

The Application Value of Quantitative Susceptibility Mapping in Grading of Meningiomas

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TARGET AUDIENCE: Researchers and clinicians interested in application of quantitative susceptibility mapping in brain tumor.

PURPOSE: Meningiomas represent the most common intracranial, extra-axial neoplasia and are categorized into three grades by the World Health Organization (WHO) (1). It has been reported that high grade meningiomas have a higher correlation with angiogenesis and subsequent increased occurrence of intracranial hemorrhages. Since Quantitative Susceptibility Mapping (QSM) has high sensitive and specificity in detecting hemorrhages (2), we apply QSM to image meningiomas and to study the relationship between magnetic susceptibility and the their grades.

METHODS: Five biopsy confirmed patients (range age 33-52, mean age 46.8) with meningiomas were recruited in this study (n=4 for grade 1 and n=1 for grade 2). T1 weighted images, T2 weighted images, and T1 weighted contrast enhanced images were acquired in all five patients. Multi-echo gradient echo images were acquired before gadolinium (Gd) injection on all patients, and after injection in three patients (n=2 for grade 1, n=1 for grade 2). These images were also used for generating the quantitative susceptibility maps using a morphology enabled dipole inversion method (3). All QSM were qualitatively evaluated by describing the intensity of the intratumoral susceptibility signal (ITSS) to the surrounding tissue and quantitatively assessed by measuring the intratumoral susceptibility values relative to lateral ventricles.

RESULTS: For pre-Gd QSMs, hyperintense ITSS were found on the grade 2 meningioma only (Fig. 1b). The susceptibility values of grade 1 meningiomas were negative, indicating diamagnetism, while the grade 2 was positive, indicating paramagnetism. Over the volume of an entire tumor, susceptibility value of grade 2 meningioma had a wider range and higher mean than grade 1 as illustrated in the histogram in Fig. 2. The increment of susceptibility values from pre- to post-Gd QSM in grade 2 was larger than in grade1 (Fig. 3).

DISCUSSION and CONCLUSION: Microscopic calcification is rather commonly reported in meningiomas, but gross and radiographically visible calcification is rare. In addition, some subset of low grade meningiomas such as metaplastic and psammomatous meningiomas contain components of metaplastic bone and calcifications (4,5). Since calcifications generally are diamagnetic, the hypointense signal on QSM in grade 1 meningiomas may reflect the diffusely distributed calcifications. The hyperintense signal on QSM and the higher mean susceptibility value in grade 2 tumor histogram suggest rich vascularity and potential hemorrhage in the high grade meningiomas. This is also supported by the fact that the increment of susceptibility values due to contrast injection was higher in grade 2 meningiomas than in grade 1. Compared to Susceptibility Weighted Imaging (SWI), QSM allows easy differentiation of dia- and paramagnetic biophysical sources in tumors such as calcifications and blood products, both of which appear hypointense on SWI. In addition, the quantitative aspect of QSM may facilitate the establishment of an objective criterion for grading meningiomas based on susceptibility values. In this study, we showed that high grade meningiomas have high relative susceptibility values and high increment of susceptibility value after enhancement than low grade ones. This preliminary data invites further study with a larger pool of population to establish QSM's utility in grading meningiomas.

REFERENCES: 1.Fathi, AR *et al.* Curr Neurol Neurosci Rep 2013;13(4):337; 2.Chen, W *et al.* Radiology 2013; 3.Liu, T *et al.* Magn Reson Med 2013;69(2):467-76; 4.Huang, J *et al.* Rare Tumors 2011;3(2):e20; 5.Lunardi, P *et al.* J Neurosurg Sci 1992;36(4):243-6.

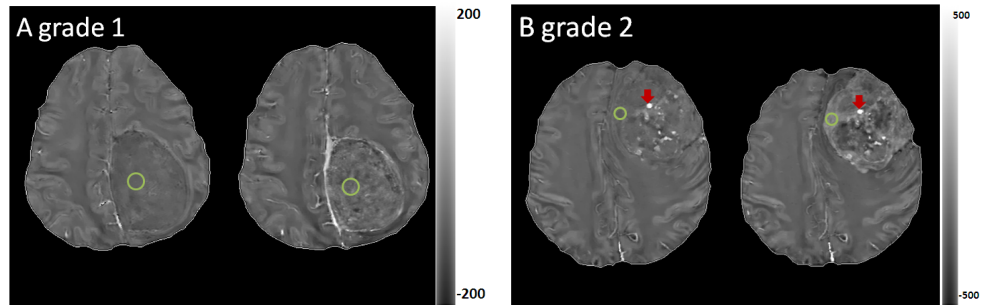


Fig 1. Pre- and post-Gd QSM (left and right in each image). Grade 1 meningioma on left parietal lobe without hyperintense ITSS(A). grade 2 meningioma on left frontal lobe with hyperintense ITSS (hemorrhage) on QSM (B). Red arrow indicates hemorrhage. Circles indicate regions where quantitative susceptibility values were measured.

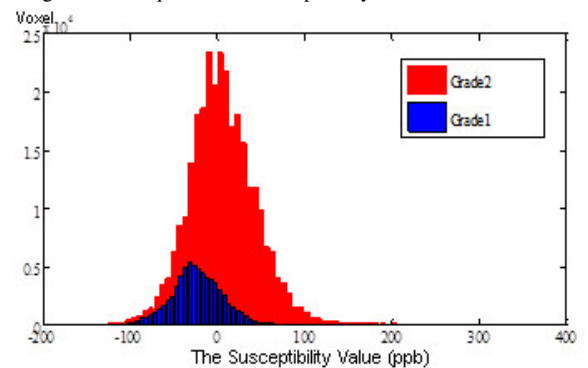


Fig 2. The signal intensity histograms of grade 2 and grade 1 meningiomas.

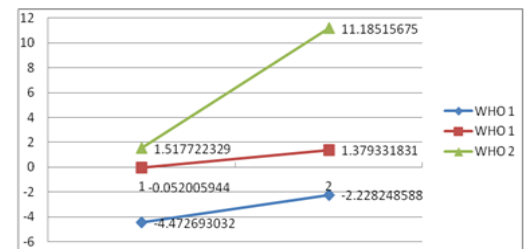


Fig 3. Comparing pre and post-Gd QSM, the increment of susceptibility values are larger in grade 2 than grade 1.