

Reproducibility of field from an easily installed insert gradient coil for prostate DWI

Horace Z. Zhang¹, Nahla M. H. Elsaid², Terry Nixon^{1,2}, Andrew Dewdney³, Gigi Galiana^{1,2}



¹Department of Biomedical Engineering, Yale University, New Haven, CT, USA

²Department of Radiology & Biomedical Imaging, Yale University, New Haven, CT, USA

³Siemens Healthcare, Erlangen, Germany

Background

- **Gradient amplitude in DWI**
 - Crucial to SNR, diffusion contrast, etc.
- **A novel way: an insert gradient**
 - Locally strong gradient with increased efficiency
 - Heavy semi-permanent gradient coils have been reported

Proposed Device

- **An inside-out nonlinear gradient**
 - Light-weight with easy installation on a scan-by-scan basis
 - Higher inductance and increased slew rate
 - 10cm diameter with gradient $\sim 500\text{mT/m}$ over intended ROI
 - Peripheral nerve stimulation mitigated

Flexibility

- **Installation by one person, under one minute**
 - Lifting and sliding (10 seconds); screw tightening (30 seconds)
 - With flexible installation, is field map reproducible?

Field Map Reproducibility

- **Field mapping**
 - 3D GRE and a trapezoidal nonlinear gradient waveform
 - Removed and pushed back in for 4 times
 - Low-rank approximation by SVD to denoise
- **Reproducibility**
 - The 4 samples of an extracted line shows similar profiles
 - The 10x error map has no significant field profiles but noise
 - The normalized RMSEs are below 2% for original field maps and below 0.2% for denoised field maps

Preliminary Validation of ADC Map

- **Calf imaging and b-value mapping**
 - Spin echo EPI with 6.5s nonlinear gradient waveform, 60% max amplitude, 3x acceleration, 6/8 partial Fourier
 - RESOLVE with linear gradient for reference ADC map
 - Reasonable b-value map; measured ADC close to reference
 - Ghost artifact & distortion due to B_0 inhomogeneity and eddy current

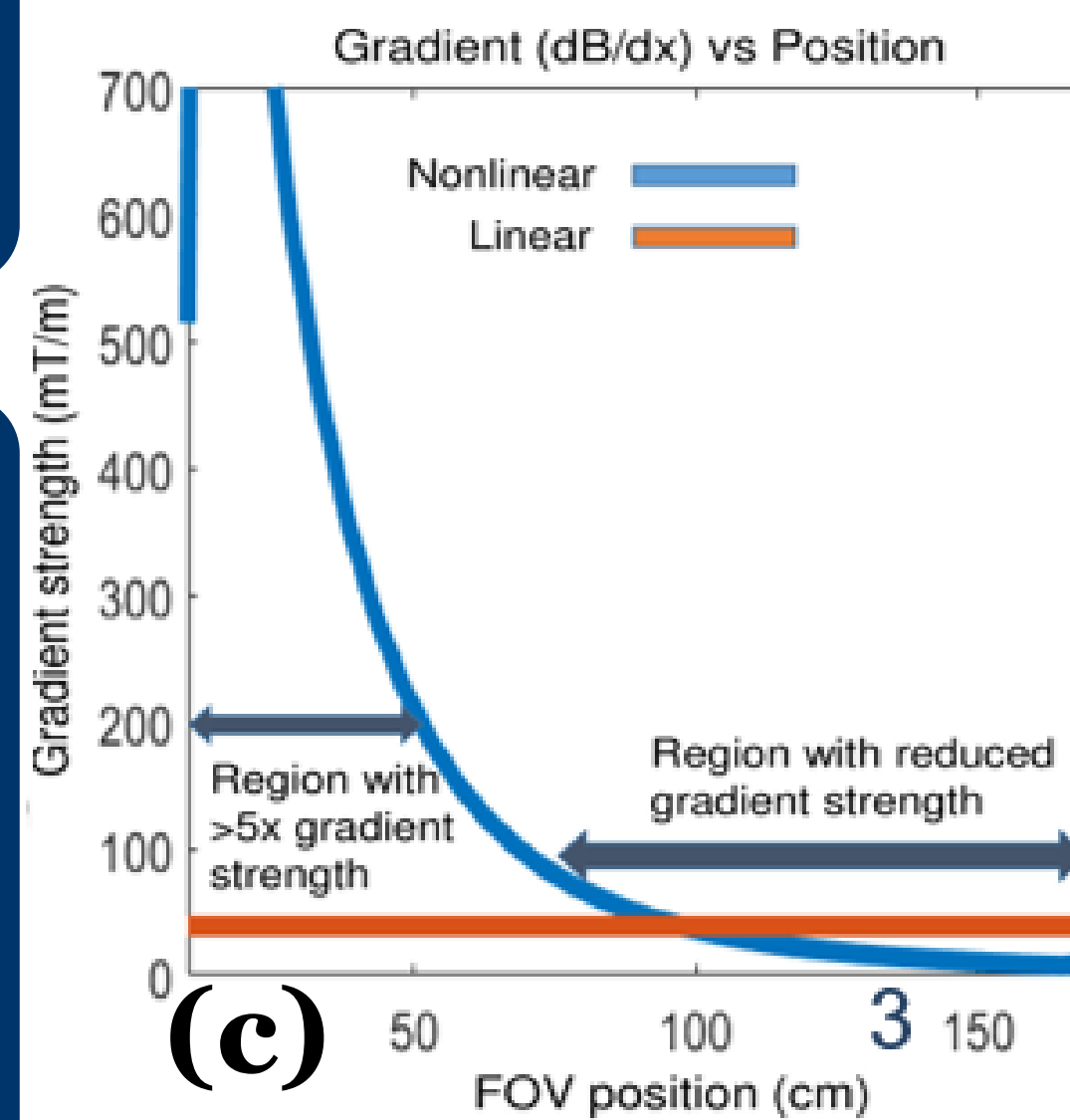
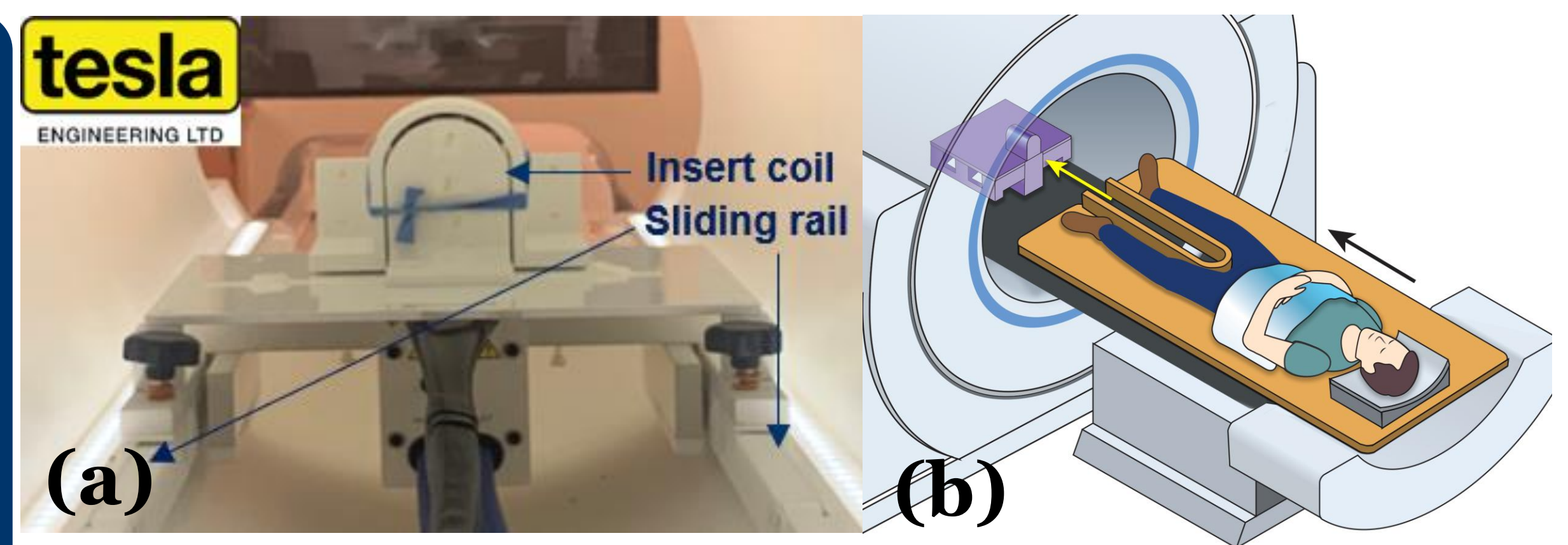


Figure 1

- (a) A sliding rail installed inside the bore and two holes were drilled for fixation.
- (b) Compact inside-out design of the coil. Reduced voltage for required slew rate and mitigated PNS.
- (c) $\sim 500\text{mT/m}$ over 10-cm intended ROI

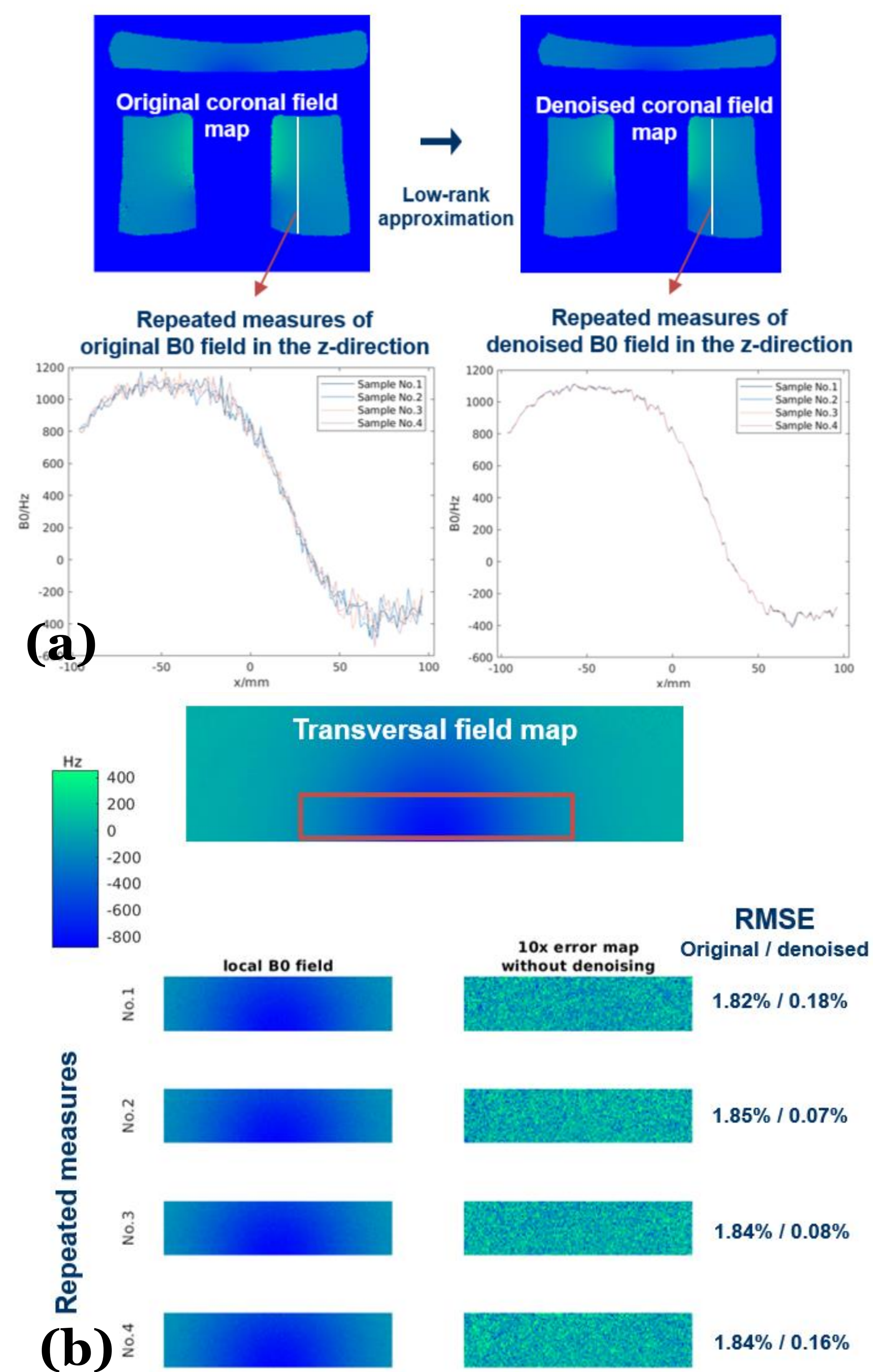


Figure 2

- (a) One line was extracted from the coronal field map, showing similar profiles of the field, especially in the denoised field maps.
- (b) 10x error map of the intended ROI shows low deviation of the b-value across measurements, further proven by RMSE.

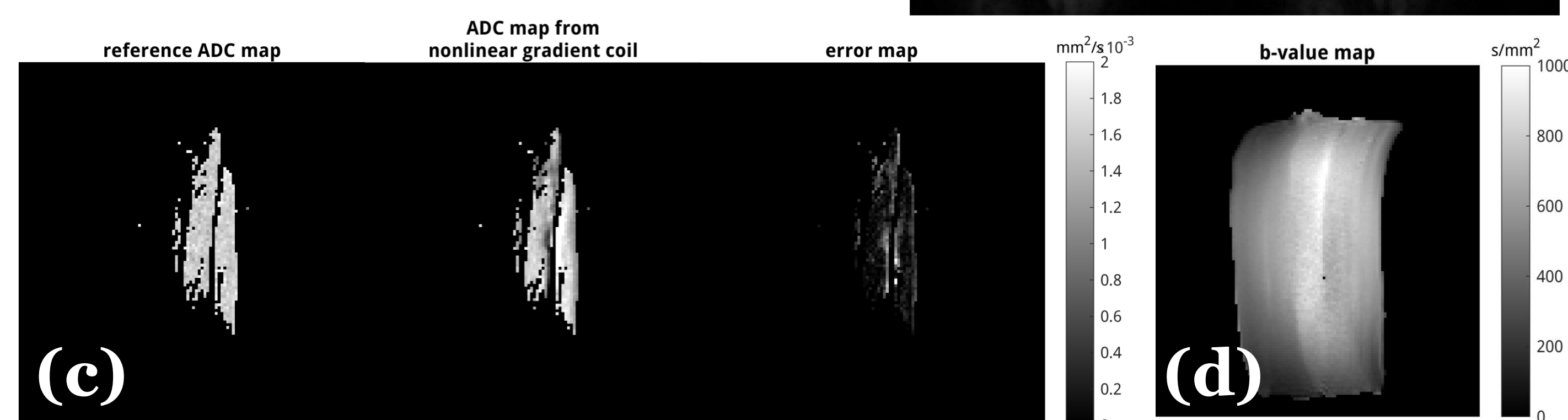
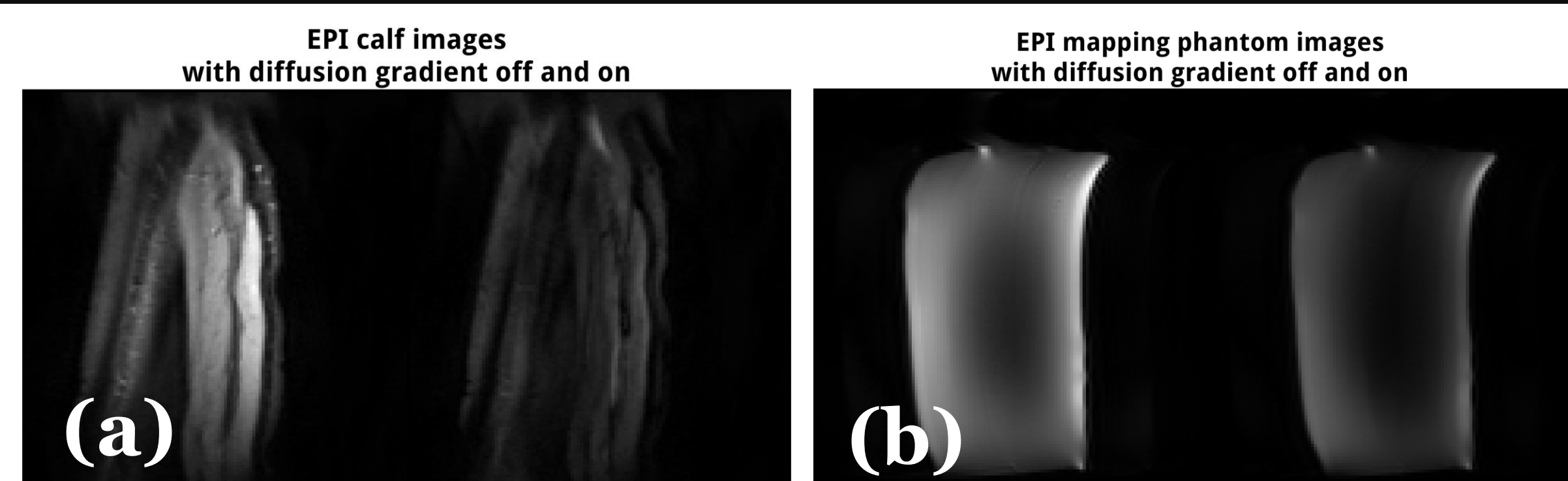


Figure 3

- (a) EPI pair of the calf.
- (b) EPI pair of the mapping phantom.
- (c) reference, measured, and error ADC maps, masked by RESOLVE sequence.
- (d) the corresponding b-value map

Reference

Setsompop et al., NeuroImage, 2013;
 Foo et al., MRM, 2020;
 Bhuiyan et al., Med Phys, 2021;
 Eckart et al., Psychometrika, 1936.