Comparison of SSFP and GRE sequences for qMT acquisition

Nicholas G Dowell[1], Hannah van den Boomen[2], and Mara Cercignani[1]
[1]CISC, Brighton and Sussex Medical School, Brighton, East Sussex, United Kingdom, [2]Life Sciences, University of Sussex, Brighton, East Sussex, United Kingdom

AIM: To assess whether the balanced steady-state free precession (bSSFP) acquisition sequence provides a suitable replacement for the standard gradient echo (GRE) sequence to acquire qMT data.

TARGET AUDIENCE: This work is of particular interest to anyone acquiring qMT data. Also for those that are studying white matter diseases and have not previously considered qMT owing to the lengthy acquisition times.

INTRODUCTION: Traditionally, qMT data has been acquired using a number of gradient echo volumes with varying MT pulse power and frequency offset. Typically, approximately 12 GRE volumes are required to perform the fitting [1] and, where high spatial resolution is required, the total acquisition time scan exceed 25 minutes. This lengthy acquisition time has proved a barrier to the use of qMT in MR protocols. However, Gloor et al [2] have introduced a new method that uses the bSSFP acquisition to significantly reduce the overall scan time to approximately 10 minutes. This impressive time-saving could permit the inclusion of the qMT technique to study white matter (WM). Although Gloor et al [2] performed a simple theoretical comparison between the two approaches, this work will be the first to compare the qMT parameters acquired from a cohort of healthy volunteers. We will compare the repeatability (and hence minimum detectable difference) and within-subject reproducibility of the 2 techniques.

METHODS: *Subjects and scanner.* 7 healthy volunteers were recruited (average age 25 years; 3 male) into the study. Each participant was scanned twice no more than 2 weeks apart using identical protocols. Data was acquired using a 12 channel head coil on a 1.5 T Siemens Avanto scanner.

Acquisition. The qMT parameters were acquired with 2 different acquisition approaches: **GRE MT –** 12 volumes were acquired using a 3D GRE with acquisition parameters: TR=30 ms, TE=5 ms, FoV=180 × 240 mm², matrix size=192 × 256, slice thickness=5mm. The MT pulse length=7.61 ms. The volumes were acquired with MT flip angle 212°, 843° for each offset Δ=400, 875, 1912, 4182, 9146, 2000 Hz. Total acquisition time=24 min. **bSSFP MT –** 13 volumes were acquired using the bSSFP sequence using the MT parameters suggested by Gloor et al [1]. The matrix size and FoV were identical to those used in the GRE acquisition. Oversampling (62.5%) was applied in the slice direction to completely remove aliasing artefacts. Total acquisition time=11 min. **T_1 mapping** was performed by acquiring three 3D GRE volumes with excitation flip angles 5°, 15°, 25°. The other acquisition parameters matched those used for the GRE MT acquisition, although no MT weighting was applied. Acquisition time=6 min. A high-resolution T_1-weighted MP-RAGE was used for anatomical reference with matrix size=256 × 256, FoV=240 × x240mm², voxel size 0.9 × 0.9 × 0.9mm³. Acquisition time=5 min.

Analysis. All MT and T_1-mapping volumes were co-registered to the high-resolution MP-RAGE scan using SPM8. The MT data was fitted using a Levenburg-Marquardt approach using the models in references [2, 3] to yield the MT parameters, including bound proton fraction, F_b. The MP-RAGE was segmented to provide grey-matter (GM) and white-matter (WM) masks that were used to analyze these tissue types independently. A measure of repeatability (= 2.77 × within-subject SD) was calculated [4] to give the minimum detectable difference of each technique.

RESULTS AND DISCUSSION: Table 1 shows that F_b measured using the bSSFP technique provides a greater contrast between GM and WM. The repeatability coefficients are substantially lower in WM with the bSSFP method, indicating that this approach offers better sensitivity to subtle changes. The repeatability in the GM is approximately the same for both methods.

Table 1 – the mean F_b and coefficient of reproducibility for the GRE and bSSFP methods

Tissue	Mean F_b		Repeatability	
	GRE	bSSFP	GRE	bSSFP
GM	7.52	6.13	0.41	0.41
WM	13.48	15.82	1.67	0.45

CONCLUSIONS: This work shows that qMT parameters may be reliably collected using the bSSFP imaging sequence. This approach offers a substantial time-saving on the common GRE approach. Where the protocol permits, this time-saving can be used to acquire higher spatial resolution.

References: [1] Cercignani M, et al. *MRM* 56:803-810, 2006. [2] Gloor M, et al. *MRM* 60:691-700, 2008. [3] Sled JG, et al. *JMR* 145:24–36, 2000. [4] Bland J, et al. *BMJ*, 312:1654-5, 1996. [5] Sled JG, et al. *MRM* 46:923–931, 2001.