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Section 2 – *Project Information*

Project Title	Translational development of cardiac diffusion tensor imaging in cardiometabolic and valvular disease using machine learning

Project Summary

Heart failure is a major global health challenge, affecting millions of people and placing a huge burden on patients, families, and the NHS. Two common conditions, diabetes and aortic stenosis, place the heart under long-term stress, causing changes in the muscle that are often invisible on standard scans. Detecting these early changes could transform how disease is diagnosed, progression is monitored, and decisions are made about who will benefit most from treatment.

This PhD project focuses on advancing a cutting-edge imaging technique called cardiac diffusion tensor imaging (cDTI). cDTI allows the student to investigate the microscopic organisation of the heart muscle, providing information that no other non-invasive method can offer. Early studies suggest it can reveal subtle changes in the heart well before symptoms appear.

The goal of this project is to develop and translate next-generation cDTI techniques so they can be used more routinely in clinical research and, in the future, in patient care. The student will work with patients with diabetes and aortic valve disease, two groups in which early detection of heart muscle injury could significantly change treatment decisions.

Working with state-of-the-art MRI systems at the University of Leicester and the NIHR Leicester Biomedical Research Centre, the student will:

- Optimise and test advanced cDTI methods in volunteers and patients
- Develop new approaches to improve image quality and reduce scan time
- Analyse how microstructural changes relate to heart function, symptoms, and biomarkers
- Apply machine learning and AI approaches to enhance data analysis and extract meaningful patterns from complex imaging datasets
- Contribute to research that may shape future clinical guidelines.

This project is suited to a motivated student interested in imaging, medical physics, data analysis, or cardiovascular health. Prior MRI experience is not required, full training will be provided, but curiosity, enthusiasm, and a desire to carry out research with real-world impact are essential.

By joining this project, the student will be part of a multidisciplinary team including imaging scientists, clinical physicists, cardiologists, and engineers. The student will contribute directly to research aiming to improve diagnosis and treatment for people living with cardiometabolic and valvular disease. This work has the potential to inform future BHF-funded clinical studies and support translation of cDTI into routine assessment of heart muscle health.

The student will receive comprehensive training in advanced cardiac MRI acquisition, analysis, and modelling, including hands-on experience with cDTI and quantitative imaging. Training will include

image processing, data science, and the application of machine learning and AI to medical imaging datasets. The student will also gain experience in clinical research methods through the NIHR Leicester Biomedical Research Centre, attend multidisciplinary meetings, and have opportunities to present findings at national and international conferences. Tailored support will develop coding skills, scientific writing, and research leadership, with mentorship from experts in MRI physics, cardiovascular research, and computational analysis.

References

1. Gotschy, Alexander, et al. "CMR diffusion tensor imaging provides novel imaging markers of adverse myocardial remodeling in aortic stenosis." *Cardiovascular Imaging* 14.7 (2021): 1472-1474.
2. Teh, Irvin, et al. "Multi-centre investigation of cardiac diffusion tensor imaging in healthy volunteers by SCMR cardiac diffusion special interest group NETwork (SIGNET)." *Journal of Cardiovascular Magnetic Resonance* (2025): 101948.
3. Huang, Jiahao, et al. "Deep learning-based diffusion tensor cardiac magnetic resonance reconstruction: a comparison study." *Scientific reports* 14.1 (2024): 5658.