Differentiation of High-Grade Astrocytomas from Solitary Brain Metastases: Comparing Diffusion Kurtosis Imaging and Diffusion Tensor Imaging

Yan Tan[1], Hui Zhang[2], Xiao-chun Wang[2], Jiang-bo Qin[2], Xiao-feng Wu[2], Lei Zhang[2], and Le Wang[2]

[1]*Department of Radiology, First Clinical Medical College, Shanxi Medical University, Taiyuan, Shanxi, China,* [2]*Department of Radiology, First Clinical Medical College, Shanxi Medical University, Taiyuan 030001, Shanxi, China*

Target audience: Preoperative differentiation between high-grade astrocytomas (HGA) and solitary brain metastasis (SBM) may contribute to more appropriate treatment plans. Diffusion kurtosis imaging (DKI) is the extension of diffusion tensor imaging (DTI), which is an MRI technique depicting the non-Gaussian water molecule diffusion [1]. DKI can be of particular interest for noninvasively differentiating HGA from SBM.

Purpose: Here, we compare the value of DKI and DTI in differentiating HGA from SBM.

Methods: Thirty-one HGA and twenty SBM who underwent 3.0T MRI scan were retrospectively identified. DKI parameters [mean kurtosis (MK), radial kurtosis (Kr), and axial kurtosis (Ka)] and DTI parameters [fractional anisotropy (FA) and mean diffusivity (MD)] values with and without correction by contralateral normal-appearing white matter (NAWM) in the tumoral solid part and peritumoral edema (**Fig.1**) were compared between HGA and SBM using the t-test. Receiver operating characteristic (ROC) curves were used to test for the best parameters.

Results: The DKI values (MK, Kr, and Ka) and DTI values (FA and MD) in tumoral solid parts did not show significant differences between the two groups. Corrected and uncorrected MK, Kr, and Ka values in peritumoral edema were significantly higher in HGA than SBM, and MD values without correction were lower in HGA than SBM (**Table 1**). The areas under curve (AUC) of corrected Ka (1.000), MK (0.889), and Kr (0.880) values were significantly higher than those of MD (0.793) and FA (0.472) values (**Fig.2**). The optimal thresholds for corrected MK, Kr, Ka, and MD were 0.369, 0.405, 0.483, and 2.067, respectively.

Discussion: Analysis of these peritumoral regions may prove to be more robust than analysis of the tumor itself. MK, Kr, and Ka values in peritumoral edema were significantly higher in HGA than SBM. We think edema in SBM is synonymous with vasogenic edema. In HGA, however, peritumoral edema is more accurately called "infiltrative edema" contained both vasogenic edema and the infiltrating tumor cells [2]. Current results also showed that the AUC of MK, Kr, and Ka values were higher than those of MD and FA values. These results suggested that the DKI parameters render the differentiation between HGA and SBM better than that of DTI parameters. The AUC of Ka values were higher than that of MK; this suggested that directional kurtosis including Ka and Kr provided more directionally specific information [3].

Conclusion: DKI and directional analysis could lead to improved differentiation with better sensitivity and directional specificity than DTI.

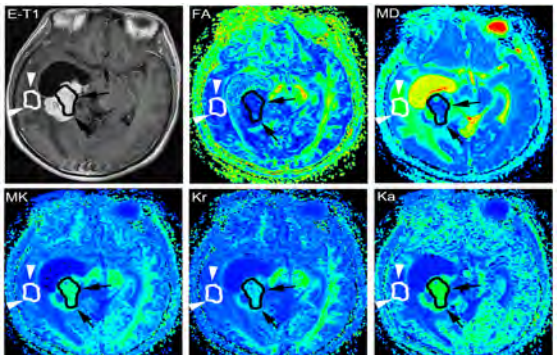

Fig. 1. The ROIs of enhanced parts of the tumor are showed as the black curve and black arrowheads. The ROIs of peritumoral edema are showed as the white curve and white arrowheads.

Table 1 DKI and DTI parameter values of peritumoral edema

Parameter	Without correction			Correction by NAWM		
	High-grade (n = 31)	Metastases (n = 20)	*P*	High-grade (n = 31)	Metastases (n = 20)	*P*
MK	0.53±0.06	0.41±0.04	0.012*	0.60±0.13	0.36±0.07	0.009*
Kr	0.57±0.08	0.44±0.06	0.017*	0.60±0.19	0.30±0.09	0.020*
Ka	0.49±0.10	0.39±0.03	0.017*	0.59±0.15	0.44±0.03	0.022*
FA	0.18±0.05	0.16±0.03	0.449	0.43±0.25	0.37±0.10	0.442
MD	1.91±0.33	2.12±0.16	0.042*	2.12±0.24	2.41±0.18	0.057

References

1. Steven AJ, Zhuo J, Melhem ER. Diffusion kurtosis imaging: an emerging technique for evaluating the microstructural environment of the brain. Am J Roentgenol. 2014;202(1):W26-W33.
2. Lee EJ, Ahn KJ, Lee EK, et al. Potential role of advanced MRI techniques for the peritumoural region in differentiating glioblastoma multiforme and solitary metastatic lesions. Clin Radiol. 2013;68(12):e689-e697.
3. Hui ES, Cheung MM, Qi L, et al. Towards better MR characterization of neural tissues using directional diffusion kurtosis analysis. Neuroimage. 2008;42(1):122-134.

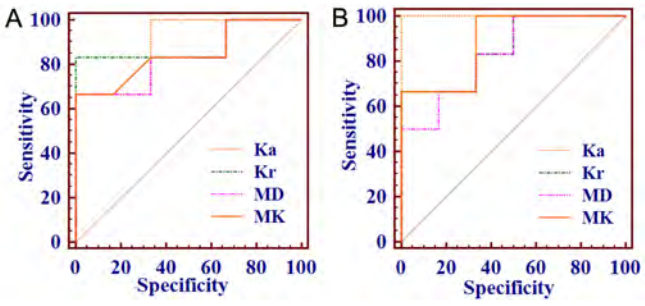

Fig. 2. ROC analysis of DKI and DTI parameter values in peritumoral edema. A: DKI parameter values of peritumoral edema without correction; B: DKI parameter values of peritumoral edema corrected using NAWM.