

Cerebral Diffusion Restriction Beyond Neoplasia: Radiological Patterns, Pitfalls, and Pearls. A Pictorial Review

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ABSTRACT

Objective: To highlight various non-proliferative causes and associated diffusion restriction patterns.

Methodology: A collection of cases has been assembled depicting diffusion restriction on MR Brain imaging stemming from non-neoplastic intracranial pathologies.

Results: Various causes were encountered including vascular (infarcts), infectious (abscess, empyema, viral infections), traumatic (hematoma), metabolic (inborn error of metabolism), toxic (carbon-monoxide toxicity) and demyelinating (tumefactive demyelinating disease).

Conclusion: This detailed pictorial helps the radiologist in narrowing the differentials improving diagnostic precision.

Keywords: Cerebral, MRI, Non-neoplastic, Restricted Diffusion.

Authors' Contribution:

All authors contributed equally to the conception, literature search, manuscript drafting, editing and review

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Introduction

Diffusion-weighted imaging (DWI) serves as useful diagnostic tool, offering function insight by examining the free diffusivity of water molecules into intra and extra cellular spaces.¹ The restriction of water movement creates unique diffusion contrast and alters ADC values. Certain pathological entities despite of their non-neoplastic nature may demonstrate increase cellularity, resulting in DWI patterns that resemble those seen in malignant lesions.²

Being aware of this possibility can minimize the risk of misdiagnosis and enhance diagnostic accuracy.

Methodology

The retrospective study was performed in Radiology Department, Shifa International Hospital, from 2020 to 2024.

A pictorial review performed after Institution Review Boards approval. A collection of cases has been assembled depicting diffusion restriction on MR Brain imaging stemming from non-neoplastic intracranial pathologies. Images were acquired on Siemens 3 Tesla, Toshiba-titan 1.5 Tesla and Hitachi 0.4 Tesla. Standard DWI sequence with b value 1000s/mm² was used.

Results

Various aetiologies were enrolled in this pictorial.

1. Vascular

i. Arterial Infarct:

A 45-year-old male presented with left sided body weakness.

MRI brain, Figure 1; restricted diffusion in right MCA territory correspondingly appearing bright on T2 without post contrast enhancement suggesting acute right MCA territory infarct.

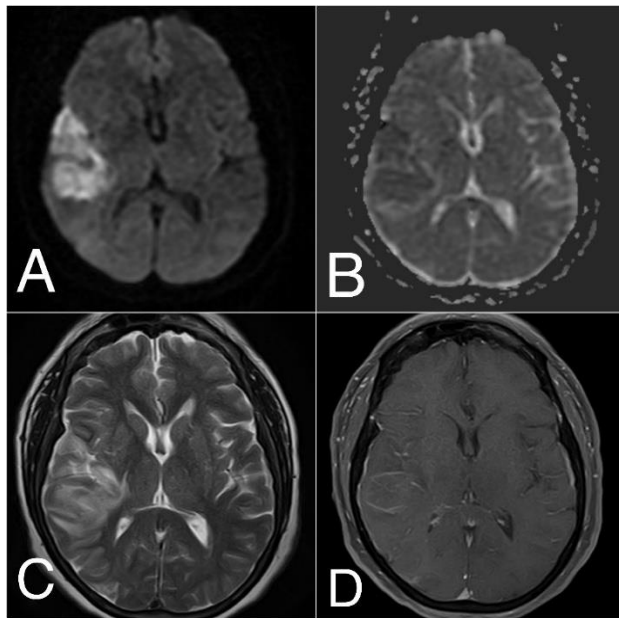


Figure 1: DWI (A), ADC (B), T2 (C), and post-contrast (D) shows diffusion restriction in right parietal lobe (bright on DWI, low on ADC), T2 hyperintensity, no enhancement—acute infarct.

ii. Venous Infarct:

A young patient presented with history of headache followed by altered sensorium. MRI brain, Figure 2; restricted diffusion in the right posterior temporal and adjacent occipital lobes, which are correspondingly high on T2, nodular areas of signal dropout were also seen, suggestive of haemorrhages (not shown). MRV (D) showing loss of signal void of right transverse and sigmoid sinuses and internal jugular vein representing dural sinus

thrombosis. Overall findings are suggestive of venous infarct owing to dural sinus thrombosis.

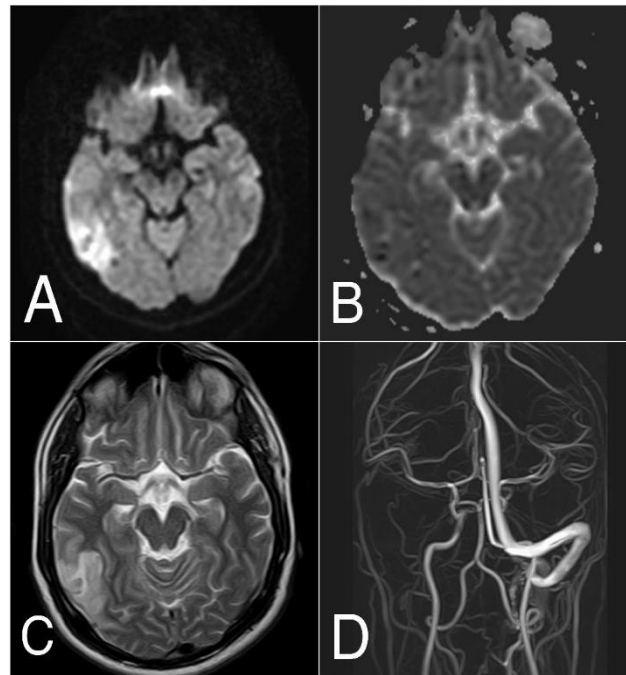


Figure 2: DWI (A), ADC (B), T2 (C) shows right temporal diffusion restriction with T2 hyperintensity; MRV(D) shows absent flow in right transverse, sigmoid sinuses, and IJV—dural sinus thrombosis.

2. Infection

i. Abscess

A 33-year-old male patient presented with history of fever for 20 days associated with generalised tonic clonic fits for one week. Patient was known case of transposition of great vessel and secondary polycythaemia. MRI brain (Figure 3) showing T2 hyperintense signal abnormality in right temporal lobe with internal restricted diffusion and surrounding peripheral enhancing rim, associated mild perifocal oedema as well. Subsequent spectroscopy showed mild to moderate elevation of lipid lactate peak and decrease NAA and choline peak at centre of lesion. Overall findings suggest brain abscess. Patient was advised burr hole drainage of abscess, but he refused, so managed by antibiotics.

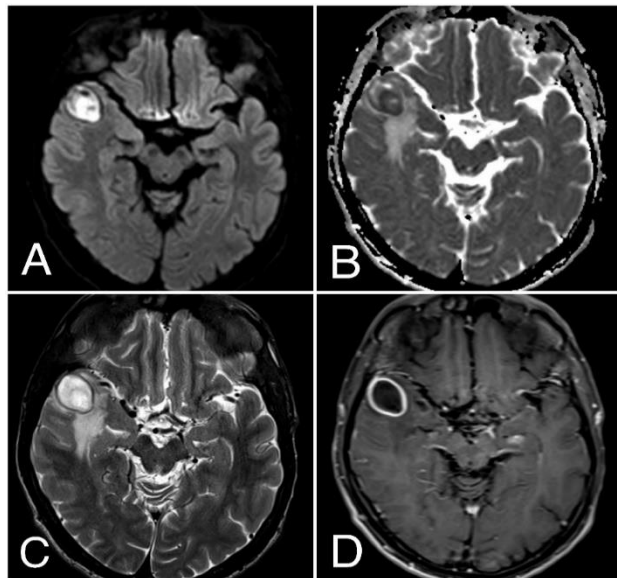


Figure 3: DWI (A), ADC (B), T2 (C), post-contrast (D) shows right temporal T2 hyperintensity with internal diffusion restriction, peripheral enhancement, and mild perifocal oedema—suggestive of abscess.

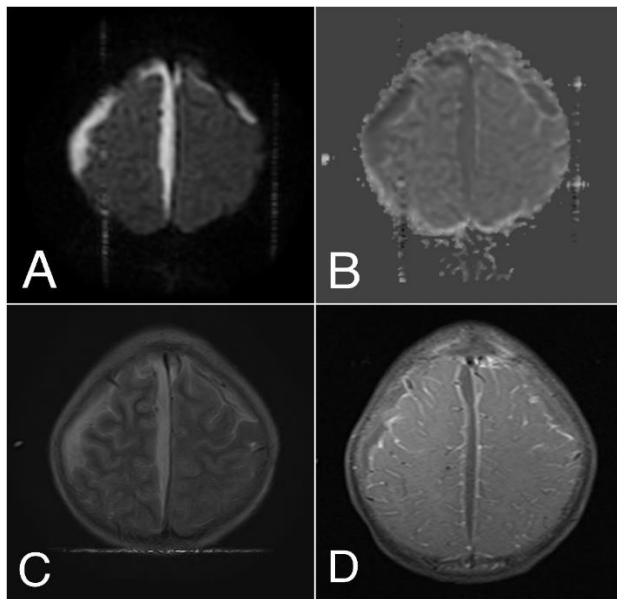


Figure 4: DWI (A), ADC (B), T2 (C), post-contrast (D) shows bilateral subdural and falxine collection with diffusion restriction, T2 hyperintensity, and peripheral enhancement—suggestive of subdural empyema.

ii. Empyema

A 15 old female presented with history of fever and fits. MRI brain (Figure-4) shows subdural collections

along bilateral cerebral convexities and midline falx with diffusion restriction, T2 hyperintensity and peripheral enhancement consistent with subdural empyema. The patient was later managed with craniotomy and evacuation.

iii. Creutzfeldt-Jakob disease.

A 62-year-old male had rapidly progressive cognitive decline for last 5 weeks preceded by viral illness. He was completely bed bound with altered sensorium, disequilibrium and apprehension. CSF analysis was normal. Infective markers were raised. EEG and autoimmune work were negative. MRI brain, Figure 5; demonstrating subtle areas of restricted diffusion in bilateral temporo- parietal cortices relatively with minimal associated mass effect; findings consistent with suspected CJD and patient managed as CJD.

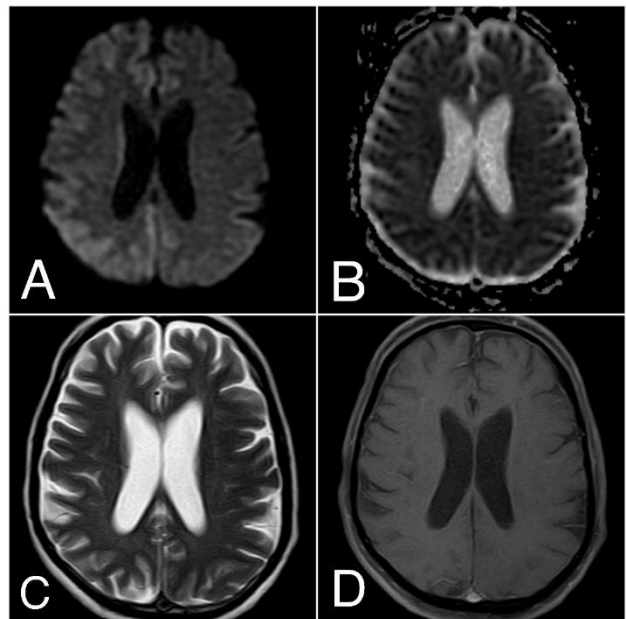


Figure 5: DWI (A), ADC (B), T2 (C), post-contrast (D) shows subtle bilateral temporo-parietal cortical diffusion restriction with minimal mass effect—findings consistent with suspected CJD.

3. Traumatic

i. Hematoma

A young lady with history of RTA presented with acute confusional state and vomiting. MRI brain

Figure 6; abnormal signal in left frontal lobe showing diffusion restriction, giving signal dropout on gradient sequence and appearing bright on T1 consistent with hematoma.

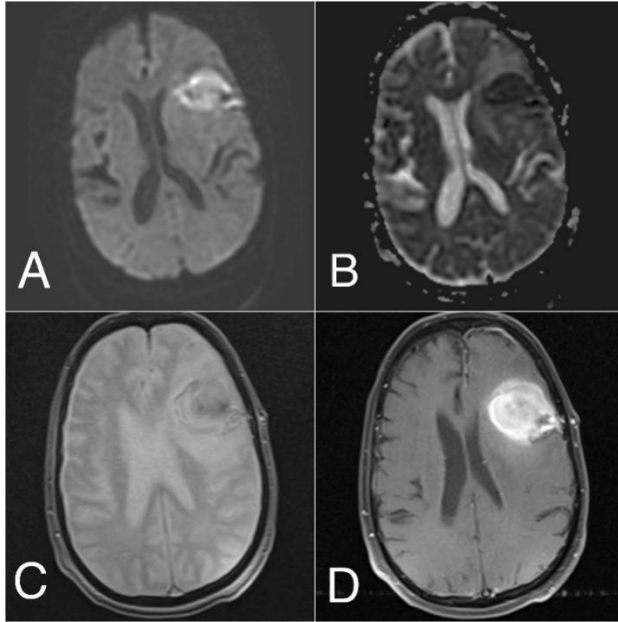


Figure 6: DWI (A), ADC (B), T2*(C) and T1 post-contrast (D) shows left frontal lobe diffusion restriction and gradient signal dropout consistent with hematoma.

4. Toxic

i. Carbon-monoxide poisoning

A 35-year-old male presenting with presented in ER in collapsed state after being found in washroom where instant gas geyser had been installed for hot water. MRI brain Figure 7; showing bilateral cortical based areas of restricted diffusion in bilateral temporal lobes suggesting acute hypoxic ischemic insult sequela of carbon monoxide poisoning. Patient was managed by supportive care.

5. Metabolic

i. Maple syrup urine disease

A 14-day-old full-term infant with lethargy, limb weakness, and failed extubations. Labs revealed hyperammonaemia and elevated leucine, isoleucine, and valine. MR findings (Figure 8) were consistent with Maple Syrup Urine Disease.

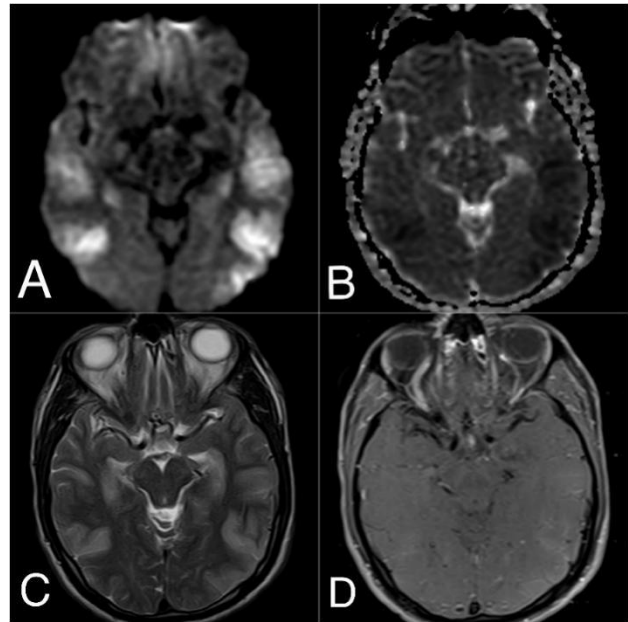


Figure 7: DWI (A), ADC (B), T2 (C), post-contrast (D) shows bilateral temporal cortical diffusion restriction—suggestive of acute hypoxic-ischemic injury from carbon monoxide poisoning.

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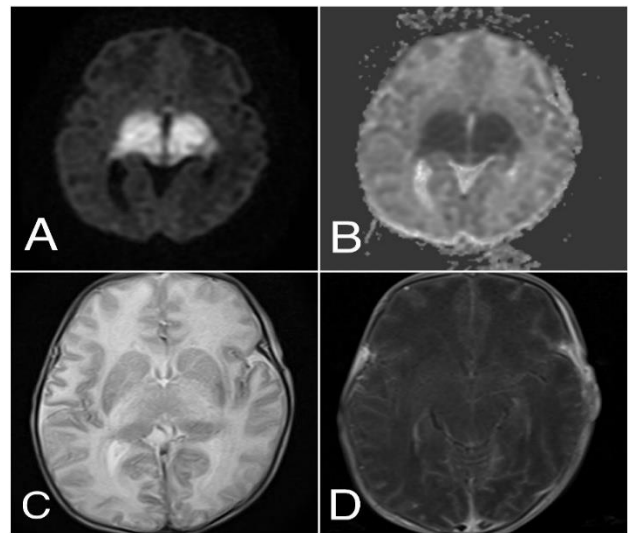


Figure 8: DWI (A), ADC (B), T2 (C), post-contrast (D) shows symmetrical diffusion restriction in bilateral basal ganglia without contrast enhancement; labs consistent with maple syrup urine disease.

6. Demyelinating

A 38-year-old male patient was in usual state of health 10 days back when he developed low grade

fever and flu-like symptoms. He remained fine for days then developed visual disturbance and altered mental sensorium. MRI brain with contrast was performed under anaesthesia. MRI brain Figure 09 show multiple T2 bright lesions in bilateral cerebral hemispheres showing patchy peripheral restricted diffusion and post contrast enhancement; differentials include tumefactive demyelinating disease, lymphoma and metastatic lesions. He underwent left mini-craniotomy and biopsy of lesion. Biopsy showed findings that were suggestive of tumefactive demyelinating disease. Tissue culture and MTB DNA were negative. Patient managed by pulse steroid doses and plasma exchange.

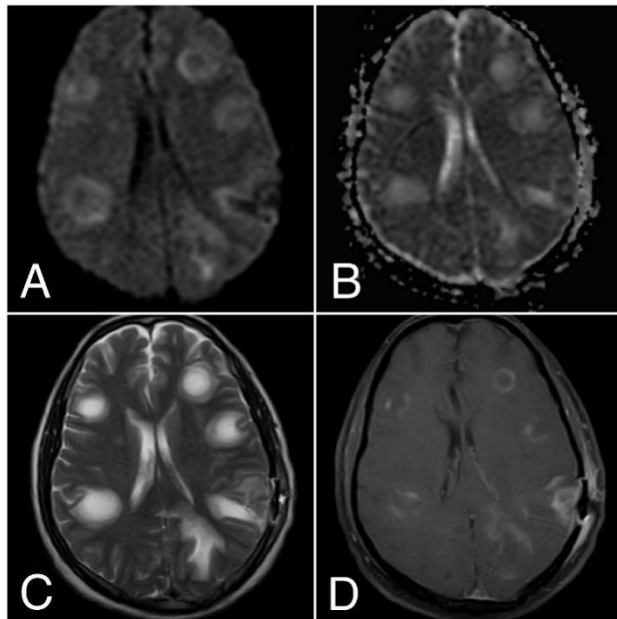


Figure 9: DWI (A), ADC (B), T2 (C), post-contrast (D) shows multiple T2-bright bilateral cerebral lesions with patchy peripheral diffusion restriction and enhancement; biopsy suggested tumefactive demyelinating disease.

7. Others

i. Choroid plexus cyst.

A 49-year-old female presented with complain of headache. No history of loss of consciousness or fits was there. MRI brain with contrast was requested. MRI brain Figure 10; showing focus of DWI bright

and ADC low signal without corresponding signal abnormality on FLAIR suggesting choroid plexus cyst.

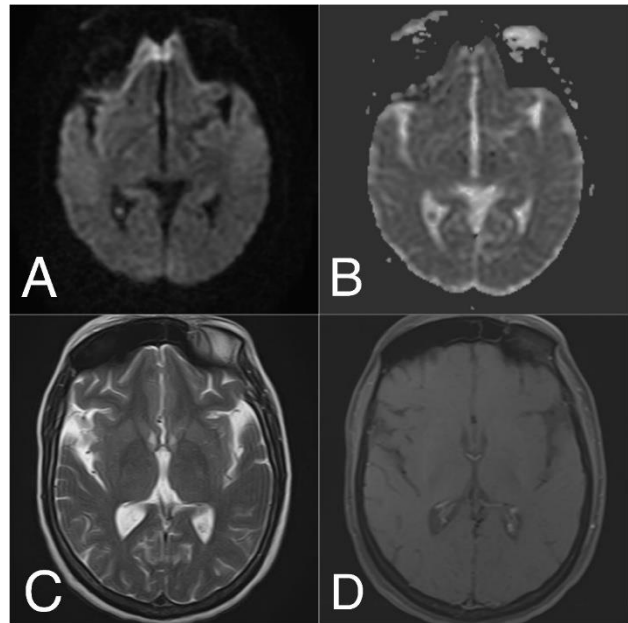


Figure 10: DWI (A), ADC (B), T2 (C), post-contrast (D) shows DWI-bright, ADC-low focus without FLAIR abnormality, consistent with a choroid plexus cyst.

Discussion

The discussion of each section outlining each possible differential diagnosis, is summarized below.

1. Infarct:

In our clinical setting, restricted diffusion is most seen in acute infarcts. Furthermore, clinical history also aids in making diagnosis.³ Within minutes of a stroke occurring, DW-MRI can identify infarcts and precisely determine their location and size. Almost all stroke treatment clinics now provide MRI and DWI, and a DW-MRI takes less than three minutes. The diagnostic accuracy remains elevated if a magnetic resonance angiography (MRA) is incorporated into the technique.⁴

2. Abscess

A brain abscess often appears as a ring-enhancing lesion on T2-weighted images and as low or moderate signal strength on T1-weighted images

during conventional magnetic resonance imaging. On T2-weighted images, a mature abscess features a low-signal-intensity capsule.⁵ Nevertheless, data from recent studies indicate that diffusion-weighted (DW) imaging is more sensitive than standard MR imaging in differentiating brain abscesses and cystic tumours.⁶⁻⁸ The appearance of a ring-enhancing lesion in the brain is not a diagnostic indicator of an abscess. Pus in brain abscesses shows a decreased apparent diffusion coefficient (ADC) and is markedly hyperintense on DW images.⁹

3. Empyema

An infection of the potentially extensible subdural space is known as subdural empyema (SDE).¹⁰ A better clinical result is largely dependent on rapid surgical intervention, proper antibiotic treatment, and early and precise diagnosis. The imaging diagnosis of SDE has traditionally relied on CT and MR imaging.^{11,12}

4. Creutzfeldt-Jakob disease

Creutzfeldt-Jakob Disease (CJD) is the most well-known human transmissible spongiform encephalopathy caused by prions. MRI plays a crucial role in its diagnosis. MRI is pivotal in diagnosing CJD, even though initial scans may show no significant abnormality, but serial scans do show characteristic hyperintensities in the involved regions as reported in this cited article where involvement was seen in frontal and paracentral regions, basal ganglia, and temporal cortex on T2 and FLAIR sequences., consistent with CJD.¹³ A hallmark MRI feature of Creutzfeldt-Jakob disease (CJD) is restricted diffusion in a minimum of two cortical areas, referred to as the cortical ribbon sign, accompanied by predominant diffusion restriction in the caudate nucleus, typically followed by involvement of the putamen and thalamus.¹⁴

5. Hematoma

Even on standard MR images, the MR appearance of developing cerebral bleeding and its underlying biophysical foundation is relatively complicated. The restricted diffusion pattern has been explained by the fact that most of the hematoma is formed by

relatively oxygenated haemoglobin, whereas the periphery exhibits early deoxygenation. Both extracellular methaemoglobin in subacute chronic hematomas and normal brain parenchyma are compared to this limited diffusion in hyperacute and acute hematomas. Therefore, even though early hematomas may be clearly seen on conventional MR imaging, they would appear on ADC maps as having the same signal strength as acute infarction. This implies that standard MR images should always be compared with ADC maps for interpretation. Published literature on MRI characteristics of chronic subdural hematoma (cSDH) remains limited, with existing data primarily centered on T1- and T2-weighted imaging or derived from isolated case reports and small case series.¹⁵ MRI may offer superior diagnostic capability in distinguishing chronic subdural hematoma (cSDH) from other subdural space pathologies, with subdural empyema representing the most critical differential consideration.¹⁶

6. Carbon-monoxide poisoning

Carbon monoxide is a colorless, odorless gas that can be fatal at high levels. In the U.S., accidental exposure leads to over 100,000 ER visits, 14,000 hospitalizations, and 400 deaths yearly; globally, it causes 28,000 deaths. Key risks include enclosed fuel use, poor ventilation, occupational exposure, and winter heating.¹⁷ Brain MRI, particularly diffusion-weighted imaging (DWI), is invaluable in identifying affected areas during acute CO poisoning. Bilateral globi pallidi showing restricted diffusion is a characteristic finding, while other areas such as the cerebral cortex, cerebellum, hippocampus, amygdala, splenium of the corpus callosum, and insula may also be involved. Irrespective of location, all lesions exhibit restricted diffusion on DWI/ADC maps, indicative of cytotoxic oedema.¹⁸

7. Maple syrup urine disease

Maple syrup urine disease has symmetric signal abnormalities in bilateral cerebral and cerebellar white matter. It also involves the internal capsule, thalamus, globus pallidus and brainstem. The

abnormal areas are hypointense on T1 and hyperintense on T2 and FLAIR. DWI also reveals considerably high signal in the fore mentioned areas.¹⁹ Diagnosis can be made upon the imaging features in first few weeks of life. Any changes in brain tissue are more pronounced on DWI images as compared to FLAIR images. Diffusion weighted sequence is most appropriate and preferred imaging for the diagnosis of maple syrup urine disease.²⁰

8. Demyelinating diseases

DWI MR technique can be used for diagnosing demyelinating disease but is mostly used in follow up cases. It helps in diagnosing new lesions prior to postcontrast scan. Few of the advanced techniques such as diffusion-tensor imaging and few of the new post processing techniques are also used for this purpose.²¹ Active plaques of multiple sclerosis exhibit diffusion restriction and post contrast enhancement. DWI sequence is very useful in differentiating tumefactive demyelinating lesions from cerebral abscess. As described above cerebral abscess shows internal restricted diffusion while tumefactive demyelinating lesions show central increased ADC values due to the necrotic component. These lesions manifest open ring enhancement with open ring at the grey matter side of the lesion. Similarly, DWI sequence plays an important role not only in diagnosis but also the prognosis of Acute demyelinating encephalomyelitis (ADEM). These lesions are usually asymmetrical involving both lobes having different shapes and sizes with nodular, amorphous, diffuse or gyral post contrast enhancement.²²

In ADEM diffusion weighted changes are variable and depend on the stage of the disease.²³ In the first 7 days of clinical onset of disease, true diffusion restriction is present that is high signal on DWI and low signal on ADC however these changes to free diffusion on follow-up scans. Patients with ADEM having no restricted diffusion or T2 shine through show full recovery upon treatment with medication while patients with restricted diffusion have late recovery.

09. Choroid Plexus Cyst

Choroid plexus cysts mostly have CSF density but can be hyperintense to CSF on FLAIR sequence.²⁴ The rim of the cyst is usually calcified. On T1 and T2 weighted sequence these have signals like CSF and are difficult to identify. Post contrast imaging shows rim enhancement in adults. About two-third of choroid plexus cyst are bright on DWI and are easier to detect. These have high signal on DWI because of restricted motion of water molecules due to higher protein content. The hypointense signal on ADC is due to increased viscosity of the cyst.²⁵ Hence DWI is helpful in distinguishing choroid plexus cysts which remain undetected within the cerebrospinal fluid on conventional imaging. Different radiological modalities specifically MRI play a pivotal role in neuroimaging, providing detailed anatomical and pathological information essential for accurate diagnosis and assessment.²⁶⁻²⁸ Magnetic Resonance Imaging (MRI), with its superior soft tissue contrast and versatile sequences such as T1, T2, FLAIR, DWI, and SWI, is pivotal in neuroimaging. It enhances imaging characterization, aids in narrowing differential diagnoses, and supports precise clinical decision-making.²⁹⁻³²

Conclusion

A significant proportion of non-neoplastic intracranial pathologies can exhibit restricted diffusion. Thus, this detailed pictorial can help the radiologists in narrowing the differentials.

References

1. Niranjana UR, Kumaran SP, Sriramanakoppa NN, Viswamitra S. Restricted diffusion in benign intracranial neoplasms: a narrative review. *Polish Journal of Radiology*. 2023;88: e494. <https://doi.org/10.5114/pjr.2023.132536>
2. Das A, Bhalla AS, Sharma R, Kumar A, Sharma M, Gamanagatti S, Thakar A, Sharma S. Benign neck masses showing restricted diffusion: Is there a histological basis for discordant behavior? *World Journal of Radiology*. 2016 Feb 2;8(2):174. <https://doi.org/10.4329/wjr.v8.i2.174>

3. Finelli PF. Diagnostic approach to restricted-diffusion patterns on MR imaging. *Neurology: Clinical Practice*. 2012 Dec;2(4):287-93. <https://doi.org/10.1212/cpj.0b013e318278bee1>
4. Jose J, James J. An MRI based ischemic stroke classification—a mechanism-oriented approach. *Annals of Indian Academy of Neurology*. 2022 Nov 1;25(6):1019-28. https://doi.org/10.4103/aian.aian_365_22
5. Hall WA, Mesfin FB. Brain abscess. In: *StatPearls* [Internet] 2024 Sep 21. StatPearls Publishing.
6. Ahmed MS, Shazlee MK, Usman R, Hamid K, Iqbal J, Hussain I. Diagnostic Accuracy of Diffusion Weighted MRI in the Diagnosis of Brain Abscess. *Pakistan Journal of Radiology* [Internet]. 2016 Oct. 26 [cited 2025 Sep. 29];26(4). Available from: <https://www.pakjr.com/index.php/PJR/article/view/75>
7. Cui L, Qin Z, Sun S, Feng W, Hou M, Yu D. Diffusion-weighted imaging-based radiomics model using automatic machine learning to differentiate cerebral cystic metastases from brain abscesses. *J Cancer Res Clin Oncol*. 2024 Mar 16;150(3):132. <https://doi.org/10.1007/s00432-024-05642-4>.
8. Siddiqui H, Vakil S, Hassan M. Diagnostic accuracy of echo-planar diffusion-weighted imaging in the diagnosis of intra-cerebral abscess by taking histopathological findings as the gold standard. *Cureus*. 2019 May 16;11(5). <https://doi.org/10.7759/cureus.4677>
9. Dmytriw AA, Sawlani V, Shankar J. Diffusion-weighted imaging of the brain: beyond stroke. *Canadian Association of Radiologists Journal*. 2017 May;68(2):131-46. <https://doi.org/10.1016/j.carj.2016.10.001>
10. Hall WA, De Jesus O. Subdural Empyema. In: *StatPearls* [Internet] 2024 Oct 6. StatPearls Publishing.
11. Aghadoost H, Salehabadi G, Fakharian E. Subdural empyema in patient with SARS-CoV-2 positivity: A rare case report of 3 patients. *Radiology Case Reports*. 2025 Mar 1;20(3):1552-8. <https://doi.org/10.1016/j.radcr.2024.11.076>
12. Haroon K, Reza MA, Taher T, Alam MS, Haque RU, Ahmed MF, Hossain SS. Acute subdural empyema in the young COVID-19 patient-A case report. *Bangladesh Journal of Neurosurgery*. 2021 Jun 5;10(2):206-9. <https://doi.org/10.3329/bjns.v10i2.53776>
13. Guennouni A, Hassar S, Oukassem S, Abourak C, Kettani N, Fikri M, Jiddan M, Touarsa F. Creutzfeldt-Jakob disease: Case report and literature review. *Radiology Case Reports*. 2025 May 1;20(5):2577-80. <https://doi.org/10.1016/j.radcr.2025.02.007>
14. Nakamichi S, Ono R, Kudo M, Horiuchi S, Kitagawa I. Cortical ribbon sign: Initial sign of Creutzfeldt–Jakob disease. *Journal of General and Family Medicine*. 2025 Jul 1;26(4):372-4. <https://doi.org/10.1002/jgf2.70019>
15. Hasan D, Nikoubashman O, Pjontek R, Stockero A, Hamou HA, Wiesmann M. MRI appearance of chronic subdural hematoma. *Front Neurol*. 2022 Aug 8; 13:872664. <https://doi.org/10.3389/fneur.2022.872664>.
16. Catana D, Koziarz A, Cenic A, Nath S, Singh S, Almenawer SA, et al. Subdural hematoma mimickers: a systematic review. *World Neurosurg*. (2016) 93:73–80. <https://doi.org/10.1016/j.wneu.2016.05.084>
17. McMahon K, Launico MV. Carbon Monoxide Toxicity. [Updated 2025 Apr 19]. In: *StatPearls* [Internet]. Treasure Island (FL): StatPearls Publishing; 2025 Jan-. Available from: <https://www.ncbi.nlm.nih.gov/books/NBK430740/>
18. Kim DM, Lee IH, Park JY, Hwang SB, Yoo DS, Song CJ. Acute carbon monoxide poisoning: MR imaging findings with clinical correlation. *Diagnostic and interventional imaging*. 2017 Apr 1;98(4):299-306. <https://doi.org/10.1016/j.diii.2016.10.004>
19. Lai, B., & Zhong, J. (2024). Maple Syrup Urine Disease. *Radiology*, 310(1).
20. Xia, W., & Yang, W. (2015). Diffusion-weighted magnetic resonance imaging in a case of severe classic maple syrup urine disease. *Journal of Pediatric Endocrinology and Metabolism*, 28(7–8). <https://doi.org/10.1515/jpem-2014-0461>
21. Rueda-Lopes FC, Hygino da Cruz Jr LC, Doring TM, Gasparetto EL. Diffusion-weighted imaging and demyelinating diseases: new aspects of an old advanced sequence. *American Journal of Roentgenology*. 2014 Jan;202(1): W34-42. <https://doi.org/10.2214/ajr.13.11400>
22. Kamr WH, El-Tantawy AM, Moustafa M, Abd-Elsalam OA. Acute disseminated encephalomyelitis: MR Diffusion weighted imaging: Potential diagnostic value and outcome predilection. *The Egyptian Journal of Radiology and Nuclear Medicine*. 2017 Mar 1;48(1):215-23.
23. Gauckler P, Shin JI, Mayer G, Kronbichler A. Eosinophilia and kidney disease: more than just an incidental finding? *Journal of clinical medicine*. 2018 Dec 8;7(12):529. <https://doi.org/10.3390/jcm7120529>
24. Huang B. Choroid Plexus Cyst. In: Rumboldt Z, Castillo M, Huang B, Rossi A, eds. *Brain Imaging with MRI and CT: An Image Pattern Approach*. Cambridge University Press; 2012:303-304.
25. Maekawa T, Hori M, Murata K, Feiweier T, Andica C, Fukunaga I, Koshino S, Hagiwara A, Kamiya K, Kamagata K, Wada A. Choroid plexus cysts analyzed using diffusion-weighted imaging with short diffusion-time. *Magnetic resonance imaging*. 2019 Apr 1; 57:323-7. <https://doi.org/10.1016/j.mri.2018.12.010>
26. Bhinder K.K., Siddiqui A.R., Tahir M.J., Maqsood H., Ullah I., Yousaf Z. Bilateral basal ganglia ischemia associated with COVID-19: a case report and review of the literature. *J Med Case Rep*. 2021;15:1–4. <https://doi.org/10.1186/s13256-021-03165-x>
27. Hameed A., Akhtar R., Bhinder K.K., Tariq AT. Enigmatic vessel: the persistent hypoglossal artery in a tetralogy of fallot patient with brain abscess-report of a rare case. *Med Rep*. 2025. <https://doi.org/10.1016/j.hmedic.2025.100167>

28. Bhinder K.K., Khalid N., Akhtar S. Multi territory ischemic stroke in a patient with Fahr's disease: report of a rare case. *Radiol Case Rep.* 2025;20(1):661–666. <https://doi.org/10.1016/j.radcr.2024.10.100>.
29. Shah M, Aslam M, Rauf M, Akhtar R, Moqet A, Bhinder KK. Stroke and Its Mimics. *Pakistan Journal of Radiology* [Internet]. 2024 Jul 1 [cited 2025 Sep 24];34(3):157–76. Available from: <https://research.ebsco.com/linkprocessor/plink?id=9e3d3a5b-56aa-337e-916a-b6396fe23adc>
30. Kanwal A, Bhinder KK, Mehboob A, Naveed A, Shafiq U, Khan N. Let Us Look at Astronomy through the Eyes of a Radiologist. *Pakistan Journal of Radiology* [Internet]. 2024 Apr 1 [cited 2025 Sep 24];34(2):93–102. Available from:
- <https://research.ebsco.com/linkprocessor/plink?id=957f91e5-4c13-30c9-8f74-712754a90b7a>
31. Bhinder KK, Wahla MS, Ullah F, Mehboob A, Gul S. Effect of Ageing in Pakistani Population on Midbrain to Pons Area Ratio Using Mri: A Retrospective Study. *Pakistan Journal of Radiology* [Internet]. 2024 Jan 1 [cited 2025 Sep 24];34(1):18–22. Available from: <https://research.ebsco.com/linkprocessor/plink?id=c919da8b-4755-3a35-a350-968668b95963>
32. Mehboob A, Bhinder KK, Naveed A, Tariq H, Ullah F, Ahmad F. Let's not forget about the Lhermitte Duclos disease: Report of a rare case. *Medical Reports.* 2023 Nov 1;1:100009. <https://doi.org/10.1016/j.hmedic.2023.100009>