# Quantitative susceptibility mapping (QSM) of intracranial calcification: comparison with gradient echo (GRE) phase images and CT

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**Purpose:** The signal of calcifications on gradient echo (GRE) images is not specific and may be mistaken for other findings such as hemorrhages. Additional CT confirmation is often needed for making proper diagnosis, prognosis, and therapy. Recently, GRE phase image and quantitative susceptibility mapping (QSM) have been shown to differentiate paramagnetic materials including hemorrhages from diamagnetic materials including calcifications in a few cases [1,2,3]. Here, we evaluate the accuracy of QSM and GRE phase images in detecting intracranial calcifications in a cohort of patients, using CT as the reference standard.

**Materials & Methods:** Two experienced neuroradiologists retrospectively reviewed GRE phase and QSM images, reconstructed using a morphology enabled dipole inversion algorithm [4], of 38 consecutive patients (ages 6-75; 24M /14F) with suspected intracranial calcifications. All patients had CT within 7 days of MRI. Abnormal signal variations on QSM and GRE phase images were identified as lesions and classified as calcifications or hemorrhages based on their signal values (display level=0) [1,2,3,5]. Sensitivities and specificities were calculated for QSM and GRE phase images using CT as reference standard. Differences between QSM and GRE phase images were assessed using the McNemar test. Inter-observer agreement was assessed by Cohen's κ coefficient [6, 7].

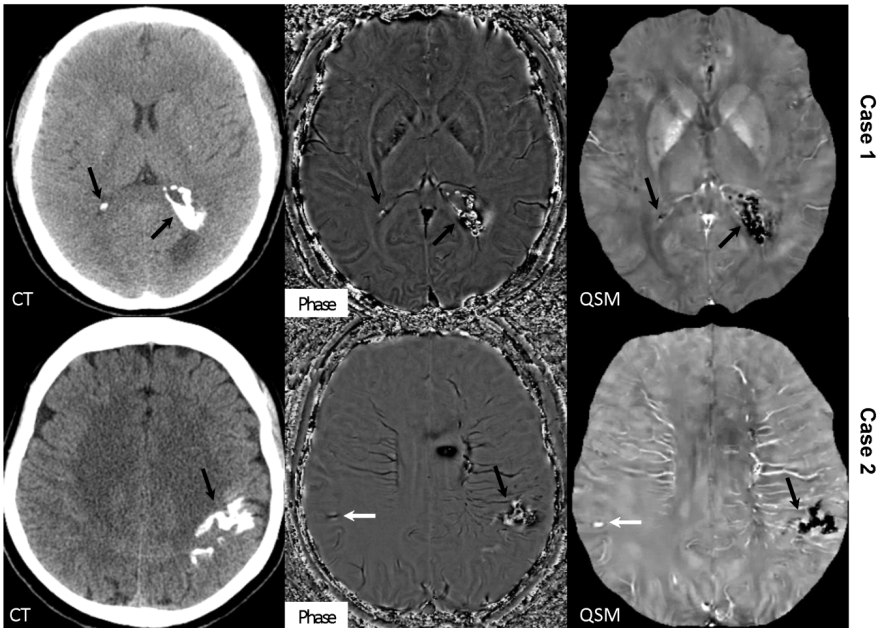


Fig 1: Typical calcifications (black arrows) showed negative on QSM, hyperintense on CT, heterogeneous but mostly positive on GRE phase images. A paramagnetic lesion suspected as a microbleed (white arrows) shows positive on QSM, negative on GRE phase, isointense on CT images.

**Results:** A total of 220 lesions were detected on QSM and GRE phase images, 168 (76.4%) of which were calcifications and confirmed by CT while the other 52 (23.6%) were not calcifications and showed hypointensity or isointensity on CT. On QSM, calcifications appeared either totally negative (98.7%) or mostly negative with some heterogeneity (Figure1). On GRE phase images, calcifications appeared either totally positive (53.6%) or mostly positive with some heterogeneity (46.4%) (Figure1). Table 1 summarizes the sensitivities, specificities, and accuracies of the two methods. QSM was found to provide higher sensitivity and specificity than GRE phase ($p<0.05$) by both readers. Inter-observer agreement of QSM ($\kappa=0.978$; 95%CI, 0.949~1) was better than that of GRE phase ($\kappa=0.877$; 95%CI, 0.81~0.944), although the inter-observer agreements were excellent for both methods.

| | Reader1 | | Reader2 | |
|---|---|---|---|---|
| | QSM | GRE phase | QSM | GRE phase |
| Sensitivity (95%CI) | 0.91 (0.86-0.95) | 0.75 (0.68-0.82) | 0.90 (0.84-0.94) | 0.79 (0.72-0.85) |
| Specificity (95%CI) | 0.85 (0.73-0.93) | 0.62 (0.48-0.74) | 0.86 (0.75-0.94) | 0.59 (0.46-0.72) |
| Accuracy | 0.90 | 0.71 | 0.89 | 0.74 |

Table 1: Diagnostic performance of QSM and GRE phase images in detecting intracranial calcifications

**Discussion and Conclusion:** Our results demonstrate that QSM is more accurate than GRE phase images for intracranial calcification identification. This is because the phase is non-local and contains blooming artifacts, while QSM, by deconvolving the phase, reflects local tissue magnetic properties.

Using CT as the gold standard, QSM showed a fairly good accuracy, whereas GRE phase a poor one. However, CT is not always a reliable gold standard, as we noted small negative lesions on QSM which did not show on CT. This may suggest that QSM is more sensitive than CT for measuring calcifications. Surgical confirmation or biopsy is difficult to obtain. Perhaps a reasonable gold standard is to pool information from both MRI and CT, which can then be used to assess the accuracy of both modalities. With such a gold standard, QSM is perhaps as accurate as CT, if not even more.

**References:** [1] de Rochefort et al. MRM:63(1):194-206; [2] Schweser et al. Med Phys:37(10):5165-5178; [3] Zhen et al. JMRI:29 (1):177-182; [4] Liu et al. NeuroImage: 2011(in press); [5] Zhu et al. Chin Med J (Engl):121(20):2021-2025; [6] Cohen J. Educ Psychol Meas:20(1):37-46. [7] Altman DG. Practical statistics for medical research. Chapman and Hall; 1991