

Quantitative Magnetization Transfer in Human Glioma

Gerard Thompson¹, Sha Zhao¹, Geoff JM Parker¹, and Alan Jackson¹

¹University of Manchester, Manchester, United Kingdom

Introduction: The bound pool fraction (f) from quantitative magnetisation transfer (qMT) imaging has been shown to relate to myelin content in animal models[1]. Since gliomas preferentially arise in and affect white matter tracts, f was hypothesised to aid detection of disease and white matter involvement in primary brain tumors which may induce change in f through invasive disruption of white matter integrity[2]. In non-myelinated tissues, the bound fraction may relate to other macromolecular properties. The effect of differing microstructural features and stromal context across different histological glioma subtypes may therefore be reflected in different ranges of f within the solid tumor. In addition, it was hypothesised that accurate calculation of f could be accomplished without B1 correction, even at higher field strengths, by using the same fundamental sequence for variable flip angle T1 mapping and qMT acquisition.

Material and Methods: 47 patients with histologically proven glioma underwent routine pre-operative tumor imaging at 3 T in addition to whole brain 2mm isotropic qMT imaging according to a locally optimized adaptation of the method of Cercignani *et al.*[3] T1 mapping was carried out using the variable flip angle technique ($\alpha=2,5,8,16^\circ$) The following WHO grades of lesions were identified I=1, II=16, III=8, IV=22. Age was 24-73 (mean 51). Within oligo grade II, 6 were 1p/19q deleted and 3 not. Regions of interest were placed on regions of solid tumor (ST) and normal appearing white matter (NAWM) and in the high-grade gliomas (HGG) within peritumoral FLAIR abnormality (PA), which is known to represent a combination of edema and microinvasive disease. A software phantom was generated to assess the impact of B1 inhomogeneity on calculation of f .

Results: There was no significant difference between the mean f values for ST across grades (figure 1,) nor between deleted and non-deleted grade II. There were significant differences between ST, PA and NAWM ($p<0.0005$). Age was significantly negatively correlated with NAWM f (figure 2, $r=-0.47$ $p=0.001$). There was excellent agreement ($R^2=0.99954$) between f calculated with and without B1 correction for both qMT and T1 mapping. An example of f in HGG is shown in figure 3, with reduction in invaded white matter peripherally, and in the splenium of the corpus callosum.

Conclusion: Bound pool fraction from qMT is sensitive for tumor presence in white matter but not specific for grade. Within oligodendroglial tumors, it is not able to distinguish 1p/19q deletion. In invasive HGG, there is a significant difference between solid tumor, peripheral FLAIR abnormality and NAWM. It is inversely related to age in NAWM in keeping with pathophysiological models of aging, and reflecting the sensitivity of the technique for detecting WM change. f provides a quantitative measure which distinguishes solid tumor from peripheral edema or FLAIR hyperintensity and NAWM, and may prove useful for treatment planning and longitudinal disease follow up in glioma. This includes automatic segmentation of LGG from brain, and detection of early peripheral WM change. Finally, f can be derived without the need for B1 correction at 3 T.

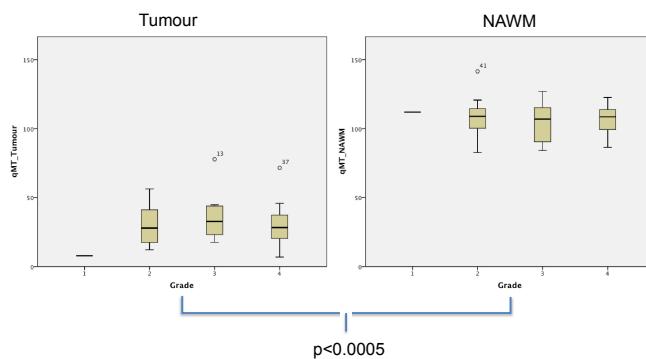


Figure 1: Comparison of qMT f between glioma grades, and between solid tumor and NAWM.

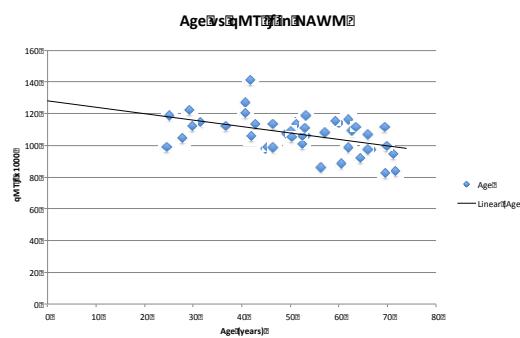


Figure 2: Comparison of qMT f in NAWM with age.

References:

- [1] Ou X, Sun SW, Liang HF, Song SK, Gochberg DF. Quantitative magnetization transfer measured pool-size ratio reflects optic nerve myelin content in ex vivo mice. Magn Reson Med. 2009 Feb;61(2):364-71.
- [2] Tozer DJ, Rees JH, Benton CE, Waldman AD, Jäger HR, Tofts PS. Quantitative magnetisation transfer imaging in glioma: preliminary results. NMR Biomed. 2011 Jun;24(5):492-8.
- [3] Cercignani M, Symms MR, Schmieder K, Boulby PA, Tozer DJ, Ron M, Tofts PS, Barker GJ. Three-dimensional quantitative magnetisation transfer imaging of the human brain. Neuroimage. 2005 Aug 15;27(2):436-41.

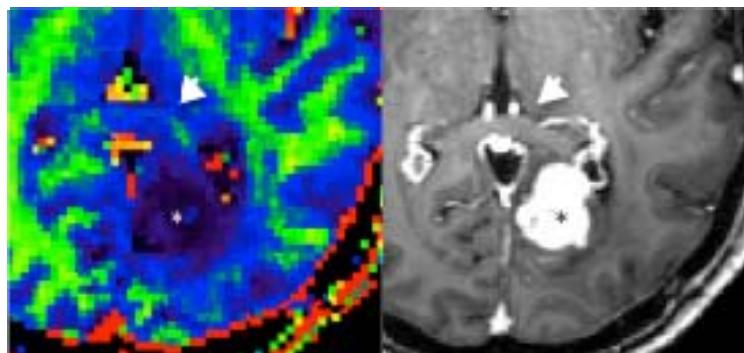


Figure 3: Comparison of qMT f between glioma grades, and between solid tumor and NAWM. Affected white matter is seen in the corpus callosum (white arrow) and surrounding the solid tumor (*).