

Quantification of 7 Tesla SWI Hypointensities in Gliomas using the Local Image Variance

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Introduction:

The purpose of this study was to analyze intratumoral structures of glial tumors in a quantitative way using Susceptibility-Weighted Imaging (SWI) at 7 Tesla (T) and the local image variance (measure of image variations in the vicinity of a pixel) as measure. SWI at 7 T allows high resolution visualization of the venous microvasculature, intratumoral blood products and micro bleeds within brain tumors. With SWI, all these structures are represented hypointense compared to the surrounding tissue which results in a high local image variance if the density of these structures is high.

In this work, we have used the local image variance in order to differentiate between low and high grade gliomas, and in addition local image variance values were correlated with histopathological analysis.

Materials and Methods:

The patient cohort included five patients with low grade gliomas (grade II) and 17 patients with high grade gliomas (grade III or IV). All tumors were histologically evaluated according to the WHO classification system. All tumor patients underwent the following T1-weighted and SWI 7 Tesla MR imaging protocol. T1-weighted data were acquired with and without contrast agent (CA) administration using an MPRAGE sequence with the following parameters: image-matrix = 320x320; resolution = 0.75x0.72x0.7mm; slices = 208; parallel imaging factor = 2, TR/TI/TE 3800/1700/3.55 ms, acquisition time = 10:29 min. Between the T1-weighted measurements a three-dimensional, fully first-order flow-compensated gradient-echo (SWI) sequence with a TE of 15 ms was performed in order to acquire SWI data at 7T. Other sequence parameters were: TR = 28ms; image-matrix = 704x704 pixel; slices = 96; parallel imaging factor = 2, acquisition time = 10.18 min, resolution = 0.3x0.3x1.2mm. After acquisition, SWI images were intensity corrected and afterwards image intensity was rescaled in the arbitrary range between 0 and 100 which ensures that no bias is introduced because of different image intensity ranges. The local image variance σ_{ij}^2 was then calculated using

$$\sigma_{ij}^2 = \frac{1}{(2L+1)^2} \sum_{k=i-L}^{i+L} \sum_{l=j-L}^{j+L} I_{kl}^2 - \left(\frac{1}{(2L+1)^2} \sum_{k=i-L}^{i+L} \sum_{l=j-L}^{j+L} I_{kl} \right)^2$$

where I_{kl} is the actual pixel intensity at the position ij . The area which contributes to the local variance is given by $(2L+1) \times (2L+1)$ which was in our case a Gaussian filter kernel with a FWHM of 3mm. Manual tumor segmentation was performed by a neuroanatomical expert on the contrast enhanced T1-weighted data. In order to correlate the microvascular density (MVD), assessed by histopathological investigation to the local image variance, the microvascular density was assessed as described by [1] which was possible in 17 out of 22 cases.

Results:

The mean local image variance for all patient datasets was 112.43 with a standard deviation (SD) of 68.65. High grade gliomas (HGG) showed a mean local image variance of 132.35 (SD=63.12) and Low grade gliomas (LGG) showed a value of 44.7 (SD=19). HGGs showed a significantly higher local image variance compared to LGGs ($p=0.000045$; t-test). The MVD for all patient datasets ranged from 32 to 283 microvessels per 0.25 mm^2 with a median of 78. Neuroradiological data (local image variance) and histopathological data (MVD) correlated significantly (Pearson's correlation coefficient=0.49, $p=0.046$). Figure 1 gives an example for a HGG and a LGG overlaid with the local image variance.

Discussion and Conclusion:

Local image variance values based on SWI images correlate with histopathological analysis in glioma and may aid non-invasive evaluation of tumor dignity and may also help in more accurate planning of stereotactic brain tumor biopsies.

References:

1) Preusser M. et al. Cancer. 2006 Jul 1;107(1):162-70.

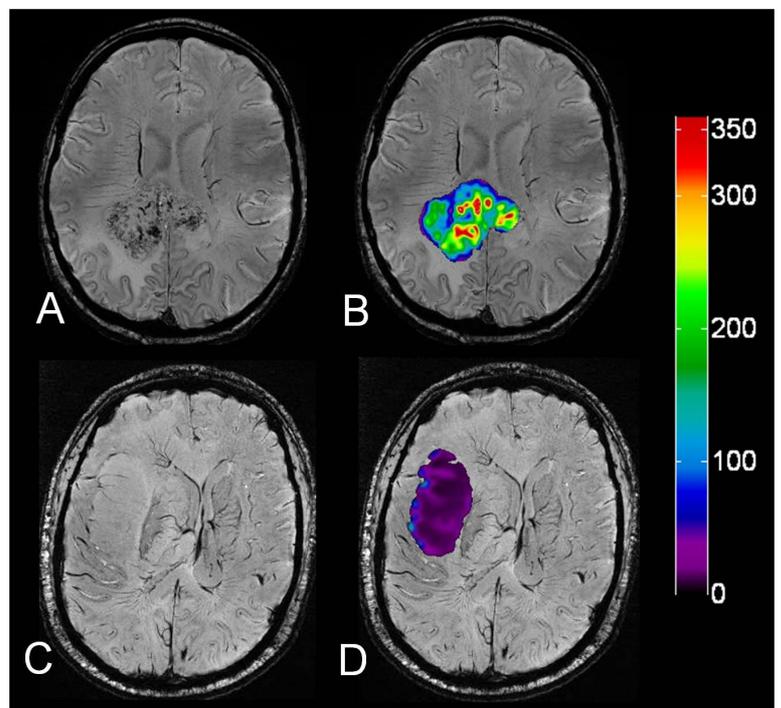


Figure 1: Intratumoral image variance; A represents a glioblastoma and in B the tumor is overlaid with corresponding local image variance. C and D represent a low grade glioma. C represents the SWI image and in D the tumor is overlaid with corresponding local image variance. Note the higher variability in B compared to D.