# APPARENT DIFFUSION COEFFICIENT REPEATABILITY AND REPRODUCIBILITY WITHIN THE PROSTATE FOR MR-GUIDED ADAPTIVE RADIATION THERAPY

Nitara Fernando[1], Tony Tadic[2], Winnie Li[2], Tirth Patel[2], Jerusha Padayachee[3], Anna T Santiago[4], Jennifer Dang[2], Peter Chung[2], Enrique Gutierrez[2], Catherine Coolens[2], Ed Taylor[2], Jeff D Winter[2]

[1]Medical Biophysics, Western University, London, Canada [2]Radiation Medicine Program, Princess Margaret Cancer Centre, Toronto, Canada, [3]Auckland City Hospital, Auckland, NZ, [4]UHN Research, University Health Network, Toronto, Canada

Radiation Oncology UNIVERSITY OF TORONTO

UHN Princess Margaret Cancer Centre

## Introduction

- Biologically-based adaptive radiotherapy (ART) is an emerging application for MR-guided prostate radiotherapy.
- Longitudinal intraprostatic apparent diffusion coefficient (ADC) values collected at each fraction can be used for ADC-driven dose adaptation as ADC increases are linked to treatment response.
- Accurate tracking of longitudinal intraprostatic ADC changes at the voxel level are required for biologically-based ART.

***Objective***:

- To quantify repeatability and reproducibility of prostate ADC values over the course of treatment using deformable image registration (DIR) to correct anatomical changes.

## Materials & Methods

- Performed repeat ADC acquisitions for 3 consecutive fractions for patients with prostate cancer (N=20) on the Elekta Unity 1.5T MR-linac.
- DIRs were generated in RayStation 8B, (RaySearch, Stockholm Sweden) between T2-weighted (T2w) images and applied to the ADC maps via the deformed vector field (DVF) as shown in Figure 1.

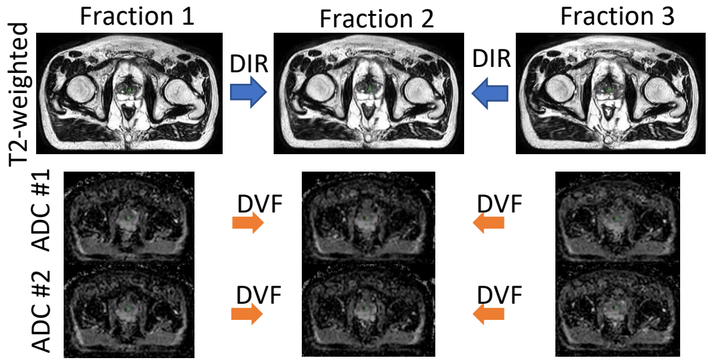
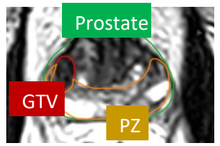



**Figure 1.** Image registration pipeline for deformable image registration (DIR) and application of deformed vector field (DVF) for voxel-wise ADC tracking.

## Materials & Methods




- All MR-visible gross tumour volumes (GTVs), non-GTV peripheral zone (PZ) and prostate clinical target volume (CTV), were manually contoured on the fraction 2 T2w-MR scans.
- Extracted individual voxel (all voxels) and mean ADC values from each contour and calculated repeatability and reproducibility using the intraclass correlation coefficients (ICC) and percent repeatability coefficient (%RC) within (repeatability) and between fractions (reproducibility).

## Results

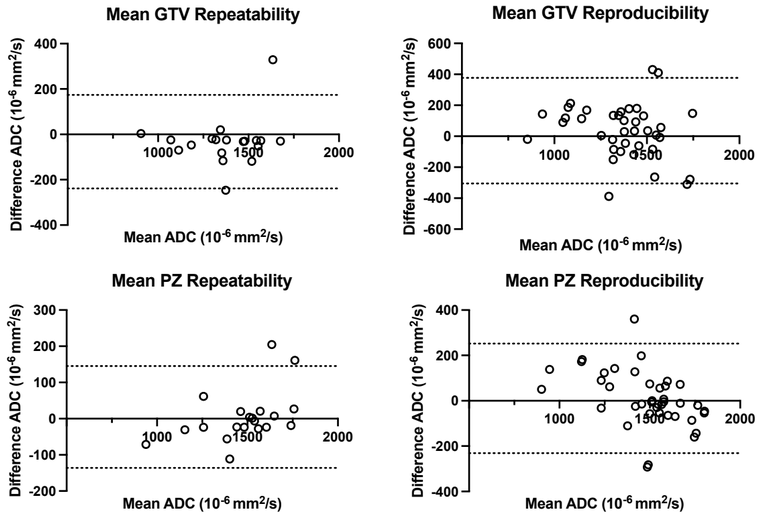



**Figure 2.** Bland-Altmann plots of mean GTV and PZ repeatability and reproducibility

- Bland-Altmann analysis (Figure 2) shows repeatability of $-33 \pm 206\times10^{-3}$ mm²/s for GTV and $5 \pm 141\times10^{-3}$ mm²/s for PZ as well as reproducibility of $36 \pm 341 \times 10^{-3}$ mm²/s for the GTV, $10 \pm 242 \times 10^{-3}$ mm²/s for PZ (mean difference ± 1.96 x SD limits of agreement)

## Results

| | | Factor | ICC | RC (%) |
|---|---|---|---|---|
| GTV | Mean ADC | Repeatability | 0.928 | 10.0 |
| | | Reproducibility | 0.877 | 19.5 |
| | All Voxels | Repeatability | 0.592 | 21.7 |
| | | Reproducibility | 0.542 | 32.1 |
| PZ | Mean ADC | Repeatability | 0.972 | 6.4 |
| | | Reproducibility | 0.952 | 12.8 |
| | All Voxels | Repeatability | 0.660 | 30.6 |
| | | Reproducibility | 0.586 | 38.7 |
| Prostate CTV | Mean ADC | Repeatability | 0.980 | 4.2 |
| | | Reproducibility | 0.941 | 10.2 |
| | All Voxels | Repeatability | 0.667 | 27.6 |
| | | Reproducibility | 0.587 | 34.5 |

**Table 1**. ICC and RC(%) values for repeatability and reproducibility for GTV, PZ, and prostate CTV.

## Discussion

- Excellent ADC repeatability and reproducibility existed for all ROIs (ICC > 0.86) for mean ADC.
- Good repeatability and reproducibility were observed for individual voxels for all ROIs. Similarly, low %RC within-fraction for ADC values existed, with greater %RC between fractions (10.2 - 36.8%).
- We found %RC and ICC results correlated with ROI volume, with greatest precision observed for CTV and least for GTV.
- Larger ROIs (CTV and PZ) may have better repeatability and reproducibility due to the greater number of voxels being sampled.

***Conclusions:***

- Found excellent reproducibility and repeatability for mean percentile ADC values in prostate, using DIR to correct for anatomical changes.
- Established the accuracy for voxel-wise ADC tracking for implementation of biologically-based ART.