e-ISSN: 0975-1556, p-ISSN:2820-2643
Available online on www.ijpcr.com
International Journal of Pharmaceutical and Clinical Research 2024; 16(6); 1454-1460

Original Research Article

Evaluation of Diffusion Weighted Magnetic Resonance Imaging Intracranial Lesions That are Non-Neoplastic

Kishan Kumar Thakur[1], Mithilesh Pratap[2], Madhukar Dayal[3]

[1]Senior Resident, Department of Radiology, Nalanda Medical College Hospital, Patna, Bihar
[2]Professor, Department of Radiology, Nalanda Medical College Hospital, Patna, Bihar
[3]Assistant Professor, Department of Radiology, Nalanda Medical College Hospital, Patna, Bihar

Received: 19-03-2024 / Revised: 17-04-2024 / Accepted: 11-05-2024
Corresponding Author: Dr. Mithilesh Pratap
Conflict of interest: Nil

Abstract:

Background and Objective: When magnetic resonance imaging (MRI) was initially used for imaging brains and other body tissues, diffusion, or the random motion of molecules, was considered problematic for image quality because it detrimentally affected signal. Diffusion-weighted imaging (DWI) became an established part of neuroimaging and is used to diagnose and characterize several neurologic disorders. DW MR imaging is also assuming an increasingly important role in the evaluation of many other intracranial disease processes.

Materials and Methods: The study was observational/correlational study. The study subjects were 60 patients, who attended the Outpatient Department Nalanda Medical College & Hospital /admitted in Medicine ward of Nalanda Medical College & Hospital with clinical symptoms and signs suggestive of non-neoplastic intracranial lesions of the brain. Study Period- September 2022 – August 2023.

Results: Sixty patients diagnosed with non-cancerous intracranial lesions underwent MRI examinations including sequences like DWI, T1W, T2W, FLAIR, and GRE, revealing diffusion restriction. Among them, 29 patients were diagnosed with ischemic stroke, 6 with HSV encephalitis, and 4 with cerebral abscess.

Conclusion: Both DWI and T2WI are equally sensitive in detecting infarction in acute stage of stroke. DWI is useful even this stage to differentiate stroke from stroke mimicking conditions. DWI is helpful in the diagnosis of cerebral abscess. DWI is helpful in the diagnosis of HSV encephalitis. Both T2WI and DWI are equally sensitive in detecting lesions in HSV encephalitis.

Keywords: MRI, DWI, HSV Encephalitis.

Introduction

When magnetic resonance imaging (MRI) was initially used for imaging brains and other body tissues, diffusion, or the random motion of molecules, was considered problematic for image quality because it detrimentally affected signal. Efforts were made to reduce the effect of diffusion in order to decrease signal loss. However, researchers soon realized that diffusion could provide valuable information, both functional and anatomic, in studies of the brain. Diffusion-weighted imaging (DWI) became an established part of neuroimaging and is used to diagnose and characterize several neurologic disorders [1]. Because DW MR imaging uses fast (echo-planar) imaging technology, it is highly resistant to patient motion, and imaging time ranges from a few seconds to 2 minutes. As a consequence, DW MR imaging has assumed an essential role in the detection of acute brain infarction and in the differentiation of acute infarction from other disease processes. DW MR imaging is also assuming an increasingly important role in the evaluation of many other intracranial disease processes [2].

Objectives

- Establish the findings of DWI MRI in various intracranial lesions.
- Correlation of DWI findings of various intracranial lesions with their conventional MRI findings.
- Establish the usefulness of DWI MRI in diagnosis of various intracranial lesions.
- Establish the findings of DWI in different stages of stroke.

Material and Method

The study was observational/correlational study. The study subjects were 60 patients, who attended the Outpatient Department Nalanda Medical College & Hospital / admitted in Medicine ward of Nalanda Medical College & Hospital with clinical symptoms and signs suggestive of non-neoplastic

intracranial lesions of the brain. Study Period September 2022 – August 2023.

Inclusion Criteria

Patients with neurological disease affecting the brain who are sent for MRI including DWI study.

Patients/relatives willing to participate in the study.

Exclusion Criteria

Patients with symptoms and signs, and prior imaging suggestive of neoplastic intracranial lesions.

Patients admitted with head trauma.

Patients having contraindications for MRI study.

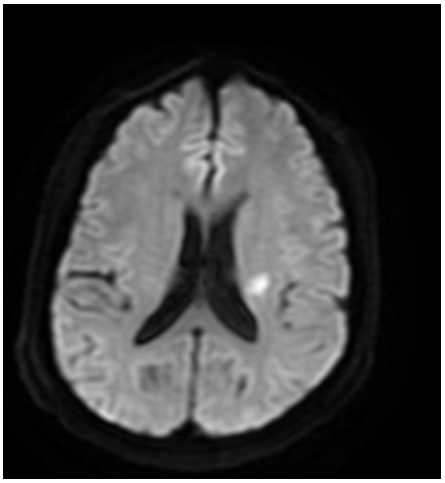
Patients/relatives unwilling to participate in the study.

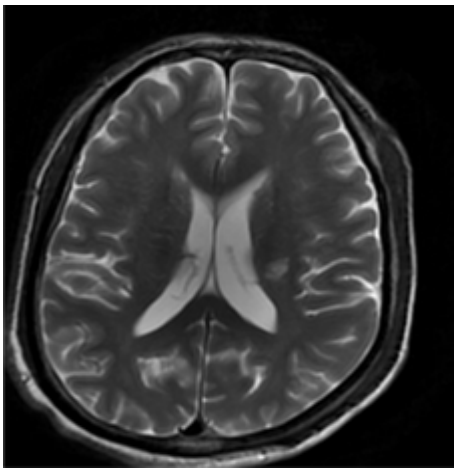
Signal intensity in DWI (Diffusion weighted imaging) is noted. Hyperintense lesions in DWI were always compared with ADC mapping to find out true diffusion restriction.

Signal intensity of the lesion in MRI sequences like T1WI (T1 weighted imaging), T2WI (T2 weighted imaging), FLAIR (Fluid attenuated inversion recovery sequence), GRE sequence and Contrast study - AxT1, SagT1, CorT1 were studied. The location, size, extent and contrast enhancement of the lesions were noted. any associated hemorrhage / calcification or edema were also noted. 1.5 Tesla (Superconductive Coil) MRI machine, GE made, model Signa Explorer in Nalanda Medical College & Hospital

Analysis of data

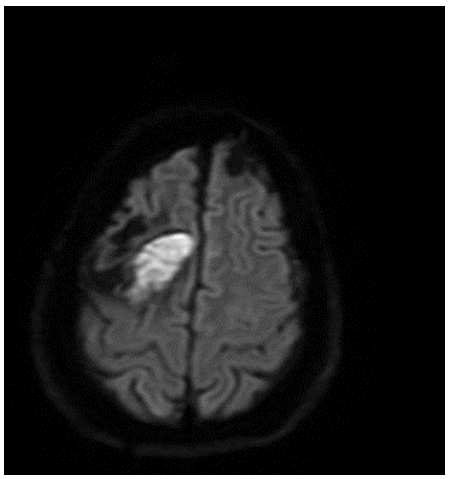
The clinical findings and MRI findings were filled in the proforma for individual patients and the data was tabulated. The intensity of lesions in each sequence were noted and compared. The sensitivity of each sequence in detecting lesions was calculated.

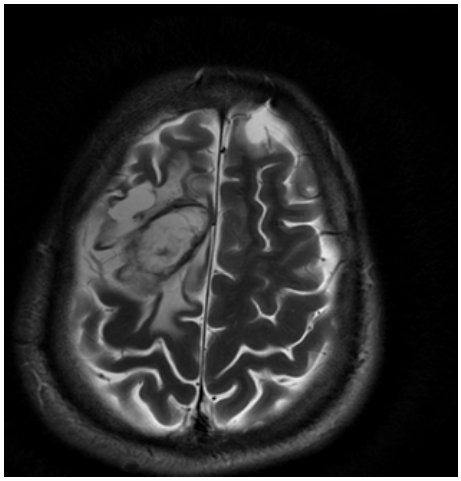




DWI T2WI

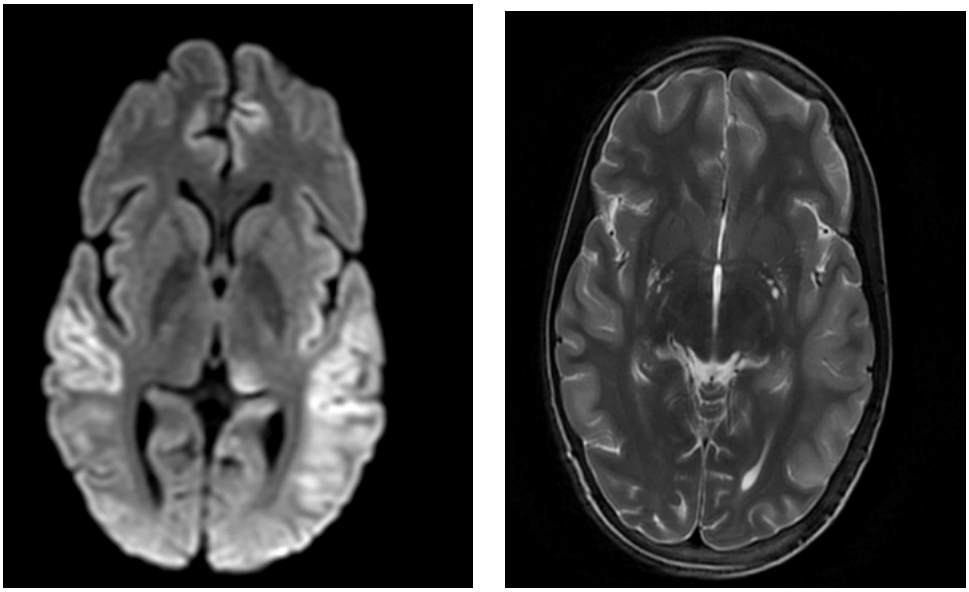
Acute infarction



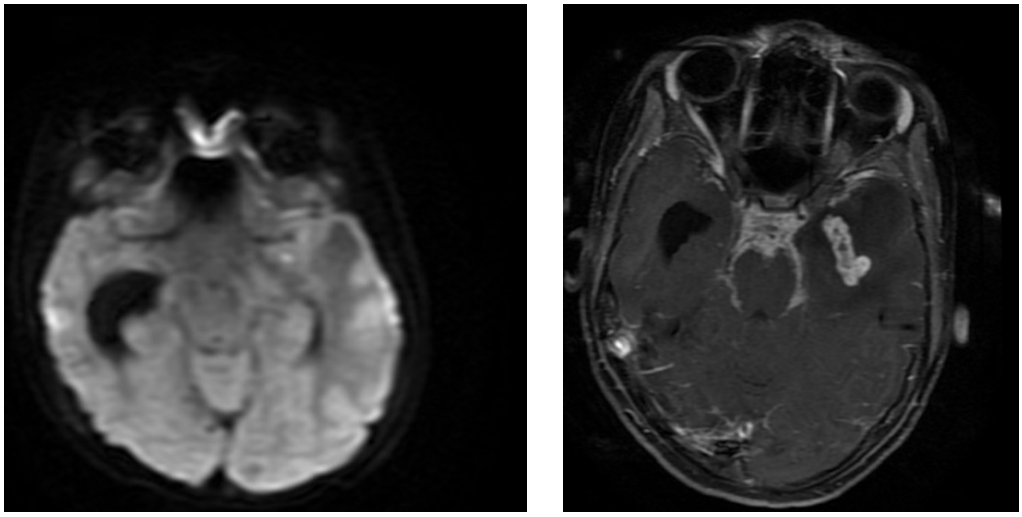


DWI T2WI

Brain Abscess



HSV ENCEPHALITIS



Central hyperintensity in TB graanuloma

Results

Sixty patients with non-neoplastic intracranial lesions who had been investigated by MRI examinations with sequence like DWI, T1W, T2W, FLAIR, GRE were included in the study. Demographics and MRI findings of 60 patients are given below**.**

Age of patients range from 1month to 74 years. The largest number of patients were in 51-60yr age group.

Table 1:

Age group (in years)	Number of patients	Percentage
0-10	8	13%
11-20	4	6.6%
21-30	6	10%
31-40	8	13.3%
41-50	8	13.3%
51-60	17	28%
61-70	7	11.6%
71-80	2	3.3%

The following table shows the intracranial lesions which showing diffusion restriction and the patients distribution**.** The majority of patients with diffusion restriction belongs to stroke..

Table 2:

Diagnosis	No. of patients
Ischemic stroke	29
Hemorrhage	3
Cerebral abscess	4
HSV encephalitis	6
Wilson disease	3
Central pontine myelinolysis	1
Canavan disease	1
Persistent seizure activity	1
Demyelinating condition	1
Snake bite encephelopathy	1
Creutzfeldt Jakob disease	1
TB granuloma	2

Signal intensity changes in different sequences, including T1W,T2W,FLAIR,DWI and GRE were noted in patients with acute infarction. All 29 patients showed diffusion restriction. Out of 29 patients, nine patients showed GRE hypointensity suggestive of hemorrhagic transformation of stroke.

	No. of patients	Percentage
Acute infarction	20	69%
Acute infarction with hemorrhagic transformation	9	31%
Total	29	100

Table 3:MRI Signal intensity changes in stroke

MRI sequences	No. of patients	Percentage
DWI(restriction)	29	100%
T1WI(hypointensity)	26	89%
T2WI(hyperintensity)	28	96%
FLAIR(hyperintensity)	25	86%
GRE(hypointensity)	9	31%

MRI signal intensity changes is noted in 7patients of HSV encephalitis, patchy diffusion restriction is noted in 6 patients, mainly in temporal lobes and insular cortex.

Table 4: MRI signal intensity changes in HSV encephalitis patients

MRI sequences	No. of patients	percentage
DWI	6	85%
T1WI	5	71%
T2WI	6	85%
FLAIR	5	71%
GRE	0	0%

There were four patients diagnosed with brain abscess and all of them showed restricted diffusion mainly in the center of abscess. All patients showed T2 hypointense rim with thin regular rim enhancement.

Table 5: MRI signal intensity changes in brain abscess

MRI sequences	No. of patients	percentage
DWI	4	100%
T1WI	4	100%
T2WI	4	100%
FLAIR	1	25%
GRE	0	0%

MRI Signal Intensity Changes in Hemorrhage: Late sub-acute bleed showed diffusion restriction which is hyperintense in both T1W AND T2W images. Three cases of late subacute bleed were studied.

Table 6

MRI sequences	No. of patients	Percentage
DWI	3	100
T1WI(hyperintensity)	3	100
T2WI(hyperintensity)	3	100
FLAIR	3	100
GRE	3	100

Snake Bite Encephalopathy

One patient diagnosed with snake bite encephalopathy showed Bilateral long TR hyper intensity in basal ganglia(right>left) with diffusion restriction in these areas and in bilateral occipitoparietal cortex .T1W hyperintensity is noted in rt. basal ganglia

Table 7

MRI sequence	T1WI	T2WI	FLAIR	DWI	GRE
Snake bite encephalopathy	hyperintensity	Hyperintensity	hyperintensity	Restriction	

We have got six cases of TB granuloma patient, of which 2 cases showed central diffusion restriction in the granuloma. All TB granuloma patient showed rim enhancement of the lesion .the signal intensity changes in various sequences are compared.

Table 8: MRI S.I changes in TB granuloma

MRI sequence	No. of patients	Percentage
DWI	2	33%
T1WI	Isointensity(3),hypo(3)	100%
T2WI	Hyperintensity(4),Iso(2)	100%
FLAIR	Hyperintensity(5),iso(1)	100%
GRE	0	

Discussion

DW MR imaging uses fast (echo-planar) imaging technology, and it is highly resistant to patient motion, and imaging time ranges from a few seconds to 2 minutes. As a consequence, DW MR imaging has assumed an essential role in the detection of acute brain infarction and in the differentiation of acute infarction from other disease processes. DW MR imaging is also assuming an increasingly important role in the evaluation of many other intracranial disease processes [2].

The majority of studies report high sensitivity and specificity for DW images and ADC maps in the diagnosis of acute stroke (94%sensitivity and 100%specificity in the study by Lövblad et al within the first 6 hours after stroke; 100%sensitivity and 100%specificity in the study by Gonzalez et al in patients imaged within 6 hours of stroke symptom onset [3].

In infections like cerebral abscess, fungal abscess, HSV encephalitis and TB granuloma DWI has an important role in the diagnosis, [4]. DWI considered is the most sensitive technique in CJD, and typically shows restricted diffusion in basal ganglia, thalamus and cortex, even in cases with no visible abnormality on conventional T2 images [5]. R. Gilberto González, et al (1999) conducted a study to evaluate the diagnostic accuracy of diffusion-weighted magnetic resonance (MR) imaging performed within 6 hours of the onset of stroke symptoms. Diffusion weighted imaging had shown 100% sensitivity and 100% specificity while conventional MR imaging had only 18% sensitivity and 100% specificity and 45% sensitivity and 100% specificity for CT. Their study proved that Diffusion-weighted MR imaging is highly accurate for diagnosing stroke within 6 hours of symptom onset and is superior to CT and conventional MR imaging [6].

K.J. van Everdingen, (1998) et al conducted study in which they compared the sensitivity of DWI with that of conventional MRI techniques in. With DWI, 98% of the ischemic lesions were detected, and with fluid-attenuated inversion recovery, 91% were detected, whereas with early T2-weighted or proton density–weighted scans, only 71% (P=0.002, $\chi 2$) and 80% (P=0.02, $\chi 2$) of lesions, respectively, were found [7].

Our results were correlating with the findings of Peter E. Riccia et al(1999) [8] except in the sensitivity of FLAIR sequence .In their study DWI showed 97% sensitivity, FLAIR 96%,and FSE showed 89% in detecting cerebral infarctions up to 10days old9. In a study Sawlani V (2009) showed that In HSE lesions there was a significant restricted diffusion with low average ADC values observed in acute stage and facilitated diffusion with high average ADC values observed in chronic stage

[9]. In a recent study Cartes-Zumelzu FW et al proved that DW imaging was superior to conventional MR imaging in evaluating the success or failure of abscess therapy [10].
DWI can depict imaging features related to treatment success or failure. A reaccumulation of pus within the abscess is related to treatment failure and can be depicted by persistent or reappearing restricted diffusion on DWI after the initial normalization or increase of apparent diffusion coefficient values [11]. In a study Bo Kiung Kanget al (2001) showed that DWI showed that hematomas were hyperintense at the hyperacute and late subacute stages, and hypointense at the acute, early subacute and chronic stages [12]. In study K. Kallenberg (2006) et al proved that PD-weighted images and DWI showed better results in the diagnosis of signal intensity changes in the basal ganglia compared with T2-weighted or FLAIR images; however, in the diagnosis of cortical changes, DWI was clearly superior. Their data suggest that DWI is the most sensitive MR imaging technique in the diagnosis of CJD [13]. Förster A et al (2013) conducted a study to establish the role diffusion weighted imaging in early diagnosis of Central pontine myelinolysis (CPM) and extrapontine myelinolysis (EPM). They found that early DWI changes are a common finding in CPM/EPM but do not regularly precede tissue changes detectable on conventional MRI sequences. Heterogenous ADC values possibly represent different stages of disease [14].

In our study one patient with central pontine myelinolysis showed long TR hyperintensity is noted in the pons with sparing of corticospinal tracts. There was diffusion restriction in the pons. In canavan disease, there is evidence of restricted diffusion within the abnormal white matter structures, likely related to myelin edema or "gelatinous –like" state of the extracellular space [15].

We had one case of canavan disease showing long TR hyperintensity of white matter with involvement of subcortical u fibres. Diffusion restriction is noted in the splenium of corpus callosum and periventricular white matter.

DWI has shown versatility across numerous pathologies, with the progression of diffusion changes providing prognostic or diagnostic insights into the underlying condition. [16]

Conclusion

- DWI sequence is the most sensitive imaging sequence in hyperacute stage of stroke.
- Both DWI and T2WI are equally sensitive in detecting infarction in acute stage of stroke. DWI is useful even this stage to differentiate stroke from stroke mimicking conditions.
- DWI is helpful in the diagnosis of cerebral abscess.
- DWI is helpful in the diagnosis of HSV encephalitis. Both T2WI and DWI are equally sensitive in detecting lesions in HSV encephalitis.
- DWI has adjuvant role in diagnosing TB granuloma, Wilson disease and central pontine myelinolysis.
- DWI is the most sensitive sequence in the diagnosis of Creutzfeldt-Jakob disease.
- DWI may be helpful in the diagnosis of Canavan disease, Persistent seizure activity, Snake bite encephalopathy and Demyelination

References

1. Baliyan V, Das CJ, Sharma R, Gupta AK. Diffusion weighted imaging: Technique and applications. World J Radiol. 2016;8(9):785–798. doi:10.4329/wjr.v8.i9.785
2. Pamela W Schaefer, P.Ellen Grant, R.Gilberto Gonzales Diffusion-weighted MR Imaging of the Brain. Radiology 2000;217(1):331-345 doi: 10.1148/radiology.217.2.r00nv24331.
3. Tadeusz W. Stadnik, MD, PhD, Philippe Demaerel, MD, PhD, Robert R Luypaert, PhD, Christo Chaskis, MD, Katrijn L. Van Rompaey, MD, Alex Michotte, MD and Michel J. Osteaux, MD, PhD Imaging Tutorial: Differential Diagnosis of Bright Lesions on Diffusion-weighted MR Images January 2003 RadioGraphics,23,
4. Gupta RK, Prakash M, Mishra AM, Husain M, Prasad KN, Husain N. Role of diffusion weighted imaging in differentiation of intracranial tuberculoma and tuberculous abscess from cysticercus granulomas-a report of more than 100 lesions. Eur J Radiol. 2005 Sep;55(3):384-92.
5. MRI of the brain and spine, 4th edition, Volume II, 2009, Scott W atlas, Lippincott, chapter 19, page no.1048.
6. R. Gilberto González, Pamela W. Schaefer, Ferdinando S. Buonanno, Lee H. Schwamm, Ronald F. Budzik, Guy Rordorf, Bing Wang, A. Gregory Sorensen, and Walter J. Koroshetz, Diffusion-weighted MR Imaging: Diagnostic Accuracy in Patients Imaged within 6 Hours of Stroke Symptom Onset. January 1999 Radiology, 210,155-16
7. K. J. van Everdingen, MD; J. van der Grond, PhD; L.J. Kappelle, MD, PhD;L.M.P. Ramos, MD; W.P.T.M. Mali, MD, PhD; Diffusion - Weighted Magnetic Resonance Imaging in Acute Stroke Stroke.1998; 29: 1783-1790 doi: 10.1161/01.STR.29.9.1783.
8. Peter E. Riccia, Jonathan H. Burdettea, Allen D. Elstera and David M. Reboussina A Comparison of Fast Spin-Echo, Fluid-Attenuated Inversion-Recovery, and Diffusion-Weighted MR Imaging in the First 10 Days af-

ter Cerebral Infarction. AJNR 1999 20: 1535-1542
9. Sawlani V. Diffusion-weighted imaging and apparent diffusion coefficient evaluation of herpes simplex encephalitis and Japanese encephalitis. J Neurol Sci. 2009 Dec 15;287(1-2):221-6. doi: 10.1016/j.jns.2009.07.010. Epub 2009 Sep 3.
10. Cartes-Zumelzu FW, Stavrou I, Castillo M, Eisenhuber E, Knosp E, Thurnher MM Diffusion-weighted imaging in the assessment of brain abscesses therapy. AJNR Am J Neuroradiol. 2004 Sep;25(8):1310-7.
11. MRI of the brain and spine, 4th edition, Volume II, 2009, Scott W atlas, Lippincott, chapter 18, page no.965-973.
12. 12. Bo Kiung Kang, MD, Dong Gyu Na, MD, Jae Wook Ryoo, MD, Hong Sik Byun, MD, Hong Gee Roh, MD, andYong Seon Pyeun, MD Diffusion-Weighted MR Imaging of Intracerebral Hemorrhage Korean J Radiol. 2001 Oct-Dec; 2(4): 183–191.
13. 13. K. Kallenberg W.J. Schulz-SchaefferU. Jastrow S. Poser, B. Meissner H.J. Tschampa, I. Zerr and M. Knauth Creutzfeldt-Jakob Disease: Comparative Analysis of MR Imaging Sequences AJNR August 2006 27: 1459-1462.
14. 14. Förster A, Nölte I, Wenz H, Al-Zghloul M, Kerl HU, Brockmann C, Brockmann MA, Groden C Value of diffusion-weighted imaging in central pontine and extrapontine myelinolysis. Neuroradiology 2013 Jan;55(1):49-56.
15. MRI of the brain and spine, 4th edition, Volume I, 2009, Scott W atlas, Lippincott, chapter 10; page.no.433
16. Gaddamanugu S, Shafaat O, Sotoudeh H, Sarrami AH, Rezaei A, Saadatpour Z, Singhal A. Clinical applications of diffusion-weighted sequence in brain imaging: beyond stroke. Neuroradiology. 2022 Jan;64(1):15-30. doi: 10.1007/s00234-021-02819-3. Epub 2021 Oct 1. PMID: 34596716; PMCID: PMC8484843.