The Role of New MRI Modalities in Diagnosis of Multiple Sclerosis

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The Role of New MRI Modalities in Diagnosis of Multiple Sclerosis

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Abstract

Background: Although clinical data are still used to suspect multiple sclerosis (MS), MRI is now included in the disease's clinical prognosis.
Aim: To evaluate the clinical importance of recent MRI techniques in MS.
Patients and methods: This study was conducted on 20 patients of both sexes having MS. All patients were evaluated by full history taking, clinical assessment, and MRI examination including recent MRI modalities; double inversion recovery (DIR); spectroscopy; fluid-attenuated inversion recovery (FLAIR) in axial, sagittal, and coronal planes; and diffusion tensor imaging.
Results: We found that DIR and T2-weighted turbo spin echo (T2W-TSE) differed significantly from FLAIR and T2W-TSE regarding white matter (WM)-gray matter (GM). DIR and FLAIR differed significantly from DIR and T2W-TSE regarding WM-cerebrospinal fluid (CSF). DIR and FLAIR differed significantly from DIR and T2W-TSE regarding GM-CSF. Moreover, FLAIR differed significantly T2W-TSE regarding lesion-WM. DIR and FLAIR, DIR and T2W-TSE, and FLAIR and T2W-TSE differed significantly regarding lesion-CSF.
Conclusion: We can conclude that DIR can add a powerful diagnostic value or act as another option for standardized T2W and FLAIR. Therefore, we intensely recommended adding DIR imaging to imaging protocol of MS.

Keywords: Double inversion recovery, MRI, Multiple sclerosis

1. Introduction

Multiple sclerosis (MS) is considered as demyelinating and degenerative disorders of neurological tissues and is the leading etiology of nontraumatic impairment in children and adults.[1]

Although clinical symptoms are still used to diagnose MS, MRI is recently involved during MS diagnosis owing to its remarkable sensitivity in displaying the spread of demyelinating abnormalities in the neurological system.[2]

The limitations of conventional MRI include low pathogenic specificity and sensitivity to diffuse destruction in normal-appearing white matter (NAWM) and gray matter (NAGM). Furthermore, conventional MRI reveals only a few relationships with clinical state.[3]

Diffusion-weighted MRI is a quantitative approach that can overcome these challenges by delivering highly specific signal lesions and highly sensitive to the entire degree of hidden damaged tissues in patients with MS.[4]

Recently, double inversion recovery (DIR) imaging has gained popularity as an imaging technique in MS.[5] It is primarily thought of as a technique for detecting GM lesions, for which it is very effective, but it has also been effectively used to analyze other lesion sites.[6]

We aimed to assess the role of the recent MRI techniques in MS discussing their pathophysiology and emphasizing their clinical importance.

2. Patients and methods

This prospective study was carried out at the Radiology Department with assistance of the Neurology Department of Al-Azhar University Hospitals between January 2019 and June 2020. The study was approved by Al-Azhar University's Ethics Board, and all participants provided informed written consent. This study was conducted on 20

patients of both sexes having MS. Claustrophobic patients and patients with MS with another brain parenchymal pathology were excluded.

All patients were evaluated by full history taking, clinical assessment, and MRI examination including recent MRI modalities; DIR; spectroscopy; fluid-attenuated inversion recovery (FLAIR) in axial, sagittal, and coronal planes; and diffusion tensor imaging.

MRI was done using a 1.5 T (Philips, Achieva, USA). All the diffusion-weighted images were transferred to workstation supplied by the manufacturer (Achieva R2.5 workstation; Philips). Images were postprocessed using the Philips software devised for tractography. The maps used were FA 2D gray maps, directionally encoded color FA maps, and fused FLAIR/DTI maps.

2.1. Statistical analysis

The data were analyzed using Statistical Package for the Social Sciences (SPSS Statistics for Windows, Version 21.0.; IBM Corp., Armonk, New York, USA). The mean and SD were used to describe the parametric numerical data. The frequency and percentage were used to describe the nonnumerical data. The following tests were used: Student t test, Mann−Whitney U test, χ^2 test, and McNemar's test. P value less than 0.05 was considered significant.

3. Results

A total of 20 patients with MS were included in this study. Their mean age was 43.15 ± 9.52 years (range, 32−53 years). The majority of the patients were females (60%). Regarding MS characteristics, the mean disease duration was 5.43 ± 2.17 years. The mean EDSS was 2.51 ± 1.63. Regarding the type of MS, most of them (90%) were relapsing remitting, 5% primary remitting, and 5% secondary remitting (Table 1).

Regarding the mean lesion load measurement by DIR, FLAIR, and T2-weighted turbo spin echo

Table 1. Distribution of patients regarding multiple sclerosis characteristics.

		Cases ($N = 20$)
Disease duration (years)	Mean ± SD	5.43 ± 2.17
	Range	0−31.2
Expanded Disability Status Scale	Mean ± SD	2.51 ± 1.63
	Range	0−6.0
Type of MS [n (%)]	Relapsing-remitting	18 (90)
	Primary progression	1 (5)
	Secondary progression	1 (5)

MS, multiple sclerosis.

(T2W-TSE) sequences, DIR differed significantly from FLAIR regarding infratentorial. Moreover, DIR differed significantly from T2W-TSE regarding periventricular. DIR and FLAIR differed significantly from FLAIR and T2W-TSE regarding deep WM. DIR and T2W-TSE differed significantly from FLAIR and T2W-TSE regarding deep GM and mixed WM-GM. There was a highly significant difference between DIR and T2W-TSE and FLAIR and T2W-TSE regarding juxtacortical and intracortical (Table 2).

Regarding mean contrast ratios, there was a highly significant difference between DIR and FLAIR, DIR and T2W-TSE, and FLAIR and T2W-TSE regarding lesion-WM. DIR and T2W-TSE differed significantly from FLAIR and T2W-TSE regarding lesion-GM (Table 3).

Regarding mean contrast-to-noise ratios, there was a significance between DIR and T2W-TSE and between FLAIR and T2W-TSE regarding WM-GM. There was a significance between DIR and FLAIR and between DIR and T2W-TSE regarding WM-cerebrospinal fluid (CSF). There was a significance between DIR and FLAIR and between DIR and T2W-TSE regarding GM-CSF. There was a significance between FLAIR and T2W-TSE regarding lesion-WM. There was a significance between DIR and FLAIR, DIR and T2W-TSE, and FLAIR and T2W-TSE regarding lesion-CSF (Table 4 and Figs. 1 and 2).

4. Discussion

MS is a common chronically inflammation demyelinating condition of the neurological system. The diagnosing and monitoring of the MS-plaques is principally established on MRI, which permits establishment of an earlier MS-diagnosing during diagnosing criteria. Moreover, MRI has a considerable predictive value in cases with clinical isolated syndrome suggesting MS and predicting brain atrophy. MS diagnosis by MRI is accomplished as a multisequence protocol involving T2-weighted, fluid-attenuating inversing recovery (FLAIR), and precontrast and postcontrast T1-weighting sequences.[7]

The current study showed that regarding the mean lesions load measurement by DIR, FLAIR, and T2W-TSE sequences, DIR differed significantly from FLAIR regarding infratentorial. Moreover, DIR differed significantly from T2W-TSE regarding periventricular. DIR and FLAIR differed significantly from FLAIR and T2W-TSE regarding deep WM. DIR and T2W-TSE differed significantly from FLAIR and T2W-TSE regarding deep GM and

Table 2. Lesion load measurement by double inversion recovery, fluid-attenuated inversion recovery, and T2-weighted turbo spin echo sequences.

Region	DIR	FLAIR	T2W-TSE	P value		
				P1	P2	P3
Infratentorial	12.52 ± 7.37	8.23 ± 3.45	8.56 ± 4.32	0.023*	0.045*	0.791
Periventricular	14.33 ± 11.44	14.12 ± 11.26	8.92 ± 3.15	0.953	0.048*	0.053
Deep WM	16.47 ± 10.51	35.65 ± 17.73	11.54 ± 7.39	<0.001*	0.094	<0.001*
Deep GM	6.81 ± 3.11	6.53 ± 3.02	4.15 ± 2.27	0.774	0.004*	0.008*
Mixed WM-GM	16.24 ± 13.66	12.82 ± 10.32	5.71 ± 3.11	0.377	0.002*	0.005*
Juxtacortical	14.23 ± 8.16	15.17 ± 8.62	32.81 ± 16.69	0.725	<0.001*	<0.001*
Intracortical	4.24 ± 2.13	3.48 ± 2.68	1.13 ± 0.73	0.327	<0.001*	<0.001*

DIR, double inversion recovery; FLAIR, fluid-attenuated inversion recovery; GM, gray matter; T2W-TSE, T2-weighted turbo spin echo; WM, white matter.
P1 = comparison between DIR and FLAIR.
P2 = comparison between DIR and T2W-TSE.
P3 = comparison between FLAIR and T2W-TSE.
* is mean the significant differences result between sequences.

Table 3. Mean contrast ratios compared between double inversion recovery, fluid-attenuated inversion recovery, and T2-weighted turbo spin echo imaging.

Region	DIR	FLAIR	T2W-TSE	P value		
				P1	P2	P3
Lesion-WM	11.27 ± 2.61	1.16 ± 0.45	0.71 ± 0.27	<0.001*	<0.001*	<0.001*
Lesion-GM	0.73 ± 0.31	0.57 ± 0.25	0.17 ± 0.09	0.080	<0.001*	<0.001*

DIR, double inversion recovery; FLAIR, fluid-attenuated inversion recovery; GM, gray matter; T2W-TSE, T2-weighted turbo spin echo; WM, white matter.
P1 = comparison between DIR and FLAIR.
P2 = comparison between DIR and T2W-TSE.
P3 = comparison between FLAIR and T2W-TSE.
* is mean the significant differences result between sequences.

Table 4. Mean contrast-to-noise ratios compared between double inversion recovery, fluid-attenuated inversion recovery, and T2-weighted turbo spin echo MRI.

Region	DIR	FLAIR	T2W-TSE	P value		
				P1	P2	P3
WM-GM	21.61 ± 6.12	18.51 ± 5.28	26.19 ± 7.71	0.095	0.044*	<0.001*
WM-CSF	0.82 ± 0.51	21.82 ± 6.12	32.71 ± 11.36	<0.001*	0.048*	0.053
GM-CSF	20.13 ± 6.12	35.51 ± 11.56	8.36 ± 4.69	<0.001*	<0.001*	0.445
Lesion-WM	34.14 ± 11.17	28.42 ± 8.63	41.73 ± 13.44	0.077	0.059	<0.001*
Lesion-GM	14.31 ± 5.26	14.55 ± 5.71	18.11 ± 7.25	0.89	0.065	0.093
Lesion-CSF	32.52 ± 7.14	47.85 ± 9.71	11.55 ± 5.39	<0.001*	<0.001*	<0.001*

CSF, cerebrospinal fluid; DIR, double inversion recovery; FLAIR, fluid-attenuated inversion recovery; GM, gray matter; T2W-TSE, T2-weighted turbo spin echo; WM, white matter.
P1 = comparison between DIR and FLAIR.
P2 = comparison between DIR and T2W-TSE.
P3 = comparison between FLAIR and T2W-TSE.
* is mean the significant differences result between sequences.

mixed WM-GM. Za DIR and T2W-TSE differed significantly from FLAIR and T2W-TSE regarding juxtacortical and intracortical.

Our results were supported by a study by Ghonim et al.,[8] as they reported that regarding overall lesion loads, DIR differed significantly from T2WI (P = 0.003 which gained 22%).

Other studies reported that DIR found more number of MS lesions than FLAIR and T2W-TSE with significant difference.[9,10]

In this study, there was a significance between DIR and FLAIR, DIR and T2W-TSE, and FLAIR and T2W-TSE regarding Lesion-WM. There was a significance among between DIR and T2W-TSE and between FLAIR and T2W-TSE regarding lesion-GM.

Our results showed that regarding mean contrast-to-noise ratios, there was a significance between DIR and T2W-TSE and between FLAIR and T2W-TSE regarding WM-GM. There was a significance
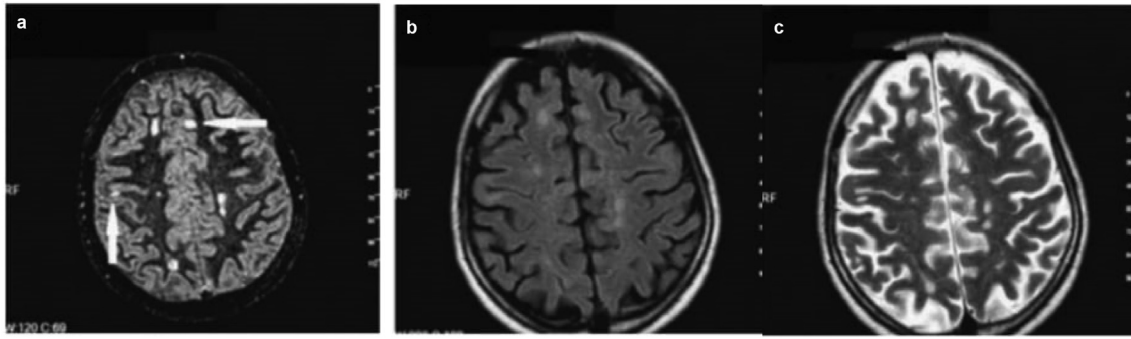
Fig. 1. *Cortical lesion are more prominent in DIR image (a) than FLAIR image (b) and T2-weighted image (c). DIR, double inversion recovery; FLAIR, fluid-attenuated inversion recovery.*
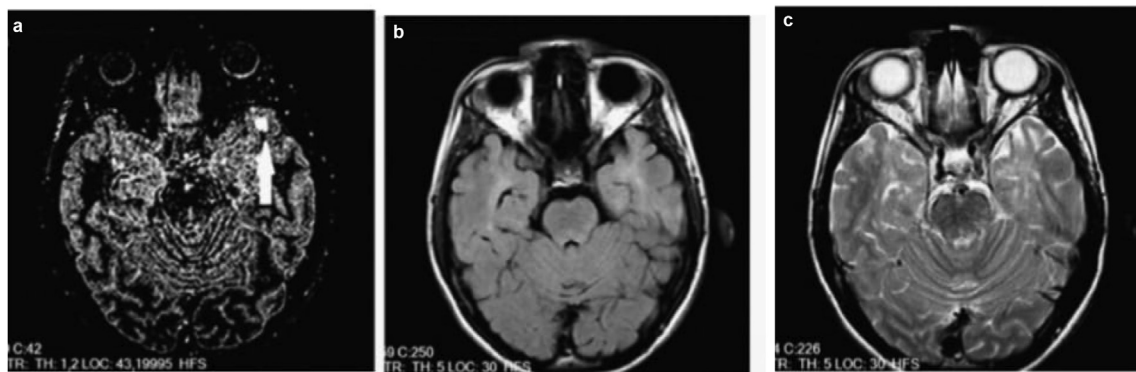

Fig. 2. *A lesion mixed in white matter-gray matter location is seen in DIR image (a) but cannot be seen in FLAIR image (b) or T2-weighted image (c). DIR, double inversion recovery; FLAIR, fluid-attenuated inversion recovery.*

between DIR and FLAIR and between DIR and T2W-TSE regarding WM-CSF. There was a significance between DIR and FLAIR and between DIR and T2W-TSE regarding GM-CSF. There was a significance between FLAIR and T2W-TSE regarding lesion-WM. There was a significance between DIR and FLAIR, between DIR and T2W-TSE, and between FLAIR and T2W-TSE regarding lesion-CSF.

Our results were supported by a study by Almutairi et al.,[11] as they reported that DIR had the greatest contrast ratio in infratentorial, which was substantially greater than other techniques ($P = 0.01$), followed by T2WI, which differed significantly from FLAIR. The largest contrast ratio difference was seen in the supratentorial region, which included juxtacortical, subcortical, and periventricular regions ($P = 0.001$). DIR had the greatest contrast ratio in these three locations, whereas T2WI was substantially larger than FLAIR. FLAIR had a substantially greater contrast ratio between CSF and lesions ($P = 0.001$), whereas DIR had a significantly greater contrast ratio than T2WI. Lesions differed significantly from NAGM were observed ($P < 0.001$) by DIR and T2WI without significant difference among them but differed significantly from FLAIR. They found that the highest contrast ratio among lesion and NAGM and NAWM ($P < 0.001$) was for DIR. Moreover, T2WI differed significantly from FLAIR.

In addition, Ghonim et al.[8] reported that DIR was significantly higher than FLAIR regarding lesions numbers diagnosed in three anatomic areas (mixed W-GM, cortically, and infratentorial) with relative gaining 28, 85, and 63%, respectively.

The study by Hamed et al.[12] discovered that signal among lesion and NAWM was considerably greater in DIR comparing with T2 and FLAIR in several anatomical regions (IT, PVWM, DWM, and JC) ($P = 0.001$). The contrast among lesion and CSF was considerably stronger in DIR compared with T2 ($P = 0.001$) but not statistically significant in FLAIR ($P = 0.071$). When compared with FLAIR and T2, DIR indicated somewhat better contrast between lesions and NAGM; nevertheless, these findings were still without significance ($P = 0.169$ and 0.221, respectively).

5. Conclusion

DIR can add a powerful diagnostic value or act as another option for standardized T2W and FLAIR. Therefore, we intensely recommended adding DIR imaging to imaging protocol of MS.

Conflict of interest

None declared.

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