# Diffusion Weighted Image Assessment of Brain Glial Tumor Cells

**Mohammed AM. Al-Jubori [1]*, Karim Al-Jashamy[2], Eskander Ali Azeez[3]**

[1] Dept of X-Ray and Sonar, Faculty of Health and Medical Sciences, Bilad Al-Rafidain University, Diyala, 32001, Iraq.
m.abd@bauc14.edu.iq , jashamy@yahoo.com , sahfynk941@gmali.com

***Article history:***
***Received:*** *9 December 2025*
***Accepted:****16 May 2026*
***Published:*** *15 June.2026*

**Keywords**: *DWI, ADC, MRI, Glial Cells, Tumor*



## Abstract

**Background:** Gliomas are the most common primary malignant brain tumors. The accurate grading of gliomas is of primary importance in the development of treatment regimens and the prognosis of the disease.
**Objective:** The study aims to investigate the role of diffusion-weighted imaging (DWI) in the assessment of accurate brain glial tumor cells.
**Methods**: The study consisted of 25 patients, ranging in age from 6 to 77 years, based on the MRI requests for brain glial tumors in Baquba General Hospital in Diyala. In the study, a 1.5-Tesla MRI system with an 8-channel brain coil and a gadolinium-based contrast agent.
**Results**: The results of this study showed highly promising outcomes in the assessment of the potential growth of the tumor and differentiation of high-grade gliomas from brain abscesses by using DWI along with ADC values. The results of MRI using DWI and ADC sequences showed a grade II glioma with a T2-weighted image of highly intense tumor, and a T1-weighted image of hypointensity.
**Conclusion:** These results considered the potential value for the progression of non-invasive imaging approaches for the grading of glioma, improving diagnostic accuracy, and patient treatment planning in clinical practice for patients with brain glial tumor.

## 1. Introduction

Gliomas represent the most prevalent primary malignant neural tumors, varying in severity from low to severe [1]. The gliomas classification is essential for therapeutic strategy and monitoring [2,3]. Diffusion-weighted imaging (DWI) facilitates tumor characterization and is employed to distinguish between high-grade and low-grade gliomas. Several reports indicated that high-grade gliomas demonstrate reduced apparent diffusion coefficients (ADCs) due to increased tumor cellular [2, 4]. The ADC histogram derived from DWI emerged as the most effective parameter for distinguishing between high-grade and low-grade gliomas [5, 6].

The fifth percentage of the cumulative ADC histogram represents a minor part of the tumor. The assessment of tumor heterogeneity is essential, as tumors showing a high intramural heterogeneity have a poor prognosis [7, 8]. It might be directly perceived by the human visual system, and is one of the primary sources of visual information [9]. Textures are complex visible patterns composed of components or sub-patterns which have different levels of brightness, intensity, and size [10, 11]. Gliomas are the most common of malignant tumors in the nervous system [12]. The WHO classifies them as grade II (low-grade) or grades III and IV (high-grade); glioma grading is important for therapeutic decision-making and prognostic evaluation [13, 14].

MRI is a safe and useful imaging modality for tissue characterization and grading of glioma. Classical MRI findings of mass effect, oedema, enhancement, and necrosis that might provide the estimation grade tumour of glioma grading [15]. Previous research indicated that the enhancement by contrast alone is insufficient for tumor grading, as certain Low-grade gliomas could show enhancement [16-18]. DWI has become a significant MRI modality, particularly in the context of cancer imaging [19].

In the case of gliomas, DWI and ADC-mapping could show promising findings in terms of measuring tumor growth potential [20-22]. Most underlying DWI studies have focused solely on first-order ADC histogram parameters, such as mean, median, minimum, maximum, and percentiles, while neglecting second-order characteristics derived from comprehensive histogram analysis, specifically skewness, kurtosis, and entropy. The second-order histogram characteristics offer supplementary insights into value distribution, thereby enhancing the representation of tumor heterogeneity [23].

Accurate classification of gliomas is essential for therapeutic strategy planning and prognosis assessment by DWI, which facilitates tumor characterization. While a strict definition of image texture is lacking. Thus, this study aimed to investigate the role of diffusion-weighted imaging (DWI) in the assessment of accurate brain glial tumor cells.

## 2. Materials and Methods

This study was conducted on 25 patients, ranging in age from 6 to 77 years (male and female). Selected the patients with brain glial MRI requests and sent them to the MRI unit of Baquba General Hospital in Diyala. Inclusion Criteria: Patients of both sexes and all ages. Patients with continuous head pain who are diagnosed with a brain glial tumor. Exclusion Criteria: Hypersensitivity to iodinated contrast agents or previous MR CM agents. Renal insufficiency (creatinine levels >150 µmol l–1) and patients with cerebral palsy and pregnant women.

The suspected patients were sent to the MRI unit at Baquba general hospital in Diyala, 1.5-Tesla MRI/archive (Philips, Amsterdam, and the Netherlands) with an 8-channel brain coil. All patients who participated in this research underwent a thorough medical history, neurological assessment, and MRI evaluation for conventional and DWI. Gadopentetate dimeglumine or gadodiamide was given intravenously at standard doses. The protocol included spin-echo (SE) and echo-planar imaging (EPI) sequences with a repetition time of 8000 ms and an echo time of 70 ms. Other parameters included the number of signals acquired [1], section thickness (5 mm), section gap (1 mm), matrix size (128 × 256 pixels), field of view (20 × 20 cm²), and diffusion gradient encoding in three orthogonal directions (b = 1,000 s/m). The total acquisition time for DWI was 70 seconds; Calculation of ADC maps was automatically achieved by the MRI software.

The intensity of measurement signals in designated regions of interest (ROIs) on diffusion-weighted imaging (DWI) is displayed directly on PACS monitors. Standardized ROI was applied to enhance the solid portion of the tumor exhibiting the highest signals on DWI. The measurement employed the method of standardizing the ROI sizes and mitigating sampling errors. The whole tumor was delineated using contrast-enhanced T1-weighted imaging, along with DWI and ADC images. The ROIs were manually delineated by tracing a line around the enhanced portion of the lesion, as determined by contrast-enhanced T1-weighted, DWI, and ADC images, with measurements derived from DWI f for each tumor-related ROI. The tumor ROIs of apparent diffusion coefficient (ADC) were calculated using the same procedure. The tumor was assessed using the mean ADC and DWI values from the specified measurements, using the calculated mean of the lowest and maximum to derive an average dataset of the observed tumor characteristics.

## 3. Results

The results of this study showed patients' genders were Female 14 (56%) and male 11 (44%), the age group matching with gender showed the highest rate of age was 41-60, most affected, as illustrated in Table 1. The most important results showed that the shape of the tumor was irregular and signal intensity was 23 (92%), while most sides that showed effect were in the frontal area 5 (20%), and also, there were 4 (16%) found at the basal ganglia, parietal, and pons areas, as illustrated in Table 2.

Table 1: The distribution of the studied sample according to age

| NO. | Age | NO. of cases | % | Male | Female |
|---|---|---|---|---|---|
| 1 | 1-20 | 8 | 32% | 1 | 7 |
| 2 | 21-40 | 5 | 20% | 4 | 1 |
| 3 | 41-60 | 9 | 36% | 5 | 4 |
| 4 | 61-75 | 3 | 12% | 2 | 1 |

Table 2: The distribution of the studied sample according to Side and tumor shape

| The distribution of the studied sample according to | | No. | % |
|---|---|---|---|
| Side of the tumor | basal ganglia | 4 | 16% |
| | Occipital | 2 | 8% |
| | Temporal | 3 | 12% |
| | Parietal | 4 | 16% |
| | Frontal | 5 | 20% |
| | Pons | 4 | 16% |
| | Mid brain | 1 | 4% |
| | Medulla oblongata | 1 | 4% |
| | Cerebellum | 1 | 4% |
| Shape of tumor Signal intensity | Regular | 2 | 8% |
| | Irregular | 23 | 92% |

The results of this study provided detailed information about the distribution of cases based on different tumor grading techniques. However, the histopathology of the DWI and ADC showed the apparent diffusion coefficient with grades I to IV that represent the tumor grades within each technique. The results showed the highest incidence was grade IV of histopathology, DWI, and ADC were 10 (40%), 10 (40%), and 9 (36%), respectively (Table 3).

Table 3: The distribution of the studied sample according to the techniques

| The distribution of the studied samples | | Mean value | NO, % out of 25 |
|---|---|---|---|
| Histopatho Type of tumor | Grade I | | 4 (16%) |
| | Grade II | | 6 (24%) |
| | Grade III | | 5 (20%) |
| | Grade IV | | 10 (40%) |
| DWI Type of tumor | Grade I | 137.316 | 5 (20%) |
| | Grade II | 314.571 | 7 (28%) |
| | Grade III | 521.3 | 3 (12%) |
| | Grade IV | 322.36 | 10 (40%) |
| ADC Type of tumor | Grade I | 1862.6 | 3 (12%) |
| | Grade II | 862.88 | 6 (24%) |
| | Grade III | 1062.15 | 7 (28%) |
| | Grade IV | 912.92 | 9 (36%) |

The important results of this study of brain MRI using DWI and ADC sequences showed a grade II glioma with a T2-weighted image of a highly intense tumor in the right pons. The T1-weighted image shows the hypointensity. The diffusion-weighted image showed an isointense tumor compared with the normal part (DWImean = 395.7). While the ADC showed hyperintensity of the tumor, that reflecting marked fluid diffusion compared with the surrounding brain tissues (ADCmean = 1334.8) (Figure 1a, b). While the grade II glioma verified with stereotactic biopsy showed the T2-weighted image shows a highly intense tumor in the right of the pons. Also, the T1-weighted image showed the hypointensity. The diffusion-weighted image areas of the tumor showed isointense compared with the normal part (DWImean = 395.7). However, the ADC map showed hyperintensity of the tumor, reflecting fluid marked diffusion compared with the surrounding brain tissues (ADCmean = 1334.8) (Fig. 2 a, b).

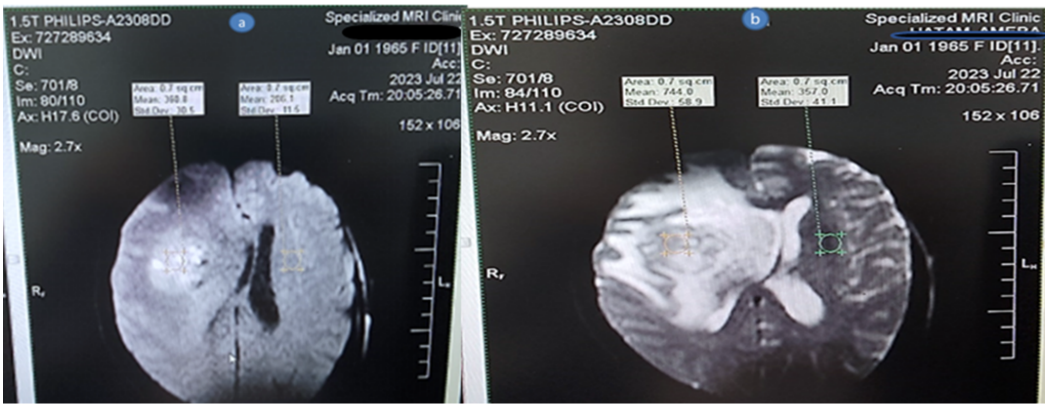


**Fig. 1** shows the a) Axial DWI image, and b) Axial ADC image. The patient had a tumor located in the Rt. The temporal lobe, which was diagnosed as glioblastoma grade IV, shows hypointensity on the T1-weighted image. The DWI showed an isointense tumor compared with the normal part, and the ADC showed hyperintensity of the tumor.

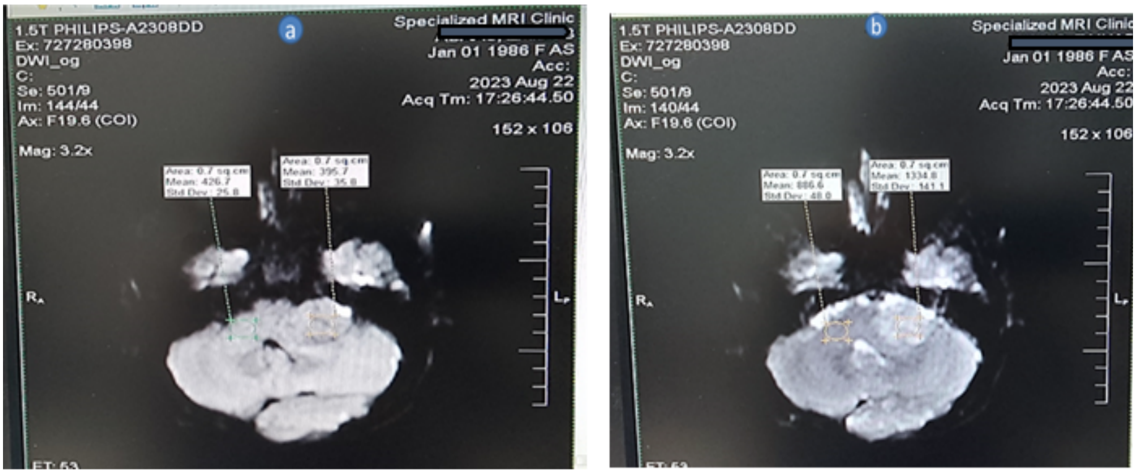


**Fig. 2** The grade II glioma verified with stereotactic biopsy. a) The diffusion-weighted image, areas of the tumor are almost isointense compared with the normal part. b) The ADC map shows hyperintensity of the tumor, reflecting the fluid marked diffusion compared with the surrounding brain tissues.

## 4. Discussion

The research presented and focused on the brain tumors, analyzing various factors such as age, gender, site of tumor, shape of tumor, and values of ADC and DWI. Here is a discussion based on the information provided [24]. The gender distribution of data showed there were female cases (56%) compared to male cases (44%). The gender distribution is important as it might indicate a potential predisposition to brain tumors or could reflect the demographics of the studied population [25]. The age distribution of the cases is not explicitly discussed in the provided text. However, the age range of cases from 1 to 75 years old. Understanding the age distribution is crucial as brain tumors can occur across different age groups, and certain types of brain tumors are more common in specific age ranges [26].

The distribution of the site tumors showed the variety of locations, with irregular shapes being more common than regular shapes. The most frequent areas for the tumors on these patients were the pons, right frontal lobe and left basal ganglia. The diversity of tumour locations in the brain confirmed that the majority of the tumors was 92% in all cases of irregular that reflecting the malignant behaviour of these tumours. Tumor shape highlighted non-round, non-lobulated shapes of the highest grade and invasive tumor type [27].

The averages of ADC and DWI were reported for each case. These quantities are important for the characterization of tumor cellularity, vascularity and tissue structure. Alterations in these values might inform the tumor invasiveness and the reaction to therapy. The results section probably shows one of the highlights of their research, and diffusion weighted imaging (DWI) might be used to assess the brain glial tumour cells. The quantitative data on the imaging appearance of ADC values, size, location and heterogeneity of accuracy diagnoses. The correlations between DWI findings and histopathological characteristics of the tumours might help to understand the biology and behaviour of solid tumours [28].

The cases of tumor grade and histopathological type were valid data that presented an important comprehension of the histopathological nature of the tumors in cases and their associations with imaging results [27]. Gliomas represent an estimated 30% of all brain and other central nervous system tumors and are responsible for up to 80% of malignant brain tumors [12]. Family history continues to be observed in diffuse gliomas based on varying mitotic, necrotic, cellular and microvascular proliferation. They are classified by the WHO into low-grade (grade II) and high-grade tumours (grades III-IV) on histopathological features. Low-grade gliomas are well-differentiated tumors that might be associated with a better prognosis as compared to high-grade gliomas [13]. Accurate grading of glioma is important in terms of guiding treatment and predicting clinical outcome. Low-grade gliomas are frequently managed with a policy of active surveillance or surgical resection [14]. Such research findings offer important nature of brain tumors, which might, if included in combination with clinical responses, survivals, and genetic indices. Further understanding of the pathogenic mechanism of brain tumor as well help clinicians manage patients more precisely.

## 5. Conclusions

These results have potential value for the progression of non-invasive imaging approaches used for the grading of glioma, which might translate into a diagnostic method to improve the accuracy, patient treatment planning in clinical practice involving patients with brain glioma tumors.

Conflict of interests

The authors declare no conflict of interest.

Acknowledgments

I would like to express my deepest gratitude to all those who supported and contributed to the successful completion of this research. Special thanks firstly to the radiology and neurology team at Collaborating Baquba General Hospital in Diyala for helping us to get such relevant imaging studies and clinical information regarding brain gliomas. Lastly, thanks to family and friends who patiently supported me through this difficulty that was definitely worth the effort.

**References**

[1] Lerner, A., Palmer, K., Campion, T., Millner, T., Scott, E., Lorimer, C., Paraskevopoulos, D., McKenna, G., Marino, S., Lewis, R., & Plowman, N. (2024). Gliomas in adults: Guidance on investigations, diagnosis, treatment and surveillance. Clinical Medicine, 24(5), 100240. https://doi.org/10.1016/j.clinme.2024.100240

[2] Mousa, M. I., Youssef, A., Hamed, M. R., Mousa, W., Al Ajerami, Y., Akhdar, H., Eisa, M. H., Ibnaouf, K. H., & Sulieman, A. (2023). Mapping high-grade glioma response to chemoradiotherapy: Insights from fractional anisotropy and mean diffusivity. Journal of Radiation Research and Applied Sciences, 16(4), 100706. https://doi.org/10.1016/j.jrras.2023.100706

[3] Daumas-Duport, C., Scheithauer, B., O'Fallon, J., & Kelly, P. (1988). Grading of astrocytomas: A simple and reproducible method. Cancer, 62, 2152–2165.

[4] Gihr, G., Horvath-Rizea, D., Kohlhof-Meinecke, P., Ganslandt, O., Henkes, H., Härtig, W., Donitza, A., Skalej, M., & Schob, S. (2022). Diffusion weighted imaging in gliomas: A histogram-based approach for tumor characterization. Cancers, 14(14), 3393. https://doi.org/10.3390/cancers14143393

[5] Kang, Y., Choi, S. H., Kim, Y. J., Kim, K. G., Sohn, C. H., et al. (2011). Gliomas: Histogram analysis of apparent diffusion coefficient maps with standard- or high-b-value diffusion-weighted MR imaging—Correlation with tumor grade. Radiology, 261, 882–890.

[6] Gihr, G. A., Horvath-Rizea, D., Hekeler, E., Ganslandt, O., Henkes, H., Hoffmann, K. T., Scherlach, C., & Schob, S. (2020). Histogram analysis of diffusion weighted imaging in low-grade gliomas: In vivo characterization of tumor architecture and corresponding neuropathology. Frontiers in Oncology, 10, 206. https://doi.org/10.3389/fonc.2020.00206

[7] Marusyk, A., Janiszewska, M., & Polyak, K. (2020). Intratumor heterogeneity: The Rosetta Stone of therapy resistance. Cancer Cell, 37(4), 471–484. https://doi.org/10.1016/j.ccell.2020.03.007

[8] Xiang, P., Zhang, X., Liu, D., Wang, C., Ding, L., Wang, F., & Zhang, Z. (2019). Distinguishing soft tissue sarcomas of different histologic grades based on quantitative MR assessment of intratumoral heterogeneity. European Journal of Radiology, 118, 194–199. https://doi.org/10.1016/j.ejrad.2019.07.028

[9] Materka, A. (2004). Texture analysis methodologies for magnetic resonance imaging. Dialogues in Clinical Neuroscience, 6(2), 243–250. https://doi.org/10.31887/DCNS.2004.6.2

[10] Ardakani, A. A., Gharbali, A., Saniei, Y., Mosarrezaii, A., & Nazarbaghi, S. (2024). Application of texture analysis in diagnosis of multiple sclerosis by magnetic resonance imaging. Global Journal of Health Science, 7(6), 68–68. https://doi.org/10.5539/gjhs.v7n6p68

[11] Anam, A. M., & Rushd, M. A. (2019). Classification of scaled texture patterns with transfer learning. Expert Systems with Applications, 120, 448–460. https://doi.org/10.1016/j.eswa.2018.11.033

[12] Toader, C., Radoi, M. P., Dumitru, A., Glavan, L. A., Covache-Busuioc, R. A., Popa, A. A., Costin, H. P., Corlatescu, A. D., & Ciurea, A. V. (2024). High-grade thalamic glioma: Case report with literature review. Medicina, 60(10), 1667. https://doi.org/10.3390/medicina60101667

[13] Lee, J., Choi, S. H., Kim, J. H., Sohn, C. H., Lee, S., & Jeong, J. (2014). Glioma grading using apparent diffusion coefficient map: Application of histogram analysis based on automatic segmentation. NMR in Biomedicine, 27, 1046–1052.

[14] Li, X., Li, R., Ren, H., Liu, H., & Liu, H. (2021). Predicting factors of tumor progression in adult patients with low-grade glioma within five years after surgery. Translational Cancer Research, 10(4), 29. https://doi.org/10.21037/tcr-21-589

[15] Bernstock, J. D., Gary, S. E., Klinger, N., Valdes, P. A., Ibn Essayed, W., Olsen, H. E., Chagoya, G., Elsayed, G., Yamashita, D., Schuss, P., Gessler, F. A., Peruzzi, P. P., Bag, A. K., & Friedman, G. K. (2022). Standard clinical approaches and emerging modalities for glioblastoma imaging. Neuro-Oncology Advances, 4(1), vdac080. https://doi.org/10.1093/noajnl/vdac080

[16] Komori, T. (2022). Grading of adult diffuse gliomas according to the 2021 WHO classification of tumors of the central nervous system. Laboratory

Investigation, 102(2), 126–133. https://doi.org/10.1038/s41374-021-00667-6

[17] Park, Y. W., Vollmuth, P., Foltyn-Dumitru, M., Sahm, F., Ahn, S. S., Chang, J. H., & Kim, S. H. (2023). The 2021 WHO classification for gliomas and implications on imaging diagnosis: Part 2—Summary of imaging findings on pediatric-type diffuse high-grade gliomas, pediatric-type diffuse low-grade gliomas, and circumscribed astrocytic gliomas. Journal of Magnetic Resonance Imaging, 58(3), 690–708. https://doi.org/10.1002/jmri.28740

[18] Scola, E., Desideri, I., Bianchi, A., Gadda, D., Busto, G., Fiorenza, A., & Fainardi, E. (2022). Assessment of brain tumors by magnetic resonance dynamic susceptibility contrast perfusion-weighted imaging and computed tomography perfusion: A comparison study. La Radiologia Medica, 127(6), 664–672. https://doi.org/10.1007/s11547-022-01470-z

[19] Caroli, A. (2022). Diffusion-weighted magnetic resonance imaging: Clinical potential and applications. Journal of Clinical Medicine, 11(12), 3339. https://doi.org/10.3390/jcm11123339

[20] Takaya, Y., Chen, H., Ten, H., Hoya, K., Jiang, C. L., Oyama, K. I., & Matsuno, A. (2021). Evaluation of the malignant potential of gliomas using diffusion-weighted and gadolinium-enhanced magnetic resonance imaging. Brain Science Advances, 7(4), 248–256. https://doi.org/10.26599/BSA.2021.9050050

[21] Cui, Y., Ma, L., Chen, X., Zhang, Z., Jiang, H., & Lin, S. (2014). Lower apparent diffusion coefficients indicate distinct prognosis in low-grade and high-grade glioma. Journal of Neuro-Oncology, 119(2), 377–385. https://doi.org/10.1007/s11060-014-1490-6

[22] Horvath-Rizea, D., Surov, A., Hoffmann, K. T., Garnov, N., Vörkel, C., Kohlhof-Meinecke, P., & Schob, S. (2018). The value of whole lesion ADC histogram profiling to differentiate between morphologically indistinguishable ring enhancing lesions: Comparison of glioblastomas and brain abscesses. Oncotarget, 9(26), 18148. https://doi.org/10.18632/oncotarget.24454

[23] Just, N. (2014). Improving tumour heterogeneity MRI assessment with histograms. British Journal of Cancer, 9(12), 2205–2213. https://doi.org/10.1038/bjc.2014.512

[24] Gupta, R. K., Jobanputra, K. J., & Yadav, A. (2013). MR spectroscopy in brain infections. Neuroimaging Clinics of North America, 23(3), 475–498.

[25] Tan, J. Y., Thong, J. Y., Yeo, Y. H., Mbenga, K., & Saleh, S. (2024). Gender, racial, and geographical disparities in malignant brain tumor mortality in the USA. Oncology, 102(8), 703–709. https://doi.org/10.1159/000536486

[26] Hourani, R., Brant, L. J., Rizk, T., Weingart, J. D., Barker, P. B., & Horská, A. (2008). Can proton MR spectroscopic and perfusion imaging differentiate between neoplastic and nonneoplastic brain lesions in adults? AJNR American Journal of Neuroradiology, 29(2), 366–372. https://doi.org/10.3174/ajnr.A0810

[27] Aydin, H., Sipahioğlu, S., Oktay, N. A., et al. (2011). The value of proton MR-spectroscopy in the differentiation of brain tumours from non-neoplastic brain lesions. JBR-BTR, 94(1), 1–10.

[28] Sharma, P., Aaroe, A., Liang, J., & Puduvalli, V. K. (2023). Tumor microenvironment in glioblastoma: Current and emerging concepts. Neuro-Oncology Advances, 5(1). https://doi.org/10.1093/noajnl/vdad009