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Impact of Patch2Self denoising on Diffusion Kurtosis Imaging at different field strengths

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***Abstract*— We aim at assessing and comparing denoising performance on Diffusion Kurtosis Imaging (DKI) estimates acquired at two different magnetic fields (3T and 7T) through a recently proposed method based on self-supervised learning.**

***Clinical Relevance*— Noise suppression at high field strengths ensures improvement in reproducibility and robustness of DKI biomarkers. This is of utmost importance in diagnostics as DKI metrics are often sensitive to low SNR acquisitions.**

I. INTRODUCTION

Despite many advantages of advanced diffusion Magnetic Resonance Imaging (dMRI) models such as DKI in improving sensitivity to tissue microstructure, both magnetic field strength and noise may represent a bias in estimation of diffusion metrics. Here we aim to assess the effect of Patch2Self denoiser [1] on DKI estimates at varying field strengths.

II. METHODS

We extracted diffusion preprocessed data from a 30-subjects HCP subset (ages 22-35) [2].

We applied Patch2Self to already preprocessed data with default parameters for both field strengths. We then computed DKI measures using DIPY v.1.4.1 [3] for raw and denoised data. For group level comparisons, we used JHU-ICBM atlas (MNI space) and warped its labels into each subject's diffusion space. We focused on White Matter since it is more susceptible to degeneracies inherent to DKI fitting. This often results in implausible negative estimates near tissue and water boundaries. We then investigated following differences before and after Patch2Self denoising through two-sided t-test with Bonferroni correction: 1) We measured degeneracies in DKI maps in specific ROIs and 2) We assessed the goodness of fit by performing a cross-validation approach per-voxel [4].

III. RESULTS

Visual inspection of DKI maps before and after denoising shows minor differences at 3T, unlike 7T, where Patch2Self drastically reduces artefactual banded signal dropouts. This presumably occurs because of field inhomogeneity inherent to ultra-high field strength (Fig. 1a). Similarly, Patch2Self alleviates more degeneracies in model estimation at 7T compared to 3T data (Fig. 1b). Finally, denoising turns out to perform well in significantly improving the consistency of microstructure model fitting at both field strengths (Fig. 1c).

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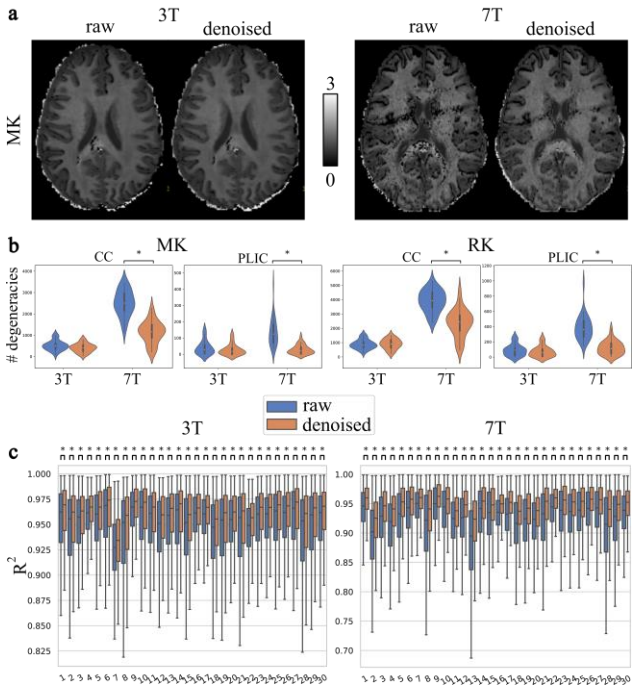

Figure 1. Denoising evaluations at 3T and 7T on DKI metrics. (a) Visual comparison for one exemplary axial slice on Mean Kurtosis (MK) map at 3T and 7T; (b) Number of implausible voxels for MK and Radial Kurtosis (RK) in Corpus Callosum (CC) and Posterior Limb of Internal Capsule (PLIC); (c) Boxplots quantifying the increase in R^2 metric after fitting downstream DKI model to axial slice. * indicates p <= 1.00e-04

IV. DISCUSSION & CONCLUSION

Qualitative and quantitative assessment of DKI measures extracted from raw and denoised data at both 3T and 7T shows that denoising performance improves with an increase in magnetic field strength. We demonstrated that contribution of Patch2Self in improving signal modeling and downstream quantitative diffusion metrics is more significant at 7T with respect to the standard 3T scanner. This work therefore paves the way for exploiting key benefits of high-field imaging in a clinal setting.

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