# Quantitative Brain Tumor Mapping Using Magnetic Resonance Fingerprinting

Chaitra Badve[1], Matthew Rogers[2], Alice Yu[2], Dan Ma[3], Shivani Pahwa[4], Andrew Sloan[5], Jeffrey Sunshine[1,4], Vikas Gulani[1,4], and Mark Griswold[3,4]

*[1]Radiology, University Hospitals, Cleveland, Ohio, United States, [2]School of Medicine, Case Western Reserve University, Cleveland, Ohio, United States, [3]Biomedical Engineering, Case Western Reserve University, Cleveland, Ohio, United States, [4]Radiology, Case Western Reserve University, Cleveland, Ohio, United States, [5]Neurosurgery, University Hospitals, Cleveland, Ohio, United States*

**Target Audience:** Audience interested in MR fingerprinting (MRF), brain tumors, and advanced neuroimaging.

**Purpose:** To evaluate quantitative relaxation parameters of different types of intra-axial brain tumors using MRF.

**Methods:** 21 patients with intra-axial brain tumors, including 10 glioblastoma multiforme (GBM), 5 oligodendrogliomas (OG) and 6 metastases (METS) were scanned using an MRF protocol[1] prior to contrast administration and before beginning any therapeutic interventions. Axial MRF data were acquired through representative areas of tumor region and quantitative $T_1$ and $T_2$ maps were generated. Guided by clinical imaging, $T_1$ and $T_2$ quantification of solid tumor component, immediate perilesional white matter (PWM) within 1 cm from enhancing margin, and contralateral white matter (CWM) was performed using ROI analysis as shown in figure 1. Student's t-test was used for statistical analysis.

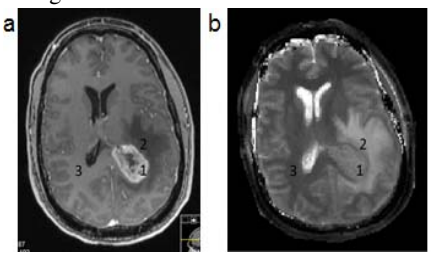


**Figure 1** Representative locations of ROIs used in analysis. 1-Solid tumor region, 2-PWM within 1cm of enhancing margin and 3- CWM, shown in a) post contrast $T_1$-weighted image and b) MRF $T_1$ map

**Results:** Relaxometry values (mean and standard deviation) for each tumor component are listed in table 1. The student's t-test, which was used to compare components, revealed significant differences between tumor elements, with significant findings highlighted in table 2.

**Table 1.** Average $T_1$, $T_2$ values of all regions

| | $T_1$ (ms) | $T_2$ (ms) |
|---|---|---|
| GBM Solid Tumor | 1970±219 | 101±13 |
| GBM PWM | 1889±408 | 109±27 |
| METS Solid Tumor | 1369±243 | 72±19 |
| METS PWM | 1551±263 | 90±17 |
| OG Solid Tumor | 2024±232 | 145±28 |
| OG PWM | 1035±99 | 58±16 |
| CWM | 1008±65 | 46±8 |

**Table 2.** Results of statistical comparison of various tumor regions. Significant results in bold.

| | $T_1$ P-Value | $T_2$ P-Value |
|---|---|---|
| GBM vs. METS Solid Tumor | **$1.7\times10^{-4}$** | **$3.8\times10^{-3}$** |
| GBM vs. METS PWM | **0.027** | **0.045** |
| GBM vs. OG Solid Tumor | 0.34 | **$7.6\times10^{-3}$** |
| All Solid Tumor vs. CWM | **$2.7\times10^{-11}$** | **$4.21\times10^{-9}$** |
| METS/GBM PWM vs. CWM | **$4.5\times10^{-8}$** | **$1.7\times10^{-8}$** |

**Discussion:** This study used MRF to produce relaxometry values which showed significant differences between various components of GBM, METS, and OGs. The results demonstrated that $T_1$ and $T_2$ values as observed with MRF are statistically different in both the solid tumor component and PWM of GBM versus METS. This work also showed a difference in the $T_2$ values of GBM and OG solid tumor regions. Finally, all tumor regions were shown to be quantitatively different than normal CWM for both $T_1$ and $T_2$. All these findings can be summarized graphically as scatter plots, as shown in figure 2. These results demonstrate that MRF generated quantitative maps can be used to reliably distinguish tumor from surrounding normal tissue and to distinguish GBMs, METs, and OGs from one another. These results are driven by differences in the molecular and cellular environments between areas studied, and reflect the sensitivity of MRF to such changes in the presence of disease. This capability has significant clinical potential because a fast, accurate, non-invasive measurement of the tumor micro-environment could potentially provide diagnostic and prognostic information and enable optimization of patient care earlier and more objectively than is conventionally achieved.

**Conclusion:** MRF is able to simultaneously measure $T_1$ and $T_2$ values of brain tumors and surrounding tissues. It can objectively distinguish tumor types and PWM changes from CWM. The preliminary data on MRF of brain tumors suggest potential application of this technique to identify and diagnose intracranial masses, delineate tumor margins, define histologic subtypes, and characterize therapeutic response.

**Acknowledgement:** The authors would like to acknowledge funding from Siemens Healthcare and NIH grants NIH 1R01EB016728-01A1 and NIH 5R01EB017219-02

**REFERENCES:**

1. Ma D, Gulani V, Seiberlich N, et al. Magnetic resonance fingerprinting. *Nature*. 2013; 495:187-193.

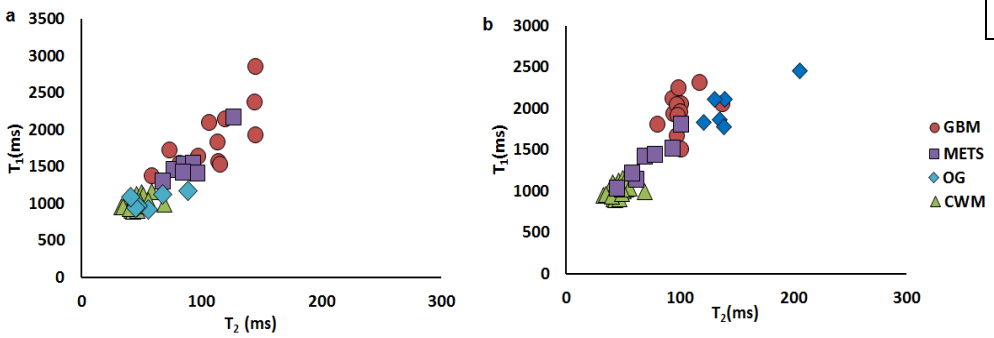


**Figure 2.** Scatter plot of $T_1$ and $T_2$ values for various regions. a) $T_1$ vs $T_2$ chart for PWM regions and CWM. b) $T_1$ vs $T_2$ chart of solid tumor regions in different tumor types and CWM.