

# Characterization of diffusion weighted MRI and apparent diffusion coefficient calculation on a low field MR-LINAC radiotherapy system at multiple gantry angles

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## INTRODUCTION

Diffusion weighted imaging (DWI) provides critical tumor biomarker information for radiotherapy. As MRI guided radiotherapy (MRgRT) techniques advance, so do the imaging tools available to physicians. DWI capability has recently been brought to the ViewRay MRIdian MR-LINAC system in a research capacity.

For use in a clinical capacity DWI on MRgRT systems must be characterized with known materials and compared at different LINAC gantry angles and to standard 1.5T or 3.0T MRI scanners.

## AIM

This work compares apparent diffusion coefficient (ADC) values from DWI echo planar imaging (EPI) acquired at 0.35T, 1.5T, and 3.0T using a NIST traceable diffusion phantom. In addition to ADC, the signal intensity of DWI images and geometric distortion were compared across gantry angles.

## METHOD

### Phantom:

- QalibreMD Diffusion Standard Model 128 phantom
- 13 vials with Polyvinylpyrrolidone (PVP) in concentrations of 0-50% in water

### Imaging:

- 0.35T ViewRay MR-<sup>60</sup>Co, 0.35T ViewRay MR-LINAC, 1.5T Philips Achieva wide bore MRI, and 3.0T Siemens Vida MRI
- For 1.5T and 3.0T systems the b-values were 0, 500, 900, and 2000s/mm<sup>2</sup>
- For the ViewRay systems the b-values were 0, 200, 500, and 800s/mm<sup>2</sup>
- All performed with phantom internal temperature at 0C
- Three independent imaging sessions on each MRI system

### Image Processing:

- Noise floor removal from each b-value image
- Eddy current correction with affine registration to b0 images
- ADC calculation with on-linear least squares fitting of all b-values



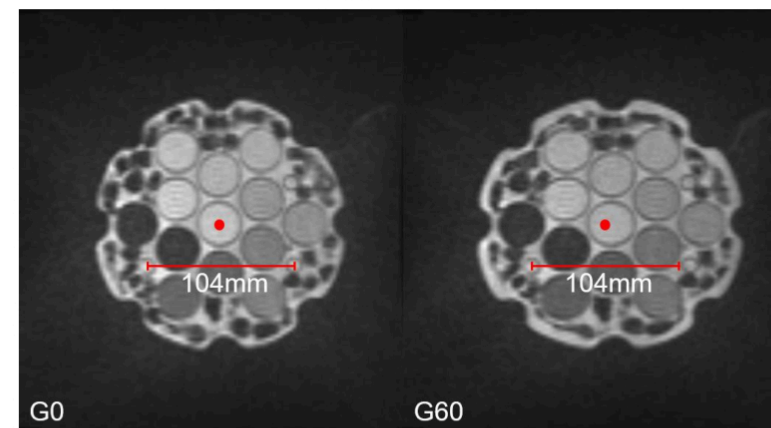
## RESULTS

Repeat scans showed consistent ADC values for all field strengths, however the low field systems produced lower than expected values

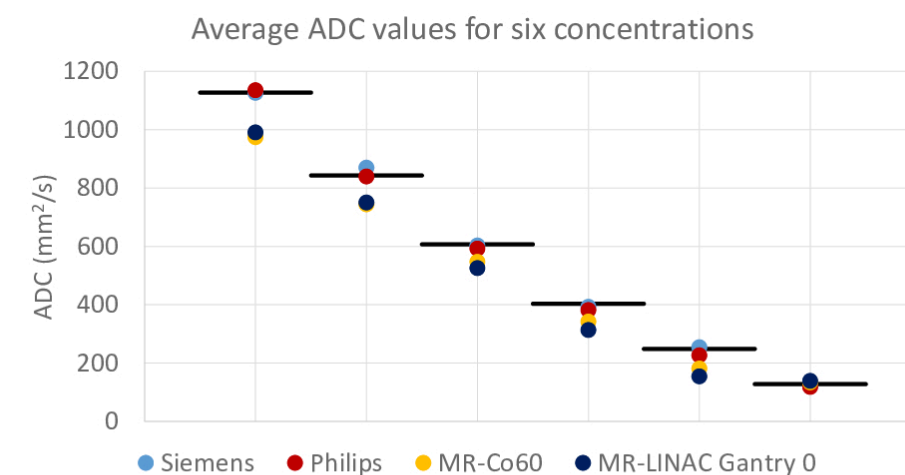
- ADC values within 1% of expected for 1.5T and 3T systems
- On 0.35T systems ADC was consistently lower than expected
- High concentration (low ADC) vials had the greatest deviation of up to 14.4% on 0.35T systems

### Geometric distortion on MR-LINAC

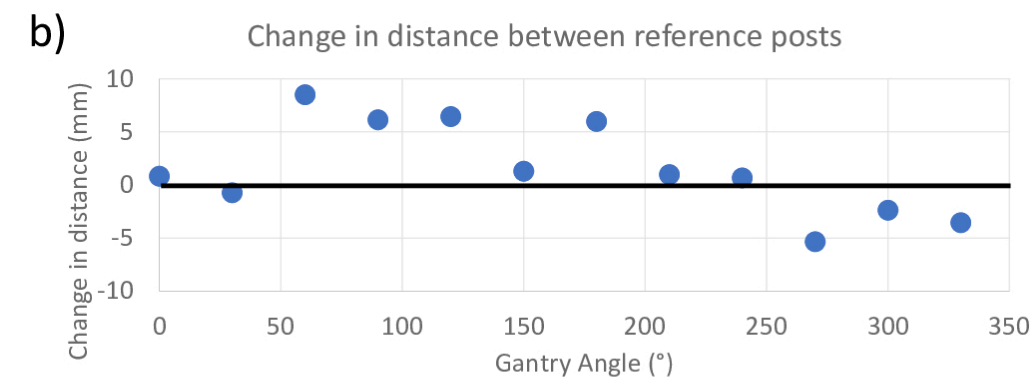
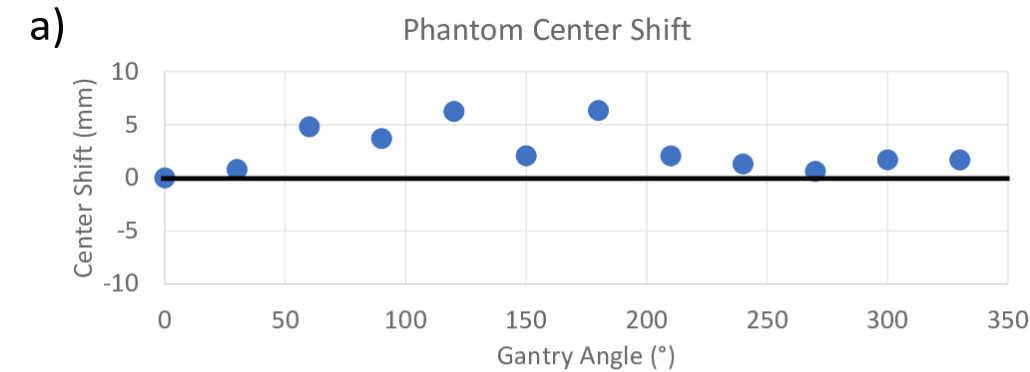
- The phantom center shifted by up to 6.4mm, depending on gantry angle
- The distance between two reference posts (A and B) was stretched by up to 8.5mm, at gantry angle 60°.



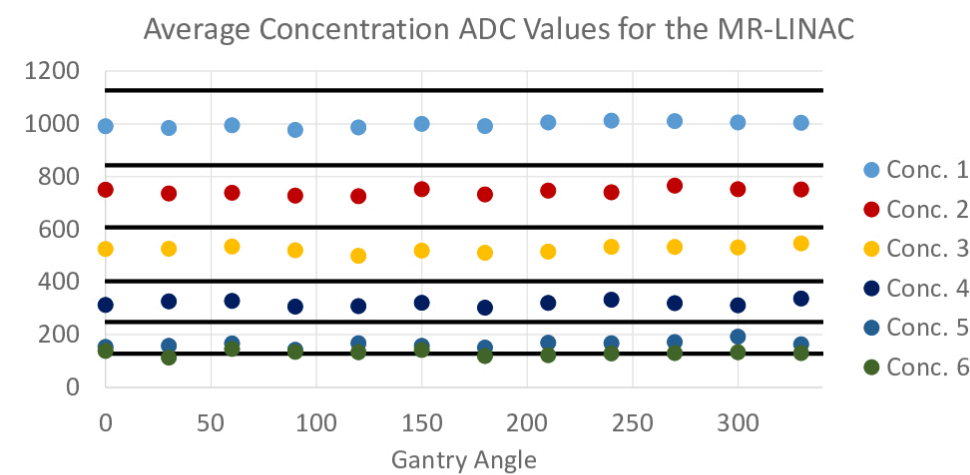
DWI images of the diffusion phantom at  $b = 0\text{s/mm}^2$  and gantry angles  $0^\circ$  (G0) and  $60^\circ$  (G60), the phantom was stationary between image acquisitions. The red dot indicates image center. The red bar indicates the distance between reference posts A and B at gantry angle  $0^\circ$



Calculated ADC averaged over each vial of the same concentration and compared across MRI machines. Black horizontal lines indicate the expected ADC value for each concentration



Geometric distortion of DWI images at different gantry angles with the 0.35T MR-LINAC system. (a) presents the phantom center shift relative to the home gantry angle ( $0^\circ$ ). (b) presents the change in distance between two reference posts in the phantom at different gantry angles compared to the home gantry angle.



Average ADC for each vial of the same concentration across gantry angles (measured every  $30^\circ$ ). Horizontal black lines indicate the expected ADC for each concentration.

## CONCLUSIONS

ADC values calculated from DWI on low field MR-Co60 and MR-LINAC machines did not match the expected values or those found from 1.5T and 3.0T dedicated MRIs.

The EPI sequence used on the MR-LINAC resulted in significant geometric distortion, primarily stretching in the phase encoding direction. This distortion was corrected with affine registration to images acquired at the home gantry angle.

Consistently low ADC values on low magnetic field systems indicate that signal decay may be too great for image generation or that the designated b-values were not achieved.

Future work is required to correct ADC values from low field MRI to the expected value provided by high field MRIs.

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## CONTACT INFORMATION

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