Research Article / Araştırma Makalesi
doi: 10.18678/dtfd.1386051

Duzce Med J, 2024;26(1):34-37
Düzce Tıp Fak Derg, 2024;26(1):34-37

Comparison of Diffusion MRI Findings of High-Graded Primary Brain Tumors and Metastatic Brain Tumors

Yüksek Dereceli Primer Beyin Tümörleri ile Metastatik Beyin Tümörlerinin Difüzyon MR Bulgularının Karşılaştırılması

Mustafa HIZAL[1]
0000-0002-4888-0962
Ahmet Kerem İMREK[2]
0000-0003-2576-4683

[1]Department of Radiology, Bolu Abant İzzet Baysal University Faculty of Medicine, Bolu, Türkiye

[2]Department of Radiology, Niğde Training and Research Hospital, Niğde, Türkiye

Corresponding Author
Sorumlu Yazar
Ahmet Kerem İMREK
dr.ahmetimrek@gmail.com

Received / Geliş Tarihi : 04.11.2023
Accepted / Kabul Tarihi : 17.03.2024
Available Online / Çevrimiçi Yayın Tarihi : 06.04.2024

ABSTRACT

Aim: Glioblastomas are the highest grade and most mortal primary brain tumors. Cerebral masses that occur with the metastasis of cancers of tissues other than brain are included in the differential diagnosis of glioblastomas. This study aimed to compare the diffusion-weighted imaging signal characteristics of primary and metastatic brain masses and to describe the findings that may be useful in the differential diagnosis.
Material and Methods: Patients with pathologically diagnosed glioblastoma and patients with pathologically diagnosed metastases or radiologically diagnosed brain metastases were included in the study. Diffusion-weighted imaging signal properties in magnetic resonance imaging examinations obtained with a 1.5 Tesla scanner were retrospectively analyzed. The signal features and short and long diameters of the lesions were measured and compared in both patient groups.
Results: A total of 54 patients, 24 glioblastomas, and 30 brain metastases were included in the study. The most common signal feature of diffusion-weighted imaging in the glioblastoma group was heterogeneous hyper- and hypointense areas observed in 20 (83.3%) patients. The most common signal feature in the metastasis group was the peripheral hyperintense ring and central hypointense signal in 16 (53.3%) patients. There was no significant relation found between the number of lesions and the primary brain tumor and metastases.
Conclusion: Although only signal characteristics are used without quantitative assessment in diffusion-weighted imaging, it may be helpful in the differential diagnosis of primary and metastatic brain masses. It is important to remember that the masses in the two groups can have comparable signal properties.
Keywords: Diffusion-weighted imaging; glioblastoma; brain metastasis; signal properties.

ÖZ

Amaç: Glioblastomalar en yüksek dereceli ve en ölümcül primer beyin tümörleridir. Beyin dışı dokulardaki kanserlerin beyne metastazı ile ortaya çıkan beyin kitleleri glioblastomaların ayırıcı tanısında yer almaktadır. Bu çalışmada, primer ve metastatik beyin kitlelerinin difüzyon ağırlıklı görüntüleme sinyal özelliklerinin karşılaştırılması ve ayırıcı tanıda faydalı olabilecek bulguların tanımlanması amaçlandı.
Gereç ve Yöntemler: Çalışmaya patolojik olarak glioblastoma tanısı almış hastalar ile patolojik olarak metastaz tanısı almış veya radyolojik olarak beyin metastazı tanısı almış hastalar dahil edildi. 1,5 Tesla tarayıcı ile elde edilen manyetik rezonans görüntüleme incelemelerindeki difüzyon ağırlıklı görüntüleme sinyal özellikleri geriye dönük olarak analiz edildi. Her iki hasta grubunda lezyonların sinyal özellikleri ile kısa ve uzun çapları ölçüldü ve karşılaştırıldı.
Bulgular: Bu çalışmaya 24 glioblastoma ve 30 beyin metastazı olmak üzere toplam 54 hasta dahil edildi. Glioblastoma grubunda difüzyon ağırlıklı görüntülemenin en yaygın sinyal özelliği 20 (%83,3) heterojen hiper ve hipointens alanlar olarak saptandı. Metastaz grubunda en sık görülen sinyal özelliği 16 (%53,3) hastada periferik hiperintens halka ve santral hipointens sinyal olarak saptandı. Lezyon sayısı ile primer beyin tümörü ve metastazlar arasında anlamlı bir ilişki bulunamadı.
Sonuç: Difüzyon ağırlıklı görüntülemede kantitatif değerlendirme yapılmadan sadece sinyal özellikleri kullanılsa da primer ve metastatik beyin kitlelerinin ayırıcı tanısında yardımcı olabilir. İki gruptaki kitlelerin karşılaştırılabilir sinyal özelliklerine sahip olabileceğini unutmamak önemlidir.
Anahtar kelimeler: Difüzyon ağırlıklı görüntüleme, glioblastom, beyin metastazı, sinyal özellikleri.

Presented as an oral presentation at the 31st Annual Diagnostic and Interventional Neuroradiology, Head and Neck Radiology Congress with International Participation (February 18-20, 2022; İstanbul, Türkiye).

INTRODUCTION

Glial cells are the major source of 75% of adult primary brain cancers. Glioblastomas are the highest grade and most mortal primary brain tumors. Cerebral masses that occur with the metastasis of cancers from non-brain tissues are included in the differential diagnosis of glioblastomas (1,2). Magnetic resonance imaging (MRI) is the primary method for imaging brain masses. Conventional MRI T2 weighted signal features, contrast enhancement, apparent diffusion coefficient (ADC) values, perfusion, and spectroscopy are used to distinguish primary brain tumors from metastases. There are few studies in the literature focusing solely on diffusion-weighted imaging (DWI) signal features. DWI is a method that examines the random movements of water molecules in tissues and is routinely used in the evaluation of cerebral mass (3-5).

We aimed to compare the DWI signal characteristics of primary and metastatic brain masses and to describe the findings that may be useful in the differential diagnosis.

MATERIAL AND METHODS

The study was conducted retrospectively after receiving the approval with decision numbered 2020/15 and dated 04.02.2020 from the Bolu Abant Izzet Baysal University Clinical Researches Ethics Committee. Patients who applied to Bolu Abant Izzet Baysal University Training and Research Hospital between 2016 and 2020 and underwent diffusion MRI for various reasons were evaluated. Initially, the number of patients was determined as 72. Patients with a history of previous surgery and intralesional bleeding were excluded from the study. For various reasons, 18 patients were excluded in the study. A total of 54 patients, including 24 glioblastomas and 30 brain metastases, were included in the study. Patients whose primary brain tumors were pathologically confirmed as grade 3 and grade 4 brain tumors by biopsy were included. In the metastasis patient group; patients who were pathologically proven to have metastasis by biopsy or whose non-brain tumor did not have a brain mass at the diagnosis stage and who developed a brain mass during the follow-up interval and were clinically accepted as metastasis were included. In metastatic brain tumors; 17 patients with lung cancer metastasis, 1 patient with malignant melanoma metastasis, 2 patients with epithelial tumor metastasis, 3 patients with renal cell cancer metastasis, 2 patients with colon cancer metastasis, 2 patients with breast cancer metastasis, 1 patient with squamous cell cancer metastasis, 1 patient with stomach cancer metastasis and 1 patient was reported as adenocarcinoma metastasis of unknown primary.

Contrast-enhanced brain MRI and other metastasis screening examinations were performed in the majority of patients included in the study, and due to the purpose of the study, the focus was on DWI. In our clinic, patients referred for contrast-enhanced brain MRI also routinely undergo diffusion MRI, in patients referred from the emergency department with suspicion of stroke, only diffusion MRI examination is performed.

Patients with a previous surgical history or intralesional bleeding were not included in the study. Contrast-enhanced brain MRI images of some patients taken after diagnosis or after surgery were used in the sample images for demonstration purposes. However, when evaluating the lesion signal, only preoperative and diffusion MR images were included.

DWI signal properties in brain MRI examinations were obtained with a 1.5 Tesla MRI (Siemens Magnetom Symphony, Erlangen, Germany) scanner. A 6-channel head coil is used to receive signals. The images were analyzed retrospectively by two radiologists with 4 and 12 years of experience. B1000 images of DWI sequences were evaluated in the DWI examinations of the patients.

Statistical Analysis

Study data were evaluated via IBM SPSS version 23.0. Patients' age, sex, and demographic data were analyzed by descriptive statistical methods. Shapiro-Wilk test was used as the normality test. Student t-test was used to examine the difference between the two groups. Categorical variables were compared with Pearson's chi-square or Fisher's exact test. The statistical significance level of $p<0.05$ was considered significant.

RESULTS

A total of 54 patients, 24 glioblastomas, and 30 brain metastases were included in the study. No significant difference was found between the groups both in age and gender. Details of the demographic characteristics of the patients were given in Table 1. The most common signal feature in the glioblastoma group was heterogeneous hyper- and hypointense areas in 20 patients. The most common signal feature in the metastasis group was the peripheral hyperintense ring and central hypointense signal in 16 patients. A detailed description of the signal characteristics was presented in Table 2. Heterogeneous hyperintense and hypointense areas were significantly more common in high-grade brain tumors. Peripheral hyperintense ring and central hypointense signal appearance were significantly more common in the metastasis group. Homogeneous hypointense signal appearance was also observed significantly more in the metastasis group. Patients with solitary and multiple masses were included in the study. In patients with multiple lesions signal characteristics of those lesions did not show different features in both primary tumor and metastasis groups.

The short and long diameters of the lesions were measured and compared in both patient groups. The length of the short diameters in the glioblastoma group was significantly higher than the metastasis group (31.50±9.25 vs. 23.46±11.55, p=0.030). Although the longest diameters were larger in the glioblastoma group, there was no significant difference between the groups (p=0.068). The relationship between the number of lesions seen in the patient groups and the diagnosis of patients was evaluated.

Table 1. Demographics of the patients

	HG Tumors (n=24)	**Metastasis (n=30)**	**p**
Age (years), mean±SD	62.14±3.39	61.91±1.61	0.829
Gender, n (%)			
Male	12 (50.0)	23 (76.7)	0.079
Female	12 (50.0)	7 (23.3)	

HG: high-grade, SD: standard deviation

Table 2. Signal characteristics of the patients

	HG Tumors (n=24)	Metastasis (n=30)	p
Signal appearance in the diffusion-weighted examination, n (%)			
Heterogeneous hyperintense and hypointense areas (Figure 1)	20 (83.3)	5 (16.7)	**<0.001**
Peripheral hyperintense ring and central hypointense (Figure 2)	2 (8.3)	16 (53.3)	
Homogeneous hyperintense (Figure 3)	2 (8.3)	4 (13.3)	
Homogeneous hypointense (Figure 4)	0 (0.0)	5 (16.7)	

HG: high-grade

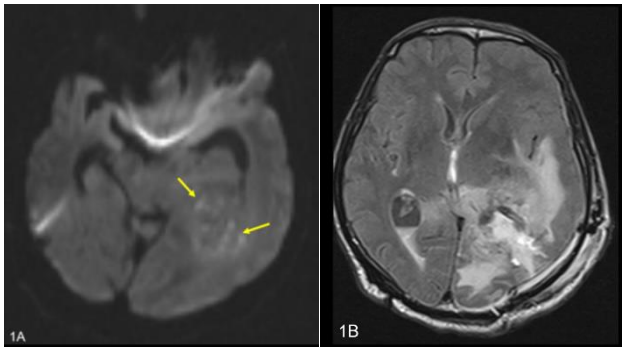

Figure 1. A) Diffusion-weighted imaging b1000, mass in the left parietotemporal lobe of a 73-year-old male patient with heterogeneous hyperintense and hypointense areas (arrows), and **B)** contrast-enhanced T1 weighted image, pathology: glioblastoma

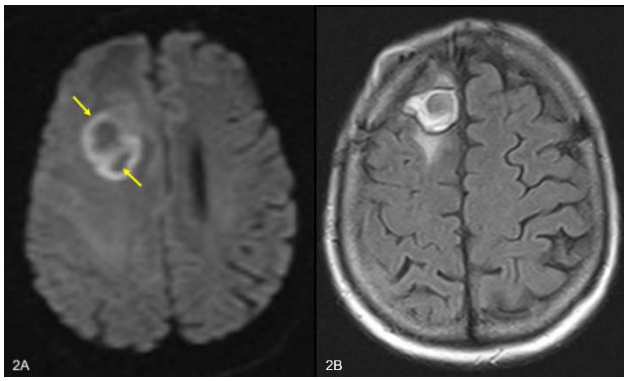

Figure 2. A) A 72-year-old male patient with peripheral hyperintense ring, and central hypointense lesion on the right frontal lobe anterior diffusion-weighted images (arrows), and **B)** contrast-enhanced T1 weighted image, pathology: lung cancer metastasis

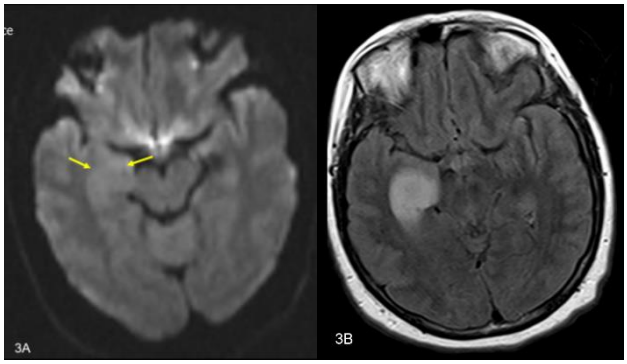

Figure 3. A) A 45-year-old female patient with a homogeneous hyperintense mass in the parahippocampal gyrus in the right medial temporal lobe on the diffusion-weighted image (arrows), and **B)** T2-weighted sequence image, pathology: glioblastoma

There were 18 solitary and 6 multiple masses in the glioblastoma group, 16 solitary and 14 multiple in the metastasis group, and no significant difference was found between the groups (p=0.072).

DISCUSSION

DWI is useful in the differential diagnosis of primary and metastatic cerebral masses, although only signal features are used without quantitative measurement (6,7). It has been proposed that a decrease in ADC values during imaging corresponds to increased cellularity, which may help determine whether tumor cells have invaded the surrounding tissues. This idea has been supported by several studies that compared the peritumoral edema of high-grade gliomas with metastases (8-14).

The most common signal we encountered in primary brain tumors was observed as heterogeneous hyperintense and hypointense signals on DWI. Since the tumor cell load is high accompanied by necrotic areas in primary glial tumors, they appear as hyper- and hypointense areas (15). The peripheral hyperintense ring was observed much more frequently in the metastasis group. This signal feature was seen in a total of 18 patients, 16 of whom were detected in the metastasis group, and was observed in approximately 89% of the patients in the metastasis group. Central hypointense areas represent necrotic areas. We think that a peripheral ring is formed because there is cellular density in the peripheral areas. Homogeneous hyperintense signal feature was seen in both groups and were not common in both groups. We think that this signal feature is seen in non-necrotic tumors. Since there are small numbers in both groups, it is not reliable in terms of discrimination. Homogeneous hypointense signal was observed only in the metastasis group and in a small number of patients. We

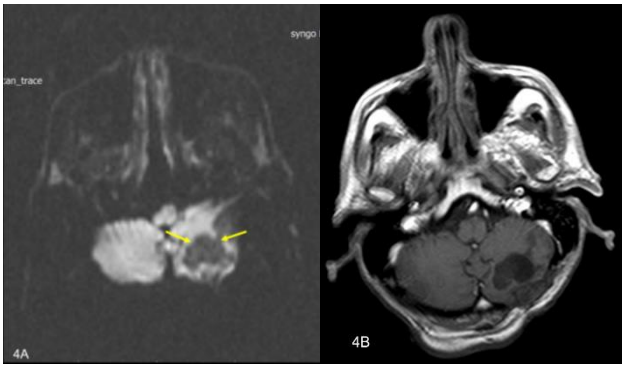

Figure 4. A) A 69-year-old male patient with homogeneous hypointense lesion in the left cerebellar hemisphere on the diffusion-weighted image, and **B)** contrast-enhanced T1 weighted image, pathology: metastatic colon cancer

think that this signaling feature is due to tumors that are necrotic in the center and have low cell density in the periphery.

Even though the primary cancer of the patients in the metastasis group was the same, we detected different diffusion signals in patients with different subtypes. For example, in patients with lung cancer metastases, the signal features of small cell lung cancer metastases and non-small cell lung cancer metastases were not always consistent. While a homogeneous hyperintense signal was observed in some of the patients with non-small cell lung cancer metastases, a peripheral hyperintense ring and central hypointense were observed in small cell lung cancer metastases.

There was no difference between glioblastoma and metastasis groups, whether the cerebral masses were solitary or multiple. Although the long diameters of the masses were found to be large in the metastasis and the short diameters of the masses in the glioblastoma group, more patients and contrast-enhanced examinations are required for the appropriate evaluation of these mass sizes. Due to our small number of patients, subtype research could not be performed in the primary and metastasis patient groups. The fact that our study was single-center and had a small number of patients was an important limitation.

CONCLUSION

Diffusion-weighted imaging may be useful in the differential diagnosis of primary and metastatic cerebral masses, although only signal features are used without quantitative measurement. Our findings may be useful in daily routine radiology practice to differentiate primary and metastatic cerebral masses without the use of further investigations.

Ethics Committee Approval: The study was approved by the Clinical Research Ethics Committee of Bolu Abant İzzet Baysal University (04.02.2020, 2020/15).

Conflict of Interest: None declared by the authors.

Financial Disclosure: None declared by the authors.

Acknowledgments: None declared by the authors.

Author Contributions: Idea/Concept: MH, AKİ; Design: MH, AKİ; Data Collection/Processing: MH, AKİ; Analysis /Interpretation: MH, AKİ; Literature Review: MH, AKİ; Drafting/Writing: MH, AKİ; Critical Review: MH, AKİ.

REFERENCES

1. Lapointe S, Perry A, Butowski NA. Primary brain tumors in adults. Lancet. 2018;392(10145):432-46.
2. Mourad AF, Mohammad HEG, Sayed MM, Ragae MA. What's the clinical significance of adding diffusion and perfusion MRI in the differentiation of glioblastoma multiforme and solitary brain metastasis? Egypt J Radiol Nucl Med. 2017;48(3):661-9.
3. Yazol M, Öner AY. Magnetic resonance imaging in brain gliomas. Trd Sem. 2016;4(1):20-36. Turkish.
4. Xiang C, Chen Q, Zha Y. Specific features of primary central nervous system lymphoma in comparison with glioblastoma on conventional MRI. Iran J Radiol. 2019;16(1):e78868.
5. Martinez-Heras E, Grussu F, Prados F, Solana E, Llufriu S. Diffusion-weighted imaging: recent advances and applications. Semin Ultrasound CT MR. 2021;42(5):490-506.
6. Kono K, Inoue Y, Nakayama K, Shakudo M, Morino M, Ohata K, et al. The role of diffusion-weighted imaging in patients with brain tumors. Am J Neuroradiol. 2001;22(6):1081-8.
7. Tien RD, Felsberg GJ, Friedman H, Brown M, MacFall J. MR imaging of high-grade cerebral gliomas: value of diffusion-weighted echoplanar pulse sequences. AJR Am J Roentgenol. 1994;162(3):671-7.
8. Yan Q, Li F, Cui Y, Wang Y, Wang X, Jia W, et al. Discrimination between glioblastoma and solitary brain metastasis using conventional MRI and diffusion-weighted imaging based on a deep learning algorithm. J Digit imaging. 2023;36(4):1480-8.
9. Swinburne NC, Schefflein J, Sakai Y, Oermann EK, Titano JJ, Chen I, et al. Machine learning for semi-automated classification of glioblastoma, brain metastasis, and central nervous system lymphoma using magnetic resonance advanced imaging. Ann Transl Med. 2019;7(11):232.
10. Zhang L, Yao R, Gao J, Tan D, Yang X, Wen M, et al. An integrated radiomics model incorporating diffusion-weighted imaging and ^{18}F-FDG PET imaging improves the performance of differentiating glioblastoma from solitary brain metastases. Front Oncol. 2021;11:732704.
11. Chiang IC, Kuo YT, Lu CY, Yeung KW, Lin WC, Sheu FO, et al. Distinction between high-grade gliomas and solitary metastases using peritumoral 3-T magnetic resonance spectroscopy, diffusion, and perfusion imagings. Neuroradiology. 2004;46(8):619-27.
12. Pavlisa G, Rados M, Pavlisa G, Pavic L, Potocki K, Mayer D. The differences of water diffusion between brain tissue infiltrated by tumor and peritumoral vasogenic edema. Clin Imaging. 2009;33(2):96-101.
13. Rollin N, Guyotat J, Streichenberger N, Honnorat J, Tran Minh VA, Cotton F. Clinical relevance of diffusion and perfusion magnetic resonance imaging in assessing intra-axial brain tumors. Neuroradiology. 2006;48(3):150-9.
14. Lee EJ, terBrugge K, Mikulis D, Choi DS, Bae JM, Lee SK, et al. Diagnostic value of peritumoral minimum apparent diffusion coefficient for differentiation of glioblastoma multiforme from solitary metastatic lesions. AJR Am J Roentgenol. 2011;196(1):71-6.
15. Hamstra DA, Rehemtulla A, Ross BD. Diffusion magnetic resonance imaging: a biomarker for treatment response in oncology. J Clin Oncol. 2007;25(26):4104-9.