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A DIAGNOSTIC COMPARISON OF DIFFUSION WEIGHTED IMAGING AND FLUID ATTENUATION INVERSION RECOVERY FOR BRAIN LESIONS

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ABSTRACT

Background: *Fluid Attenuated Inversion Recovery (FLAIR) and Diffusion Weighted Imaging are essential MRI sequences used for detection and identification of brain lesions. FLAIR is effective for visualizing lesions near CSF, while DWI is good in identifying acute ischemic stroke. This study will compare their diagnostic accuracy to know the most reliable sequence for lesion identification.*

Objective: *The objective of this study is to compare the accuracy of DWI and FLAIR imaging in detection of brain lesions, to assess the sensitivity, and specificity of DWI and FLAIR in overall brain lesion detection and to calculate sensitivity of DWI and FLAIR for each type of brain lesion within the studied population.*

Method: *The data was collected from Allied Hospital, Faisalabad. 106 patients' data of age group 20 years and above and having any of the five types of brain lesions who underwent MRI brain with DWI and FLAIR was collected by using a close-ended self-modified questionnaire. Chi square, correlation, Cohn's Kappa, sensitivity, specificity, positive predictive value and negative predictive value was also calculated between DWI and FLAIR techniques. Sensitivity and specificity of DWI and FLAIR for each type of brain lesions was also calculated.*

Results: *The most common brain lesions detected by DWI and FLAIR was brain tumor (22.64%) and multiple sclerosis (18.86%) respectively. The most common site in which DWI and FLAIR detected most of the lesions is temporal and frontal lobe respectively. Sensitivity, specificity, positive predictive value and negative predictive value of DWI and FLAIR for overall detection of brain lesion are 83.33%, 100%, 100%, 38.46% and 56.52%, 28.57%,83.87%, and 9.09% respectively. The sensitivity of DWI and FLAIR for each type of brain lesion included in this study was also calculated separately. The result of chi square test, correlation and Cohn's Kappa was 0.002, 1, and 1.0 respectively which shows significant results, perfect correlation and agreement respectively between DWI and FLAIR protocols.*

Conclusion: *DWI is more accurate protocol for overall detection of brain lesions. DWI showed more accurate results for detection of ischemic stroke, brain tumors and brain abscess than FLAIR. DWI and FLAIR showed equal sensitivity for hematoma. FLAIR is detected as accurate protocol for detection of multiple sclerosis.*

Keywords*: Diffusion weighted imaging, Fluid attenuation inversion recovery, MRI brain, Brain lesions.*

INTRODUCTION

The impact of brain lesions relates to the area of brain according to their location. Generally, the area of brain where a lesion is present will not work as it normally would. The symptoms of brain lesions can be constant or intermittent and can be sudden or gradual. When it comes to the timing of symptoms, every type of brain lesion has an indicative pattern (1). As brain lesions can be caused by various pathological alterations, different types of brain lesions tend to manifest with different characteristics on different imaging modalities (2). Substantial focal neurological deficits (such as Weakness of arm, legs and face on one side) along with head pain may cause by brain lesion. Behavioral defects, cognitive defects, fatigue, and dizziness with one or many focal neurological defects may be cause by multiple brain lesions (3).

The unique and sophisticated MRI method known as Diffusion weighted MRI sequence relies on the haphazard migration of water molecules throughout and between the extracellular and intracellular regions. In diffusion weighted images, the molecular mobility of water determines the image contrast. The depiction of mass lesion, details on the mass's location, homogeneity, and signal strength, the existence of perilesional edema, and the extent of contrast enhancement are all provided by conventional MRI, but Diffusion-weighted sequencing is necessary for evaluation of cellularity, architecture, tumor grade, aggressiveness, and histological criteria in brain stroke and hematoma staging, as these factors cannot be assessed by conventional MRI (4). Moreover, Fluid attenuation inversion recovery is employed to assess the degree of white matter hyperintensities and rule out subacute AIS and stroke mimics (5). Quick treatment decisions are made possible by brief imaging baseline methods, as time is of the essence when managing AIS (6). Attempts have been attempted to replace FLAIR with tha T2-weighted echo planar imaging sequence prior to the introduction of diffusion gradients (b = 0 sec/mm2; henceforth referred to as b0) in order to get around these restrictions (7). The DWI-FLAIRS mismatch rating is a well-established method for patient classification when the duration since stroke start is unclear. A DWI lesion that is apparent and does not show comparable parenchymal hyperintensity on FLAIR indicates that the time from initiation was less than 4.5 hours, suggesting that intravenous thrombolysis may be beneficial. In these situations, deep learning may be able to supplement human rating and assist in decision making by increasing the mismatch concept's availability and accuracy (8). DWI is a foundation of current attractive reverberation imaging (MRI), especially in neuroimaging and oncology. Its quick mechanical progressions have widened its applications, making it a dynamic and growing field (9). Integrating DWI into standard bosom MR imaging conventions might further develop responsiveness, making it an important instrument for bosom malignant growth discovery and portrayal. This conversation accentuates enhancing procedures and clinical uses of DWI in bosom imaging (10). The so called DWI-FLAIR mismatch, which occurs when a hyperintense lesion on diffusion weighted imaging (DWI) and the lack of a corresponding lesion on T2-weighted fluid attenuated inversion recover (FLAIR) imaging are combined to predict a time from stroke onset of less than 4.5 hours in patients with acute ischemic stroke (11).

Material and Methods

A study was performed on total 106 patients (60 male and 46 females) suspected to have brain lesions. Out of 106 patients 53 patients (31 males and 22 females) underwent Diffusion weighted Imaging MRI and 53 patients (29 males and 24 females) underwent Fluid Attenuation Inversion Recovery MRI. Age of patients were 20 years and above that was included in the study, and age of patients were categorized into five age groups that is 20-29 years, 30-39 years, 40-49 years, 50-59 years, 60 and above. A cross sectional study was performed on patients that were having brain lesions from one of the any mentioned type of brain lesions such as ischemic stroke, brain abscess, hematoma, multiple sclerosis, and brain tumors in Allied Hospital, Faisalabad on 1.5T Magnetic resonance imaging machine in the duration of eight months. Patients that were claustrophobic or patients that were having brain lesions other than ischemic stroke, brain abscess, hematoma, multiple sclerosis, and brain tumors were excluded from this study. Independent variable of this study was imaging techniques that were used for detection of brain lesions. Imaging techniques that were used in this study was Diffusion weighted imaging MRI and Fluid

attenuation inversion recovery MRI. Dependent variable of this study was accuracy of lesion detection in the brain by Diffusion weighted imaging MRI and Fluid attenuation inversion recovery MRI.
A close ended self-modified questionnaire was used for the collection of data and data was analysed by using SPSS version 23. Data was analysed by applying Chi square test between DWI and FLAIR. Correlation was also calculated between DWI and FLAIR protocols. Sensitivity, specificity, positive predictive value, and negative predictive value was also calculated of DWI and FLAIR MRI protocols for overall brain lesions detection. Sensitivity of DWI and FLAIR protocols was also separately calculated for each type of brain lesion included in the study. Inter-rater agreement was calculated between DWI and FLAIR protocols. Various frequency charts and table of age, gender, location of lesion, type of lesion are also constructed by using SPSS version 23.

Results:
Total 106 patients who are suspected to have neurological disorders, 60 (56.6%) males and 46 (43.4%) were female which is shown in Table 1.

Table no. 1 Gender of participants

Gender of patient

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	60	56.6	56.2	56.2
	Female	46	43.4	43.8	100.0
	Total	106	100.0	100.0	
Total		106	100.0		

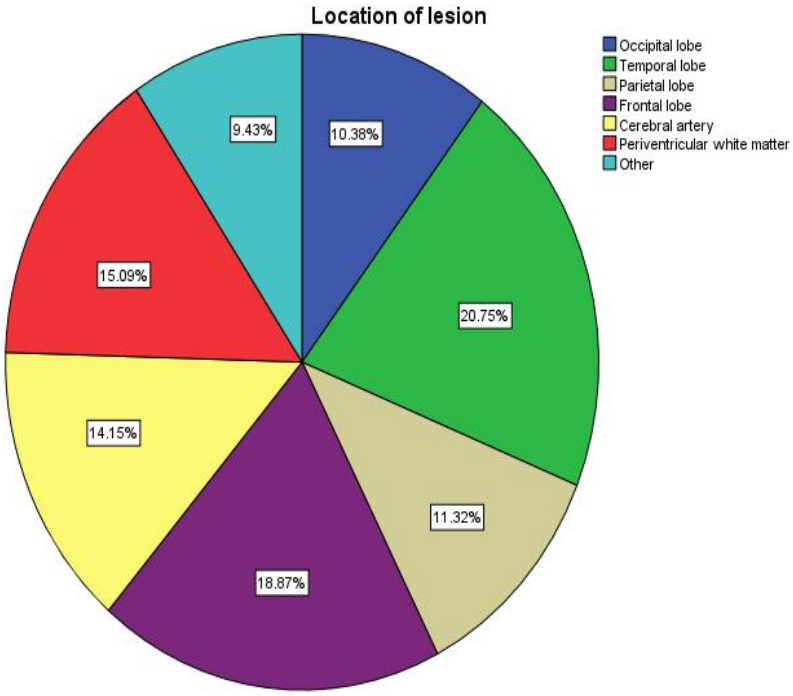
Patients were categorized into five age groups; patients from 20-29 (11.3%), 30-39 (21.7%), 40-49% (22.6%), 50-59 (27.4%), and 60 and above (17%). Among these age groups most brain lesions were detected in age group 50-59 that is 27%. Age distribution of participants are shown in Table 2.

Table no. 2 Age of participants

Age of patient

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	20-29	12	11.3	11.3	11.3
	30-39	23	21.7	21.7	33.0
	40-49	24	22.6	22.6	55.7
	50-59	29	27.4	27.4	83.0
	60 and above	18	17.0	17.0	100.0
	Total	106	100.0	100.0	

In sample size of 106 patients, total brain lesions were detected in following 7 regions. Most of the lesions out of 106 were detected in temporal lobe that is 22 (20.8%). Lesion detection on the basis of location are shown in Pie chart 1.



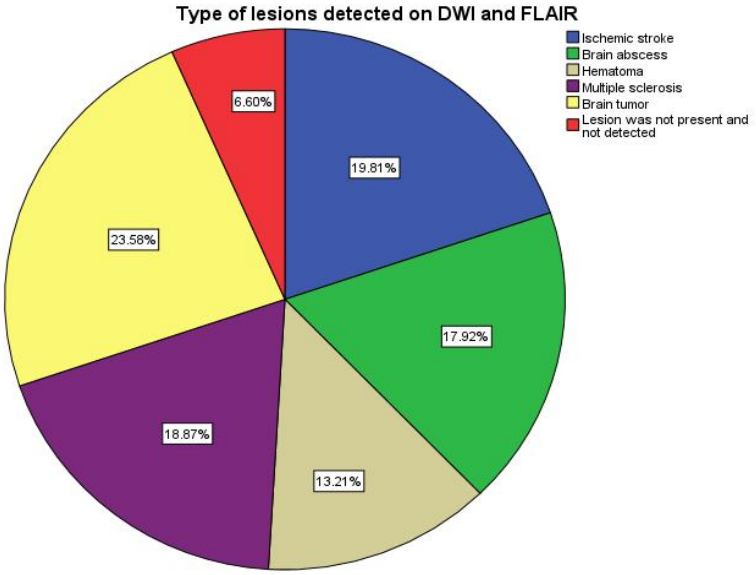
Pie chart 1 Location of Brain Lesions

DWI detected most of the lesions in frontal lobe, while FLAIR detected most lesions in temporal lobe. Location of lesions detection by DWI and FLAIR separately are shown in Table no 3.

Table no. 3 Location of Lesions by DWI and FLAIR

		Location of lesion							Total
		Occipital lobe	Temporal lobe	Parietal lobe	Frontal lobe	Cerebral artery	Periventricular white matter	Other	
DWI or FLAIR	DWI	6	10	9	11	4	8	5	53
	FLAIR	5	12	3	9	11	8	5	53
Total		11	22	12	20	15	16	10	106

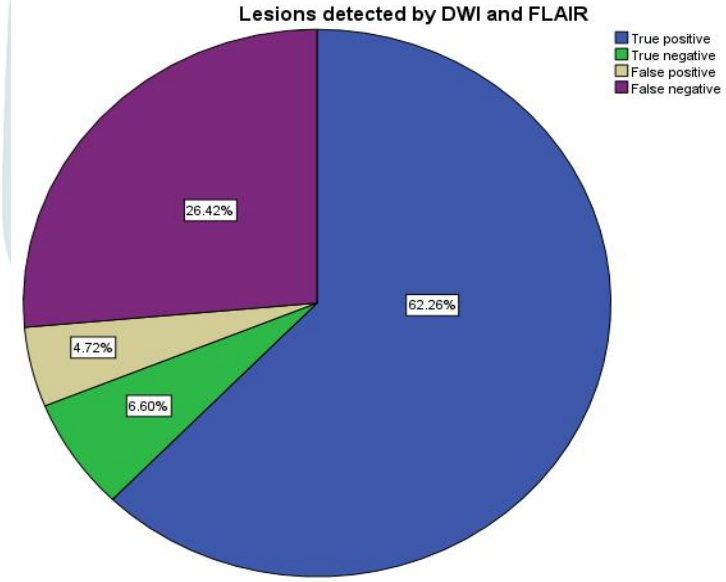
Five types of brain lesions were included in the study. Lesion detection by DWI and FLAIR are shown in Pie chart 2.



Pie chart 2. Types of lesions

According to the results, among these DWI detected more lesions than FLAIR MRI. DWI detected more lesions of ischemic stroke, brain abscess, brain tumors and lesions caused by hematoma. While FLAIR gives the best results for the detection of lesions caused by multiple sclerosis.

Total number of true positive, true negative, false positive and false negative cases detected by DWI and FLAIR are as follow in Pie chart 3.



Pie chart 3. TP, TN, FP and FN cases

Out of 106 sample size, DWI detected most of the true positive case that is 40 while FLAIR detected only 26 true positive cases. While DWI detected 5 true negative cases and FLAIR detected only two true negative cases. Detail of lesion detection by DWI and FLAIR separately are shown in Table 4.

Table No. 4 TP, TN, FP, FN cases by DWI and FLAIR separately.

		DWI or FLAIR		
		DWI	FLAIR	Total
Lesions detected by DWI and FLAIR	True positive	40	26	66
	True negative	5	2	7
	False positive	0	5	5
	False negative	8	20	28
Total		53	53	106

According to these cases the sensitivity and specificity of DWI and FLAIR were calculated for detection of brain lesion. Sensitivity and specificity of DWI for brain lesions was 83.33% and 100% respectively, while the sensitivity and specificity or FLAIR for the detection of brain lesions was 56.52% and 28.57% respectively.

Sensitivity and specificity of DWI and FLAIR for each type of brain lesion included in this study are mentioned in the following Table no. 5.

Table no. 5 Sesitivity of DWI and FLAIR for each category of lesions

Name of lesion	DWI	FLAIR
	Sensitivity	Sensitivity
Ischemic stroke	100%	25%
Brain abscess	100%	42%
Hematoma	100%	100%
Multiple sclerosis	33%	90%
Brain tumor	85%	45%

Positive predictive value and negative predictive value for DWI and FLAIR was also calculated for detection of brain lesions. PPV of DWI was 100% while the NPV of DWI was 38.46%. PPV and NPV of FLAIR was 83.87% and 9.09% respectively.

Chi square test was applied between DWI and FLAIR for detection of lesion as true positive, true negative, false positive, and false negative. The results of Chi square test is shown in Table no. 6.

DWI or FLAIR * Lesions detected by DWI and FLAIR Crosstabulation

Count

		Lesions detected by DWI and FLAIR				
		True positive	True negative	False positive	False negative	Total
DWI or FLAIR	DWI	40	5	0	8	53
	FLAIR	26	2	5	20	53
Total		66	7	5	28	106

Table no. 6 Chi square results

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	14.398[a]	3	.002
Likelihood Ratio	16.565	3	<.001
Linear-by-Linear Association	10.021	1	.002
N of Valid Cases	106		

a. 4 cells (50.0%) have expected count less than 5. The minimum expected count is 2.50.

According to results, ci square test shows significant results between DWI and FLAIR that is 0.002 which is less than 0.5

Correlation between DWI and FLAIR was also calculated by keeping alpha at 0.01. The results shows perfect correlation between lesions detected by DWI and FLAIR that is 1 as shown in Table 7.

Table No. 7 Correlation between DWI and FLAIR

Correlations

		DWI or FLAIR	Lesions detected by DWI and FLAIR
DWI or FLAIR	Pearson Correlation	1	.309**
	Sig. (2-tailed)		.001
	N	106	106
Lesions detected by DWI and FLAIR	Pearson Correlation	.309**	1
	Sig. (2-tailed)	.001	
	N	106	106

**. Correlation is significant at the 0.01 level (2-tailed).

Cohen's Kappa was also calculated between DWI and FLAIR. The calculated value of Cohen's Kappa is 1.0 which shows perfect agreement between DWI and FLAIR protocols.

Discussion

In this study 106 patients were included. Among which 53 patients underwent DWI MRI and 53 patients underwent FLAIR MRI. Study provides the results that DWI MRI is much better in detecting Brain lesions as compared to FLAIR imaging. These results of our study are compliance with the study of Mahamdhusen Makada and his colleagues who conducted study in 2023. They took 100 patients who underwent conventional MRI and DWI MRI. The results of their study was that DWI MRI provides beneficient results in characterization of of intracranial lesions and fascilitates FLAIR and T2-weighted imaging (4).

Out of 106 patients, 18.87% lesions were of multiple sclerosis that is detected by DWI and FLAIR. The sensitivity of FLAIR and DWI for detection of Multiple Sclerosis is 90% and 33% respectively, which shows that FLAIR is more suitable protocol for detection of brain lesions caused by Multiple Sclerosis. This result of our study is much compatible with the study of Nafisi-Moghadam and his colleagues who

did comparison of Diffusion Weighted Imaging and Fluid Attenuation Inversion Recovery for detection of Multiple Sclerosis plaque. They took 40 patients and the results of their study was that FLAIR picked up 127 MS plaques while DWI picked up only 68 MS plaques (12).

In our results sensitivity of DWI in detection of ischemic stroke in early stages is 100%. The study of D.M Vishali and his colleagues who conducted cross sectional study of 50 patients who were suspecting intracranial lesions also suggests that DWI is most sensitive protocol in rapid detection of ischemic stroke and in differentiating stroke from acute infarcts (13).

Ravi Ningappa conducted study in 2016 to investigate the role of ADC values and DWI for evaluating different malignant and benign brain tumors. They concluded that ADC and DWI can give better results to detect brain mass lesions. The results of our study that is DWI showed 85% sensitivity for brain tumor lesions corresponds with their results (14).

Tokunori Kimmura and his colleagues concluded that diffusion weighted imaging with T2 water suppression technique is better than those with FLAIR for solving CSF partial volume effect problems. Our study have correspondence with their study and also suggest that DWI is better in detection of brain lesions than FLAIR (15).

Conclusion

The conclusion of this study is that DWI is more accurate protocol for overall detection of brain lesions. DWI showed more accurate results for detection of ischemic stroke, brain tumors and brain abscess than FLAIR. DWI and FLAIR showed equal sensitivity for hematoma. FLAIR is detected as accurate protocol for detection of multiple sclerosis.

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