

FIELD STABILIZATION FOR QUANTITATIVE SUSCEPTIBILITY MAPPING USING REAL-TIME FIELD CONTROL

Based on a publication by **Pinar Senay Özbay**, Post-Doctoral Fellow at the National Institutes of Health

Stabilization of the field was achieved through real-time field control which strongly improved the precision of quantitative susceptibility values.

Quantitative susceptibility mapping (QSM) relies on the phase component of gradient echo (GE) images for a voxel-wise estimation of the magnetic susceptibility of tissue. The acquisition of these images is typically performed by gradient echo (GRE) sequences at long echo times and high field. However, these sequences are very sensitive to magnetic field perturbations caused by hardware imperfections such as eddy currents, temperature drifts and cardiac motion. Those disturbances can lead to an overall decrease in image quality, distortions of pixel-intensity values, which in turn affect the applicability and reliability of these techniques as quantitative methods at high field. To eliminate these challenges, the Clip-on Camera was employed to stabilize the field via a real-time updating of the shims and thus recover the quality of gradient-echo-based QSMs despite the field perturbations.

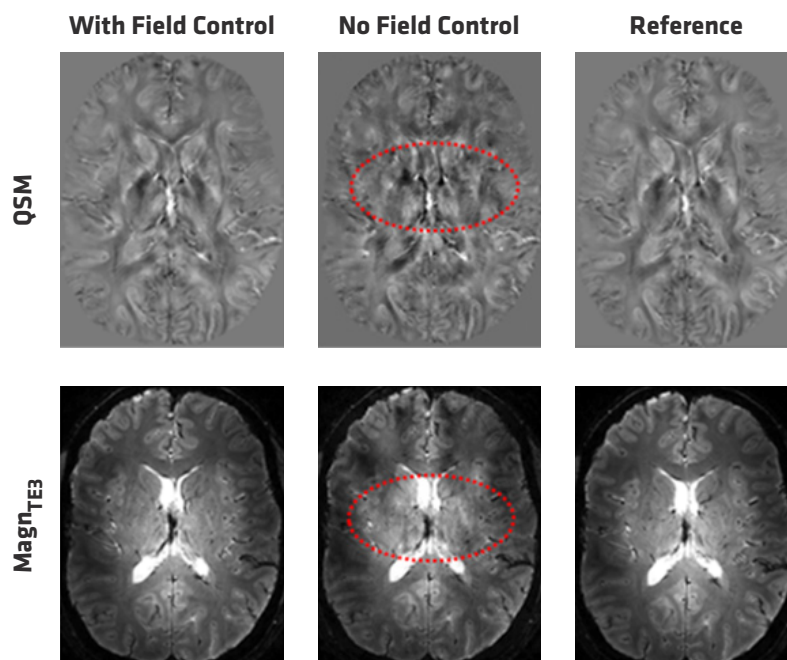


Figure 1: The following magnitude ($TE=29.5$ ms) images and susceptibility maps were acquired under normal breathing (right) and under intentional deep breathing without (middle) and with (left) active field control.

Scan/Region	Putamen		Globus pallidus		Caudate nucleus		
	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation	
Volunteer 1	Reference	0.031	0.016	0.072	0.026	0.028	0.020
	With FP, no FC	0.010	0.029	0.093	0.037	0.008	0.032
	With FP, with FC	0.030	0.019	0.061	0.030	0.031	0.020
Volunteer 2	Reference	0.033	0.001	0.105	0.025	0.026	0.015
	With FP, no FC	0.001	0.200	0.255	0.205	0.042	0.220
	With FP, with FC	0.041	0.002	0.125	0.010	0.023	0.073
Volunteer 3	Reference	0.030	0.015	0.152	0.019	0.021	0.010
	With FP, no FC	-0.062	0.320	0.063	0.350	0.022	0.150
	With FP, with FC	0.052	0.005	0.150	0.002	0.051	0.015

Table 1: The following table presents the mean susceptibility differences (in ppm) in regards to frontal white matter, and standard deviations in regions of deep gray matter structures.

Results

Performing field control with the use of the Clip-on Camera successfully removed phase errors in the phantom images that were caused by time-varying field perturbations. In volunteers, field control significantly curbed the effects of field perturbations. As a result of the continuous monitoring of field deviations, the real-time update of the shim system reduced the deviations from the control experiment from $93 \pm 53\%$ to $31 \pm 46\%$ across all of the regions investigated.

Conclusion

Without field control, controlled field perturbations distinctly exposed issues with GRE imaging at high field both in phantom and in vivo and thus weakening the claim that susceptibility maps are reliably quantitative. With the application of the Clip-on Camera, significant field stabilization was achieved and image quality together with quantitative susceptibility values were restored to the reference values that were acquired under minimum perturbations.

Clip-on Camera

Know the image encoding during your MR scan.

- ▶ Captures field perturbations regardless of their origin
- ▶ Delivers the requisite input to remove phase errors in images
- ▶ Offers real-time field feedback for field stabilization



Further information: Enhanced quantitative susceptibility mapping (QSM) using real-time field control. Özbay PS. Magnetic Resonance in Medicine: 2017.

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