Quantitative susceptibility mapping

see Quantitative susceptibility mapping for iron.

Quantitative Susceptibility Mapping (QSM) provides a novel contrast mechanism in Magnetic Resonance Imaging (MRI) different from traditional Susceptibility Weighted Imaging.

The voxel intensity in QSM is linearly proportional to the underlying tissue apparent magnetic susceptibility, which is useful for chemical identification and quantification of specific biomarkers including iron, calcium, gadolinium, and super paramagnetic iron oxide (SPIO) nano-particles. QSM utilizes phase images, solves the magnetic field to susceptibility source inverse problem, and generates a three-dimensional susceptibility distribution. Due to its quantitative nature and sensitivity to certain kinds of material, potential QSM applications include standardized quantitative stratification of cerebral microbleeds and neurodegenerative disease, accurate gadolinium quantification in contrast enhanced MRI, and direct monitoring of targeted theranostic drug biodistribution in nanomedicine.

The goal of this study was to demonstrate the use of quantitative susceptibility mapping (QSM)-based images to precisely localize the globus pallidus internus (GPi) for deep brain stimulation (DBS) planning and to enhance postsurgical visualization of the DBS lead positions.

METHODS: Presurgical T1-weighted (T1w), T2-weighted (T2w), and QSM images as well as postsurgical CT images were obtained in 29 patients with Parkinson's disease. To enhance the contrast within the GP, a hybrid contrast was created by linearly combining T1w and QSM images. Contrast-to-noise ratios (CNRs) of the GPi on T1w, T2w, QSM, and hybrid images were compared. The CNR differences were tested using the 1-way ANOVA method. The visualization of the DBS lead position was demonstrated by merging the postsurgical CT with presurgical MR images.

RESULTS: The hybrid images yield the best CNRs for GPi depiction and the visualization of the postsurgical DBS lead position was significantly improved.

CONCLUSIONS: QSM-based images allow for confident localization of borders of the GPi that is superior to T1w and T2w images. High-contrast hybrid images can be used for precisely directed DBS targeting, e.g., GPi DBS for the treatment of advanced Parkinson's disease [1)].

The precision and accuracy of direct targeting with quantitative susceptibility mapping (QSM) was examined in a total of 25 Parkinson's disease patients between 2013 and 2015 at the Department of Neurosurgery, Mount Sinai Health System, New York. QSM was utilized as the primary magnetic resonance imaging (MRI) method to perform direct STN targeting on a stereotactic planning station utilizing computed tomography/MR fusion. Intraoperative microelectrode recordings (MER) were obtained to confirm appropriate trajectory through the sensorimotor STN.

Estimations of STN thickness between the MER and QSM methods appeared to be correlated. Mean STN thickness was 5.3 mm. Kinesthetic responsive cells were found in > 90% of electrode runs. The

mean radial error (±SEM) was 0.54 ± 0.1 mm. Satisfactory clinical response as determined by Unified Parkinson's Disease Rating Scale (UPDRS III) was seen at 12 mo after surgery.

Direct targeting of the sensorimotor STN using QSM demonstrates MER correlation and can be safely used for deep brain stimulation lead placement with satisfactory clinical response. These results imply that targeting based on QSM signaling alone is sufficient to obtain reliable and reproducible outcomes in the absence of physiological recordings [2)].

In their analysis, Rasouli et al accept that the raw measurements they derived by the 2 methods (microelectrode recording [MER] vs quantitaive susceptibility mapping [QSM]) do not exhibit a high degree of correlation. They offer several reasons for this (differences in resolution, standard deviations, and narrow range of measurements), thereby justifying the use of normalized data and the Bland–Altman analysis. In contrast to the Bland–Altman analysis, which suggests agreement, the intra-correlation coefficient (ICC) = 0.12 implies that there is high variability between QSM and MER measurements within an individual (ie, they are not in good agreement). More useful in our view would be to see how well the actual measurements made with the 2 methods agree on a case by case basis. How often do the measurements agree within 0.1, 0.5, 1, 2 mm, etc.? Such valuable information would allow the readers to decide for themselves whether a measured subthalamic nucleus (STN) span on QSM is a legitimate proxy for the gold standard of measuring the STN with MER and we urge the authors to publish this data in a subsequent letter [3)].

Quantitative Susceptibility Mapping (QSM) MRI allows accurate assessment of iron content in cerebral cavernous malformations (CCM), and a threshold increase by 6% in QSM has been shown to reflect new symptomatic hemorrhage (SH) in previously stable lesions.

It is unclear how lesional QSM evolves in CCMs after recent SH, and whether this could serve as a monitoring biomarker in clinical trials aimed at preventing rebleeding in these lesions.

In 16 CCM patients who experienced a SH within the past year, whose lesion was not resected or irradiated.

The data acquisition was performed using QSM sequence implemented on a 3T MRI system ASSESSMENT: The lesional QSM assessments at baseline and yearly during 22 patient-years of follow-up were performed by a trained research staff including imaging scientists.

Biomarker changes were assessed in relation to clinical events. Clinical trial modeling was performed using two-tailed tests of time-averaged difference (assuming within-patient correlation of 0.8, power = 0.9 and alpha = 0.1) to detect 20%, 30% or 50% effects of intervention on clinical and biomarkers event rates during two years of follow-up.

The change in mean lesional QSM of index hemorrhagic lesions was +7.93% per patient-year in the whole cohort. There were 5 cases (31%) of recurrent SH or lesional growth, and twice as many instances (62%) with a threshold (6%) increase in QSM. There were no instances of SH hemorrhage or lesional growth without an associated threshold increase in QSM during the same epoch [4)].

1)
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2)
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4)
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