Editorial for Quantitative Susceptibility Mapping for Characterization of Intraplaque Hemorrhage and Calcification in Carotid Atherosclerotic Disease

Plaque imaging on MR provides useful information about the vulnerability of carotid plaque in patients with atherosclerosis. Intraplaque hemorrhage is often seen in symptomatic plaques, which may also contain lipid-rich necrotic cores. Differentiating intraplaque hemorrhage (IPH) from lipid-rich necrotic cores on MR imaging is important, because IPH is associated with a high hazard ratio for subsequent stroke or transient ischemic attack.[1] High-resolution black-blood T1-weighted imaging (BB-T1) is a very useful method to detect IPH as high signal intensity on BB-T1.[2] Ruptured fibrous cap and thinning of fibrous cap are also important findings, and are evaluated with contrast-enhanced MR angiography.

Although a high signal on T1-weighted images inside the plaque is believed to represent IPH, histopathological demonstration of such MR findings is central to understanding carotid plaque imaging. In addition, calcification may be present inside the fibrous cap overlying the lipid core. Such intraplaque calcification can be represented as a higher attenuation value on CT compared with IPH and lipid-rich necrotic cores. Intraplaque calcification on MRI shows low intensity in each sequence,[1] but some overlap may exist.

Recently, differentiation between hemorrhage and calcification has been realized by quantitative susceptibility mapping (QSM) using phase images of MRI. The reproducibility and consistency of susceptibility values have been reported using QSM in the brain,[3] and the relationship of QSM and CT in hemorrhage and calcification is also important for radiologists to interpret susceptibility values in the brain.[4] With the successful results for QSM within the brain, QSM outside the brain has gained attention. In this study, the authors describe a new QSM protocol for identifying IPH and calcification in the carotid artery.[5] Accurate description of IPH and the reproducibility of QSM for plaque measurements were demonstrated for the first time.[5] They have also shown consistency between QSM and histopathological analysis.[5]

Plaque imaging has already been introduced to clinical routines, and improvement of image resolution[6] and reduction of scan time[7,8] have been explored to add clinical value. A pilot study of QSM for carotid plaque demonstrated that IPH, lipid-rich necrosis, and calcification can be differentiated on QSM,[9] and the current study augments the utility of in-vivo QSM studies for carotid plaque imaging in larger patient population.[5] QSM provided an accurate delineation of IPH and calcification when compared with the other BB-T1 such as T1-weighted Sampling Perfection with Application of optimized Contrasts using different flip angle Evolution (T1-SPACE) and magnetization prepared rapid acquisition with gradient echo (MP-RAGE). Moreover, the authors conducted a reproducibility study of QSM for carotid plaque for the first time. An ex-vivo QSM study of carotid plaque also demonstrated the visualization of hemorrhage and calcification inside the carotid plaque by comparing the results with findings from subsequent histopathological examination.[10]

Applications of QSM to carotid plaque imaging thus appear promising, but several challenges remain. Dense calcification may produce a large diamagnetic effect, but small amounts of calcification nearby the fibrous cap may show only a small diamagnetic effect. Colocalization of calcification and hemorrhage may thus lead to underestimation of the area of diamagnetic lesion associated with calcification, because the paramagnetic effect derived from IPH or iron deposition will overwhelm the relatively smaller diamagnetic effect of the calcification.[10] CT offers highly reproducible quantitative measurements of calcification, so comparisons between QSM and CT may provide more accurate information regarding calcification in the carotid plaque.[4] However, differences in neck positions for both modalities as well as physiological movements may hamper precise comparisons between these modalities.

Improvement of the through-plane and in-plane image resolution of QSM is desirable, but it has a trade-off relationship with reduction of scan time.

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