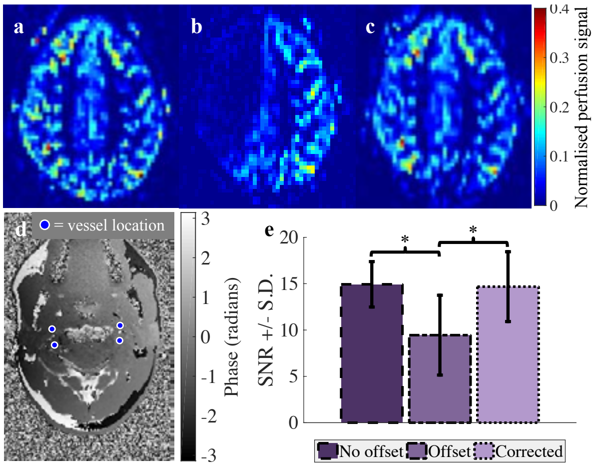
Off-resonance Correction Method for Magnetic Resonance Perfusion Imaging and Angiography

We present here a novel method to correct the effects of magnetic field inhomogeneity on a popular, non-invasive magnetic resonance technique used for both perfusion imaging and angiography. This correction greatly improves the robustness of the technique, both in terms of its image quality and quantitative accuracy.

Imaging of blood flow, both through the arteries (angiography) and into the tissue (perfusion), are of great importance in the assessment of vascular diseases, such as stroke and arteriovenous malformation. They provide information on the function and health of tissue and blood vessels in the brain. This knowledge aids clinicians with diagnosis, prognosis and treatment planning.

Common perfusion imaging and angiography methods require injection of contrast agents and/or use of ionising radiation. Arterial Spin Labelling (ASL) is a non-invasive imaging technique based on Magnetic Resonance Imaging (MRI) that can be used to acquire perfusion images and angiograms in the brain without the use of contrast agents. The most popular ASL technique is Pseudo-Continuous ASL (PCASL). A related method, vessel-encoded PCASL (VEPCASL), is also able to provide vessel-selective information about which arteries feed different parts of the brain. However, magnetic field inhomogeneity (off-resonance) leads to a reduction in labelling efficiency, resulting in poor image quality, underestimation of blood flow and inaccurate vessel-selective information. Current methods for off-resonance correction are limited, with many requiring additional lengthy scans or manual intervention.

The method presented here corrects for off-resonance effects present during (VE)PCASL by incorporating knowledge of magnetic field inhomogeneities into the labelling process using an Optimised Encoding Scheme (OES). It is simple, fast, automated and allows off-resonance to be corrected without increasing the PCASL scan time: only a rapidly acquired field map is required. Unlike other correction methods, it is applicable to VEPCASL and PCASL, and can account for any pattern of off-resonance and any number of vessels. We have shown both theoretically and experimentally that this method greatly improves the robustness of these techniques in the presence of magnetic field inhomogeneity, which could significantly boost their clinical utility in a range of patient groups.



Images of the PCASL perfusion signal in the brain of a representative subject and the mean SNR of this perfusion signal across a group of subjects. The perfusion signal is shown for a: no offsets in the labelling plane, b: offsets, un-corrected in the encoding, leading to loss of perfusion signal in part of the brain, and c: an offset corrected encoding, which recovers the lost perfusion signal. d: Field map of the labeling plane showing the field offsets. e: Mean signal-to-noise ratio (SNR) ± standard deviation of the perfusion signal across all subjects, showing quantitatively the signal loss due to field inhomogeneity which is recovered using the proposed correction method.

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