Phantom Validation of Geometric accuracies of 3-Tesla (T) Magnetic Resonance Imaging (MRI) in Gamma Knife Radiosurgery (GKRS)

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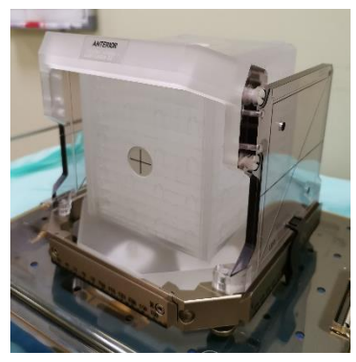
Introduction

Increasing the MRI field strength may enhance visualization and resolution of small brain lesions, in turn improving the accuracy of GKRS delivery. However, concerns remain regarding the influence on geometric distortion caused by the metallic stereotactic skull frame, posts and fixation screws in a frame based Gamma Knife Radiosurgery. In this study we aim to explore the validity of using 3T MRI for GKRS planning and geometric distortions correction algorithms provided by the MRI manufacturer. This study consisted of the investigation of phantom geometric accuracy on MPRAGE sequence by verifying 21 geometrically know positions (targets) and coordinates in stereotactic space.

Materials & Methods

The QUASAR GRID phantom by Modus Medical Devices Inc. was used to evaluate geometrical distortion for stereotactic radiosurgery. 2 MR scans (MPRAGE 3D and MPRAGE 3D without distortion correction algorithm) were obtained. The phantom was scanned on 3T Skyra MRI Siemens scanner using the CP angle head coil. The analysis was done by using Leksell GammaPlan (LGP) to compare the maximum & mean fiducial errors for 2 scans. 22 geometrically known positions (targets) and coordinates were obtained and deviation of these locations were calculated using Excel Sheet. The geometrical distortion is reflected on fiducial errors and absolute errors.



Results

Table 1: Errors acquired for 2 MR stereotactic scans.

	MPRAGE 3D	MPRAGE 3D without geometrical distortion correction
Mean fiducial error	0.70 mm	2.30 mm
Maximum fiducial error	0.90 mm	3.10 mm
Mean absolute error	1.04 mm	1.05 mm
Maximum absolute error	1.78 mm	1.99 mm

Discussions

The acceptable tolerance for mean and maximum fiducial error is less than 1.0 mm. MPRAGE 3D meets the criteria where MRPAGE scan without distortion correction fails to. Increased geometrical distortion was detected on MPRAGE 3D without applying geometrical distortion correction algorithm. This stem an effective performance of the automated distortion correction algorithms integrated in the Siemens MRI. Increased geometrical distortion will affect the precision of treatment volume and shift the functional target location for treatment (etc trigeminal neuralgia). AAPM Task Group 40 suggests that tolerance of geometric uncertainty in MRI used in SRS treatment planning should not more than 2 mm. MPRAGE 3D is well within acceptance level. Further work is still needed to fully characterize MR-related distortion.

Conclusion

Analysis on phantom QA data demonstrated the accuracy of our Gamma Knife 3T MRI imaging protocols, where the geometric accuracy of the 3 T MRI imaging protocol is operating within the appropriate tolerance.

Reference

1. Pappas, E. P., Alshanqity, M., Moutsatsos, A., Lababidi, H., Alsafi, K., Georgiou, K. Georgiou, E. (2017). MRI-Related Geometric Distortions in Stereotactic Radiotherapy Treatment Planning: Evaluation and Dosimetric Impact. *Technology in cancer research & treatment*, *16*(6), 1120–1129. doi:10.1177/1533034617354542.