Computer-aided detection of brain tumor invasion using morphological and diffusion-weighted MR.

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Introduction

Accurate discrimination of brain tumor from other tissues using noninvasive imaging is a high priority for the planning of surgical and radiotherapy treatments. Prior to treatment, the area of contrast enhancement on T_1 MRI is typically identified as tumor, and regions of hyperintensity on T_2 images outside the tumor area are termed peritumoral edema. However, evidence of tumor invasion in the peritumoral edema has been reported so radiation treatment (*e.g.*, IMRT) frequently targets both regions but may be targeting some areas unnecessarily. Therefore, the objective of this study was to establish the feasibility of computer-aided detection of tumor invasion within edema using morphological and diffusion-weighted MRI in order to facilitate more effective dose distribution.

Methods

A retrospective analysis was performed using *de novo* meningiomas (*N*=3) and GBM (*N*=3) patients. Meningiomas were used as controls as they typically have no tumor invasion within the perritumoral areas, while GBMs tend to have invasion. T_1 (pre- and post-contrast), T_2 FLAIR, DWI, and DTI were acquired on a 1.5-T MR scanner (GE Healthcare, Waukesha, WI). Feature maps of ADC and FA were calculated from the diffusion-weighted images. Figure 1 illustrates the classification scheme. Images within each study were coregistered. Using the morphological images as inputs, a threshold-based segmentation and manual classification scheme determined the contrast-enhanced and peritumoral areas. A multilayer perceptron neural network (MLPNN) [1] performed the final classification of the peritumoral area while the contrast-enhanced area was assigned to be pure tumor. The MLPNN inputs consisted of the ADC and FA values in addition to the standardized T1 signal [2], and the output was in the range 0 (pure edema) to 1 (pure tumor). The MLPNN was trained using edema voxels from meningiomas, since peritumoral edema of meningiomas is typically pure edema, and tumor voxels from contrast-enhanced regions of GBMs.

Results

As expected, the final classifications indicated the hyperintense FLAIR region outside the area of contrast enhancement was fairly homogeneous edema for meningioma cases (not shown). The final classifications for GBM cases displayed zones of tumor within the peritumoral edema. Figure 2 displays some of the acquired images, feature maps, and results for an example GBM case. Figure 3 shows evidence of recurrence (*e.g.*, new enhancing areas) post-resection/post-radiation for the same patient in the same areas where our classification indicated tumor invasion.

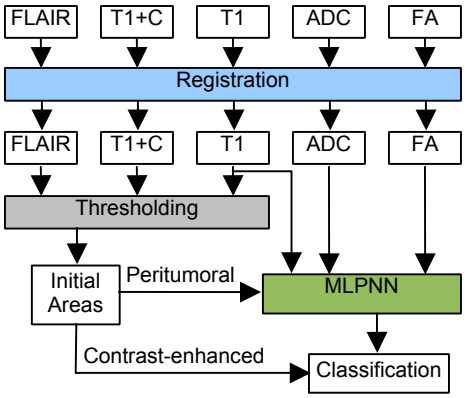

FIGURE 1. Scheme for classification of peritumoral and contrast-enhanced areas.

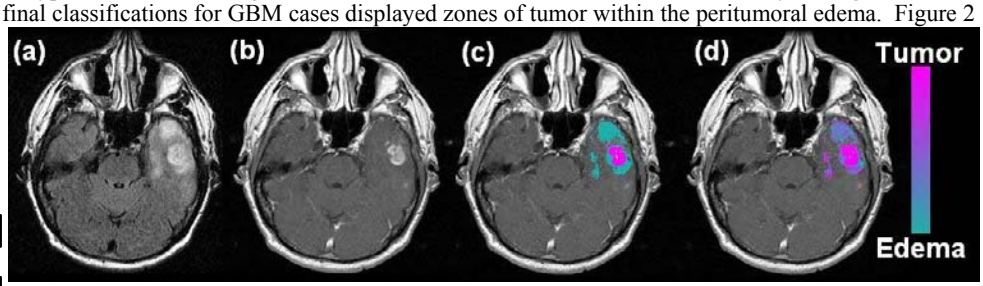

FIGURE 2. Example untreated *de novo* GBM case showing (a) FLAIR, (b) post-contrast T1, (c) peritumoral (aqua) and tumor (magenta) areas defined by morphological images, and (d) final classification showing mixture of edema and edema with tumor in the peritumoral areas.

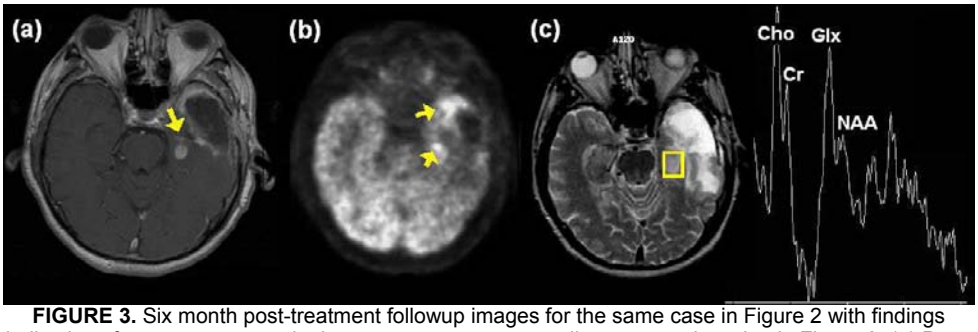

FIGURE 3. Six month post-treatment followup images for the same case in Figure 2 with findings indicative of tumor recurrence in the same areas corresponding to tumor invasion in Figure 2. (a) Post-contrast T1 image shows new enhancement (arrow), (b) FDG PET shows increased uptake (arrows), and (c) ^{1}H MRS shows elevated choline within a voxel (box) over the new enhancing area.

Discussion

The CAD scheme utilized by this study found areas of tumor invasion confirmed by followup studies. This preliminary study demonstrates the promise of using pattern recognition and computational intelligence for detection of tumor invasion. This distinction cannot be observed with standard imaging alone. As existing morphological and functional imaging techniques were used, this could be beneficial immediately. A future direction for this work includes validation of the results using histological analysis of samples obtained during stereotactic surgery.

Acknowledgements

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