Differentiation Between Glioblastoma and Brain Metastasis Using Diffusion Tensor Imaging

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Introduction

Differentiation between glioblastomas and brain metastases can be difficult in patients presenting with a solitary enhancing mass. The management of these two neoplasms is vastly different, and surgical biopsy is often required for a definitive diagnosis. Several investigators have attempted to make a preoperative distinction between these two entities on the basis of apparent diffusion coefficient (ADC) and fractional anisotropy (FA), with mixed results[1-2]. ADC and FA constitute only a fraction of the information available from diffusion tensor imaging (DTI) data. More detailed features of tensor shape such as linear and planar anisotropy coefficients (CL and CP) may further elucidate tissue characterization. A high CL value is expected in highly organized tracts where fiber bundles have similar orientations, whereas high CP is expected for the regions with crossing or radiating fibers[3]. The purpose of this study was to determine whether DTI metrics related to tensor shape could be helpful in differentiating glioblastomas from brain metastases.

Materials and Methods

Fifty-nine patients with enhancing lesions were included in this study. Histopathologic analysis of the resected tissue confirmed the diagnosis of glioblastoma in 40 patients (25M/15F, age 28-77) and brain metastasis (10 lung, 5 melanoma, 3 breast, 1 colon) in 19 patients (12M/7F, age 44-80). All patients underwent MR examination before surgery on a 3T Siemens Tim Trio scanner with a 12-channel phased-array head coil. DTI data was acquired using a 12 direction single shot; spin echo EPI sequence with parallel imaging using GRAPPA and acceleration factor of 2. Sequence parameters were as follows: TR/TE = 4900/83, NEX = 6, FOV = 22 x 22 cm^2, b = 0, 1000 s/mm^2, slice thickness 3 mm, no intersection gap. The total scan time was approximately 7 minutes. DTI post processing was performed off-line using DTI Studio, Version 2.4 (H. Jiang, S. Mori, John Hopkins University). The images were corrected for motion and eddy-current artifacts and then contrast-enhanced T1 weighted images, FA, ADC, CL and CP maps were coregistered using custom software programmed in Interactive Data Language (IDL). Masks were drawn over the enhancing part as well as regions of peritumoral edema on every slice by a neuroradiologist to create a 3D composite mask. DTI metrics were measured and compared between glioblastomas and brain metastases using an unpaired t-test.

Results

Representative images from a glioblastoma and brain metastasis patient are shown in Fig 1. DTI metrics from the enhancing part of the tumor are shown in Table 1. FA, CL and CP values from glioblastomas were significantly higher than those of brain metastases ($p < 0.01$). In the peritumoral edema regions, glioblastomas tended to have lower CL, but the difference didn't reach significance ($p = 0.054$), with no other parameter exhibiting any significant difference between the two tumor types. In addition, 30 out of 40 glioblastomas and 10 out of 19 brain metastases showed a capsule-like ring surrounding the tumor on CP maps (arrows in Fig. 1).

Discussion

Our prior studies on rat models of intra-cranial tumors demonstrated the value of tensor shape measurement in tissue characterization[4]. Prior studies reported that FA value correlates with the cellularity and vascularity of the tumor core, as reflected by higher FA values in high-grade gliomas[5-6]. However, the mechanism involved in this relationship is poorly understood. High CL, CP and FA values in glioblastomas observed in our study may be due to the high cellularity and vascularity of these tumors. In our study, CL was found to be the most sensitive DTI metrics in differentiating glioblastomas from brain metastases, as it was higher in both tumor and peritumor regions of a glioblastoma. In terms of the capsule-like ring surrounding some of the tumors, similar finding were reported in metastasis and mengingiomas[7-8]. These findings suggest that the ring structure is non-specific and may be attributed to the compression of surrounding tissue or edematous separation of the fibers[7-8]. Our study indicates that DTI metrics including shape-oriented measures may provide useful information in differentiating glioblastomas from brain metastases.

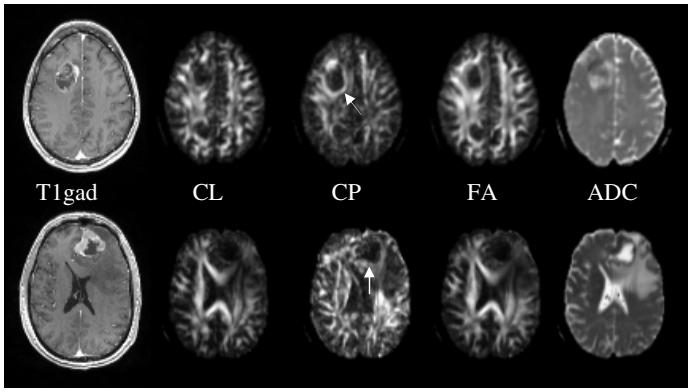

Fig.1 MR images of patients with glioblastoma (upper row) and brain metastasis (lower row) showing ring enhancement. Higher CL,CP and FA from the enhancing part in glioblastoma were noted compared to metastasis. Note the capsule-like ring on CP maps of both glioblastoma and metastasis patients (arrows).

Table 1: DTI metrics from the enhancing part between glioblastomas and brain metastases

Subject	CL	CP	FA	ADC ($10^{-3}mm^2/s$)
Glioblastoma (n=40)	0.15 ± 0.04	0.14 ± 0.04	0.16 ± 0.05	1.14 ± 0.20
Metastasis (n=19)	0.10 ± 0.02*	0.11 ± 0.02*	0.12 ± 0.03*	1.09 ± 0.26
P value	0.0004	0.002	0.0006	0.438

Data are reported as mean ± standard deviation

*indicates statistically significant difference ($p < 0.01$)

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