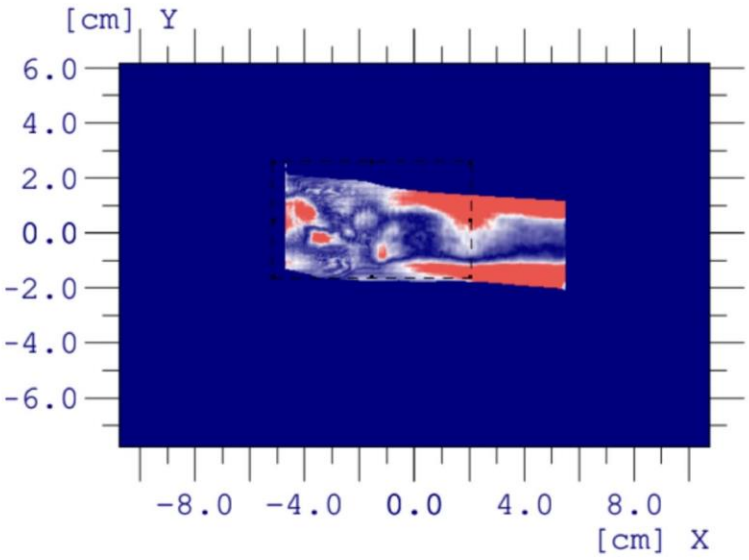
Material/Methods:

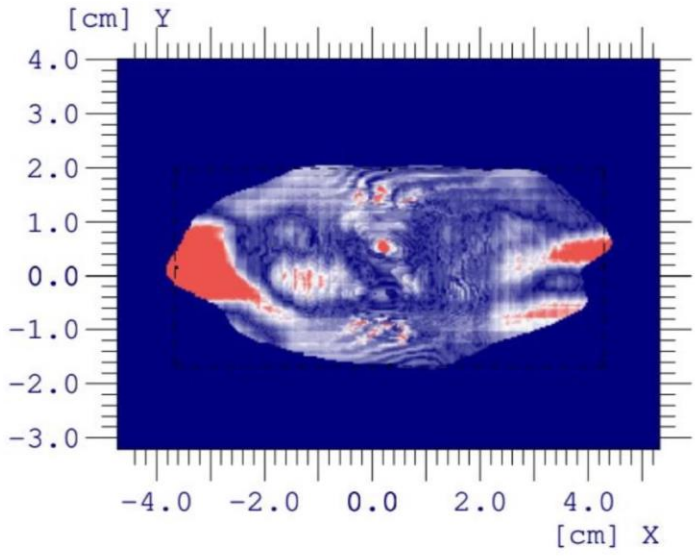
A Cyberknife model M6 equipped with Incise2 MLC was used in this study. The new phantom contained three embedded fiducials, 2 fixed (F2, F3) and one moveable (F1) in the longitudinal direction. Two plans were built in Accuray Precision (V3.1.0) using two targets, T1 and T2 located at 2,5 cm and 6,5 cm respectively from fiducial COM. Both plans were delivered firstly without induced errors, mimicking the ideal scenario. Subsenquencially, errors of 2 mm, 4 mm and 6 mm were applied in F1 using a caliper. Two semiflex A1SL ionization chambers, C1 and C2 were used to measure the dose at targets T1 and T2 respectively. Additionally, an ETB3 film was placed in the phantom coronal mid plane to access dose distribution. RBEs values and dose differences were registered and reported accordingly. Figure 1 illustrate the axial (left) and coronal (right) slices for the plan created for T1. The purple and blue lines represent isodoses of 8Gy and 2Gy respectively.



Results:

Dose differences were seen to be greater as RBE gets wider and for targets farther from fiducial CDM. 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 bellow 5%, mitigated by the proximity with COM. Furthermore, wider values of RBE led the fiducial extraction algorithm to trigger array rotations that were not totally representative. The impact on dose distribution in the coronal mid plane of the phantom is illustrated in Figure 2 for T1 (lower) and T2 (upper).





Conclusion:

RBE has been shown to be a powerful indicator of fiducial array deformation, albeit users must be aware that larger RBE might induce array rotations compromising dosimetric accuracy. This is particularly important for targets farther from fiducial COM. Performing these analyses is paramount for a better understanding of fiducial tracking accuracy in Cyberknife and confirms manufacturer recommendations.

Keywords: Cyberknife, fiducials, tracking

References:

DIETERICH S, CAVEDON C, CHUANG C, et al. Report of AAPM TG 135:

quality assurance for robotic radiosurgery. Med Phys 2011 Jun;38(6):2914-36.

VANDERVOORT E, PATROCINIO H, CHOW T et al. COMP Report: CPQR technical

quality control guidelines for CyberKnife Technology. J Appl Clin Med Phys, 2018 Mar;19(2):29-34

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Analysis of CBCT registrations for re-setup Gamma Knife® G-frame patients

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Purpose/Objective:

Leksell Gamma Knife® Icon™ is equipped with cone beam computed tomography (CBCT) to be used as the stereotactic localization and pre-treatment verification in Gamma Knife treatment planning. The CBCT can be performed for frameless and framed patients. Gamma Knife applies setup shift corrections for frameless patients after verification of CBCT registration, but the setup deviations will not be corrected for framed patients. Since the localization box induces certain errors in stereotactic space, an improved frame-based workflow was introduced. Gamma Knife CBCTs can be used to define stereotactic coordinates for frame-based treatments.

Co-registration of the stereotactic reference CBCT with the verification CBCT gives the transformation mapping of the center of the stereotactic space. This study analyzes the setup translation and rotation deviations of CBCT registrations between the stereotactic reference CBCT and verification CBCT for G-frame patients. Furthermore, the CBCT registration deviations of the patients who had been off the treatment couch after stereotactic definition CBCT were compared to the deviations of the patients who were docked on the couch during the whole procedure.

Material/Methods:

Pre-plans of 57 G-frame patients were created before the frame procedure days. These patients were mainly multiple brain metastases and trigeminal neuralgia cases. The CBCT images were acquired after frame placement and used to define the stereotactic space. The second CBCT was taken prior to treatment and co-registered with the first CBCT to verify the setup. The translational and rotational shifts in X, Y, and Z coordinates at (100,100,100) and the maximum shot displacements calculated in Gamma Knife planning system were recorded and reviewed. The first group has 41 out of 57 patients who were never undocked and stayed on the couch waiting for the treatment; the second group has 16 out of 57 patients who had been undocked from the treatment couch after the stereotactic reference CBCT was acquired. There was a total of 21 verification CBCTs included for these 16 patients.