Towards a quality framework for localized FC relaxometry

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Quality assurance (QA) concerns the accurate and repeatable production of data that meets the requirements of the user. In MRI, quality control checks are well established and ubiquitous, especially in the clinical environment where QA is mandatory for the diagnosis and management of disease. Complete guidelines for routine checks have been produced by various organisations, most notably by the American College of Radiology (ACR), American Association of Physicists in Medicine (AAPM), and the Institute of Physics and Engineering in Medicine (IPEM)[1-3]. However, despite the relevance of quality in MR relaxometry to increasingly critical applications in industry and research (including biomedicine) no equivalent consensus has been achieved. Apart from assuring data accuracy from any one experiment, QA is essential for multi-site studies and particularly useful for identifying degradation in the performance of equipment.

While certain routine QA tests within the scope of MRI are equally important for localized relaxometry (e.g. SNR, geometric accuracy), application-specific quality checks can be postulated depending on the approach. The two vastly differing approaches to localized T_1 dispersion measurement in heterogeneous samples are either to acquire images following evolution at a chosen magnetic field strength and combine them to produce a calculated T_1 map, or to apply single-voxel techniques to acquire signals from a volume of interest (VOI) directly. To assure accuracy, test results should be compared against 'gold standard' methods (e.g. for T_1, flip-angle-invariant inversion-recovery with a small uniform sample and long TR). Action levels should be set such that neither deficiencies in accuracy nor instrumental variance exceed the inherent variation expected between samples and subjects.

For biomedical applications, two befitting phantoms are (a) a sphere incorporating a hollow cylinder through which a smaller sample slides (for localization profiling), and (b), a sphere containing thin-walled cubes of various sizes. All vessels are then filled with stable, inert substances with bio-equivalent relaxation parameters. Suggested checks using (b) include:

- For image-based localized relaxometry, at various field strengths and for each cube in (b), pixel counts correctly classified within actual T_1 ±10%; with those incorrectly classified broken down into internal and edge pixel counts.
- For spectroscopy-style localized relaxometry, contamination quantified by measuring T_1 within a voxel coincident with a cube in (b).
- For both, routine checks of accuracy and repeatability across the entire field range.

References

[1] American College of Radiology, *MRI Quality Control Manual*, 2004.
[2] American Association of Physicists in Medicine, *AAPM Report No. 100*, 2010.
[3] Institute of Physics and Engineering in Medicine, *Report No. 80*, 1999.