Ex-Vivo Diffusion Tensor Characterization of Peri-Fibrotic Myocardial Regions In Myocardial Infarction

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Introduction:

Diffusion tensor imaging (DTI) is a powerful MRI technique for studying tissue microstructure, though its use in the cardiovascular system poses technical challenges [1]. Recently, ex vivo cardiac DTI has become a key tool for examining how cardiomyopathies affect heart structure. This study investigates changes in diffusion properties and macrostructure of the peri-infarct areas during chronic myocardial infarction (MI), with DTI findings supported by histology.

Methods:

3D multishell Stejskal–Tanner DTI was performed on an ex vivo heart with myocardial infarction at an 11.7 T Bruker scanner using a transceive cryoprobe and two reference power settings to reduce excitation field inhomogeneity. Imaging parameters included three b-values (0, 1500, 3000 s/mm²) and the spatial resolution of 200 µm³. The diffusion data were reconstructed as described in [2]. Mean, axial, and radial diffusivity maps (MD, AD, and RD, respectively), fractional anisotropy (FA), and restricted diffusion index (RDI) were calculated. To assess fibrosis, samples were fixed in formalin afterwards, frozen, sectioned (10 µm slices, 100 µm intervals), and stained with Sirius Red and Fast Green (SR/FG). Tractography-based fiber orientations were finally reconstructed and compared with histological images.

Results and Discussion:

MD, AD, and RD were significantly higher in peri-infarct tissue than in remote myocardium ($P < 0.05$), suggesting that MRI and the collagen deposition disrupts tissue integrity and enhances water diffusion. FA was also elevated in peri-infarct regions, reflecting higher anisotropy from dense collagen alignment. RDI was higher in peri-infarct areas, consistent with increased extracellular collagen seen in histology. Tractography and SR/FG staining confirmed transverse fiber orientations and collagen alignment along mesocardial sheetlets in peri-fibrotic zones (Fig. 1).

Conclusion:

Diffusion metrics and histological findings converge to provide a coherent depiction of chronic post-infarction remodeling with elevated MD, AD, RD, and RDI in peri-infarct regions. Tractography and SR/FG staining matched with fiber orientations, highlighting DTI's effectiveness in capturing fibrosis, cell loss, and fiber reorganization in chronic MI.

References:

[1] Dall'Armellina, E., et al, *J. Cardiovasc. Magn. Reson.* **27**, 101109 (2025).
[2] Yeh, F. C., Wedeen, V. J., Tseng, W. Y., *IEEE Trans. Med. Imaging* **29**, 1626–1635 (2010).

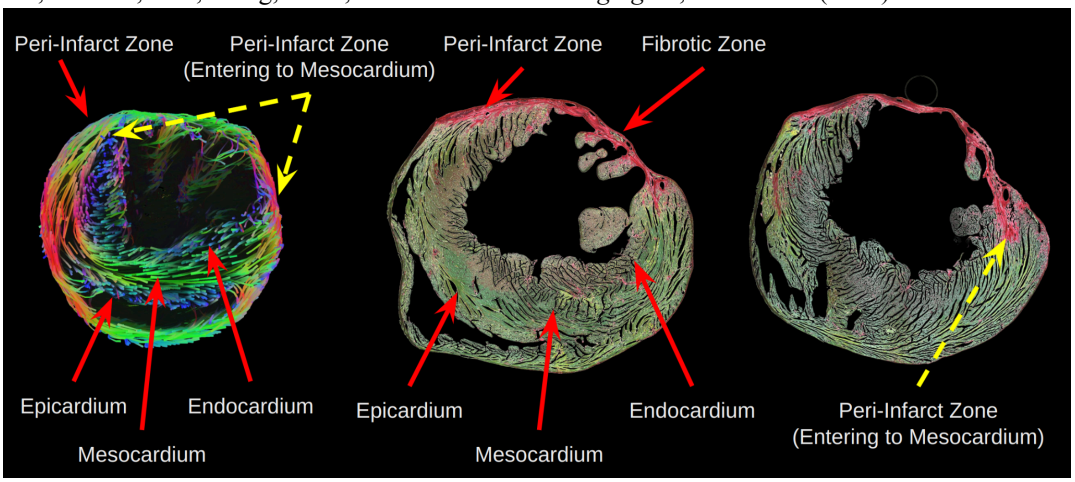

Fig 1. Representative image showing the peri-infarct zone's fiber tracking correlation with the SR/FG histology