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Variability of T1 in purpose recruited normal volunteers and patients as a function of shim (B0), flip angle (B1) and myocardial sector at 3T

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Background

The purpose of this study was to assess inter-subject and spatial variability of T1 measurements in normal volunteers and investigate potential reasons for non-uniform T1 measurements such as off resonance and imperfect flip angle at 3T. A comparison group of patients with normal studies was used to assess how well findings translate to the clinical setting.

Methods

36 subjects (including 20 normal volunteers) were scanned using an investigational prototype sequence on a 3T scanner (MAGNETOM Skyra, Siemens AG, Germany). T1 was measured using three Methods

MOLLI with a flip angle of 20˚, MOLLI with flip angle 35˚, and 2-parameter SASHA with a variable flip angle (VFA) readout. B0 and B1 field maps were generated. Sector level, intra-subject, between-subject, B0-related, and B1-related variability of T1 was assessed with coefficient of variation (COV) and clustered linear mixed models.

Results

The mean T1 value for normal volunteers varied by T1 method (Table, pairwise comparisons all $p<0.001$). Between-subject variation (based on a single average T1 per subject) was about 3% and did not vary significantly between methods (Table). However, intra-subject variability was about 5% for all three methods. Between-subject spatial variation of T1 at a sector level was ±1.5% for both T1 MOLLI flip angle 20˚ and MOLLI flip angle 35˚, and ±1.3% for SASHA.

Using a clustered linear mixed model, absolute B0 offset (shim) was the strongest predictor of T1 for MOLLI flip angle 20˚ ($p<0.0001$), MOLLI flip angle 35˚ ($p<0.0001$), and SASHA ($p=0.0056$). Between-subject effects were weaker but significant for MOLLI flip angle 20˚ ($p=0.0001$), MOLLI flip angle 35˚ ($p=0.0002$), and SASHA ($p=0.0028$). B1 (% prescribed flip angle) was a significant predictor of T1 for all methods in univariable analysis but generally not significant in multivariable analysis. However, we had limited numbers of sectors with a flip angle deviation >20%.

Similar findings were found in patients imaged only with the MOLLI flip angle 20˚. Between-subject variation in T1, intra-subject variation of T1, and B0 offsets were not significantly different from the normal volunteers (Table 1).

Conclusions

B0 inhomogeneity is the biggest source of error in measuring T1 at 3T. B0 offsets artifactually reduce measured T1 by MOLLI and to a lesser degree by SASHA. Between-subject effects are generally second order after B0 effects.

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Table 1 Comparisons of Normal Volunteers and Patients

	Normal Volunteers (N=20)	Patients (N=16)
Mean T1 MOLLI FA 35° Between-subject COV (Mean±SD) Intra-subject COV (Maximum)	1247±54 ms 3%±1.2% 5.3%	NA
Mean T1 MOLLI FA 20° Between-subject COV (Mean±SD) Intra-subject COV (Maximum)	1297±50 ms 2.6%±1.1% 5.4%	1318±47 ms 2.7%±1% 4.3%
Mean T1 SASHA Between-subject COV (Mean±SD) Intra-subject COV (Maximum)	1539±47 ms 2.6%±0.9% 4.7%	NA
Shim: Mean Per subject Absolute B0 Offset ± SD	41.2±17.4 Hz	34.0±18.7 Hz
Shim: Avg Per Subject Max B0 Offset ± SD	90.7±27.2 Hz	85.6±54.8 Hz
Flip Angle: Mean per subject B1 (% of prescribed)	101.7±5.2 %	NA
Flip Angle: Avg per Subject Max B1 (% of prescribed)	118.2±5.9%	NA

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