



Magnetic Resonance Imaging (MRI) Double Inversion Recovery Sequence in Diagnosis of Multiple Sclerosis

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Authors' contributions

This work was carried out in collaboration among all authors. Author ASG designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Authors RLY and MAM managed the analyses of the study. Author MFD managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Aims: The current work aimed to assess the diagnostic value of Magnetic Resonance Imaging (MRI) Double Inversion Recovery (DIR) sequence in diagnosing of multiple sclerosis.

Methodology: This study conducted on (42 patients) from the Diagnostic Radiology and Medical Imaging Dep. at Tanta University Hospital in the period from March 2018 to December 2019.

Results: In accordance to the total lesions loads, it was found that DIR was higher significantly than T2WI (P-value= 0.003 with a relative gaining of 22%), we found that double inversion recovery (DIR) sequence was higher significantly to FLAIR regarding the number of diagnosed lesions in 3 anatomical areas (Mixed W-GM, cortical and infra-tentorial) with relative gaining of 28%, 85% and 63% respectively. A non-significant change was found among the two sequences regarding periventricular white matter, deep white matter and juxta-cortical lesions detecting.

Conclusion: Conventionally MRI has corner-stone roles in diagnosing, characterizing and

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following-up of multi-sclerosis. Finally, we concluded that DIR can be used as a addition to or even as an alternative for typical T2 and FLAIR. Therefore, we strongly recommend the addition of DIR sequences in the everyday MR protocol of MS cases.

Keywords: Double inversion recovery; conventional; magnetic resonance imaging; multiple sclerosis.

ABBREVIATIONS

CIS : Clinically Isolated Syndromes
CNS : Central Nervous System
DIR : Double Inversion Recovery
DWM : Deep White Matter
FLAIR : Fluid-Attenuated Inversion Recovery
MS : Multiple Sclerosis
PVWM : Periventricular White Matter
TSE : Turbo Spin-Echo

1. INTRODUCTION

Multiple sclerosis (MS) is the very common chronically inflammation demyelinating disease of the central nervous system (CNS), mainly influencing the white matter in addition to parts of the gray matter [1]. The diagnosing and monitoring of the MS-plaques is principally established on MRI, that permits for establishing of an earlier MS-diagnosing during diagnosing criteria [2]. Also, MRI has a considerable predictive value in cases with clinical isolated syndrome (CIS) suggesting of MS regarding the predicting and brain atrophy [3].

MRI in the MS-diagnosing is accomplished as a multi-sequence protocols involving T2-weighted, fluid-attenuating inverting recovery (FLAIR) and pre- and post-contrast T1-weighting sequence [4].

The pulse sequence showed various sensitivities in detecting inflammatory brain lesion dependent on their anatomical site. FLAIR imaging delivers the maximum sensitivities in detecting lesions near the CSF, like the juxta-cortical and the periventricular white matter, but is lesser in sensitivity in the posterior fossa T2-weighted conventional spin-echo or turbo spin-echo (T2 TSE) sequence are found to have higher sensitivity in the detecting infratentorial lesion but have problems in juxta-cortical lesions detection [5].

double inversion recovery pulse sequence (DIR) affords 2 dissimilar pulse versions, that attenuate the CSF in addition to the entire white matter, consequently accomplishing a higher delineating amid gray and white matter that significantly

improve detecting the intra cortical lesion, focal cortical lesion in MS and other neurological situations [6].

2. MATERIALS AND METHODS

This study conducted on (42 patients) admitted to Diagnostics Radiology and Medical Imaging Dep. at Tanta University Hospital, in the period from March 2018 to December 2019 and fulfilling the inclusion and exclusion criteria.

2.1 The Inclusion Criteria

Patients who are suspected clinically to have multiple sclerosis disease (about 34 patients), previous MRI with multiple sclerosis plaques (8 patients) and cases who will decide to participate the current work in accordance to the ethics issues and agreement will be attained from them.

2.2 Exclusion Criteria

Cases in extremely bad overall conditions, cases with contraindication to MRI (cases with a heart pacemaker or cardiac defibrillator, or aneurysm clip in their brain, or have cochlear implant, or have implanted neural stimulator etc.), cases with elevated serum-creatinine and decreased renal functions who cannot bear post gadolinium MRI and cases not able to bear base-line MRI scans or scans not of satisfactory quality to be analyzed (e.g. excessively movements artifacts).

2.3 Methods

Cases experienced the next: explanation of importance of this work, cases should approve their participation in the current work regarding the ethics consideration, complete history-taking, Overall and neurologically examinations of the cases, Conventionally MRI: Axial T1WI, T2WI, FLAIR, Sagittal FLAIR and Axial and sagittal post contrast T1WI and Non- conventionally MRI modes: Double inversion recovery sequence (DIR) and Contrast administration if needed.

2.4 MR Imaging Acquisition

The Imaging process was executed on MRI (Toshiba 1.5 Tesla device) in the Radiology dep

of Tanta University Hospital with typical head coils for brain. T2W-TSE, FLAIR and DIR sequences were accomplished. We put into comparison these 3-sequences in the axial level with similar anatomical location, via parameters comprising field of viewing (FOV), matrix, voxel sizes and slice width.

2.5 Statistical Analysis

The Data analysis was performed via SPSS-21. The data normality was primary examined by one-sample Kolmogorov-Smirnov testing. Qualitative data was introduced in the form of numbers and percentages. Correlation among categorically variables was analyzed using Chi-square testing. Continuous variables were introduced in the form of mean \pm SD (standard deviation) for parametrical data and Median for non-parametrical data. The two groups of the study were matched via Student t testing (parametrical data) and Mann-Whitney testing (non-parametrical data). For all previously stated

statistical tests, the threshold of significance was set at 5% level (p-value).

3. RESULTS

This study was carried out on 42 patients 30 females (71.4%) and 12 males (28.6%) Table 1.

Regarding overall lesion loads, we recorded that DIR was significantly higher than T2WI (P-value= 0.003 with a relative gaining of 22%). See Table 2.

In the Table 3 we found that double inversion recovery (DIR) sequences were significantly higher than FLAIR regarding lesions numbers diagnosed in 3 anatomic areas (Mixed W-GM, cortically and infra-tentorial) with relative gaining 28%, 85% and 63% respectively. But, non-significant change was found among both sequences regarding PVWM, DWM and JC lesion detection.

Table 1. Demographic characters of the investigated cases

Variables	Study group	
	No.	%
Sex		
Male	12	28.6%
Female	30	71.4%
Age/years (Mean \pm SD)		32.05 \pm 6.58

Table 2. Analyzing of the lesions load measuring and relative matching of double inversion recovery (DIR) versus T2WI sequences

Region	T2WI	DIR	P-value	Relative ratio of DIR/T2WI (%)
PVWM	9.5 \pm 3.1 7.6 (0-35)	12.5 \pm 3.8 12 (0-41)	0.039*	35%
DWM	10.8 \pm 3.5 10.0 (0-38)	10.2 \pm 3.8 8 (1.0-34)	0.834	-2%
Mixed W-GM	6.1 \pm 2.6 5.1 (0-20)	9.2 \pm 3 8.1 (0-25)	<0.001**	48%
JC	9.3 \pm 2.1 5.00 (0-25)	9.1 \pm 2.6 6 (0-22)	0.696	-1%
Cortical	0.6 \pm 0.2 0.0 (0-7)	1.5 \pm 0.8 1 (0-9)	0.003*	97%
IT	1.3 \pm 0.3 1.0 (0-9)	1.9 \pm 0.5 2.0 (0-15)	0.025*	45%
Total	35 \pm 9.6 30 (3-107)	42.5 \pm 13.4 55 (6-121)	0.003*	22%

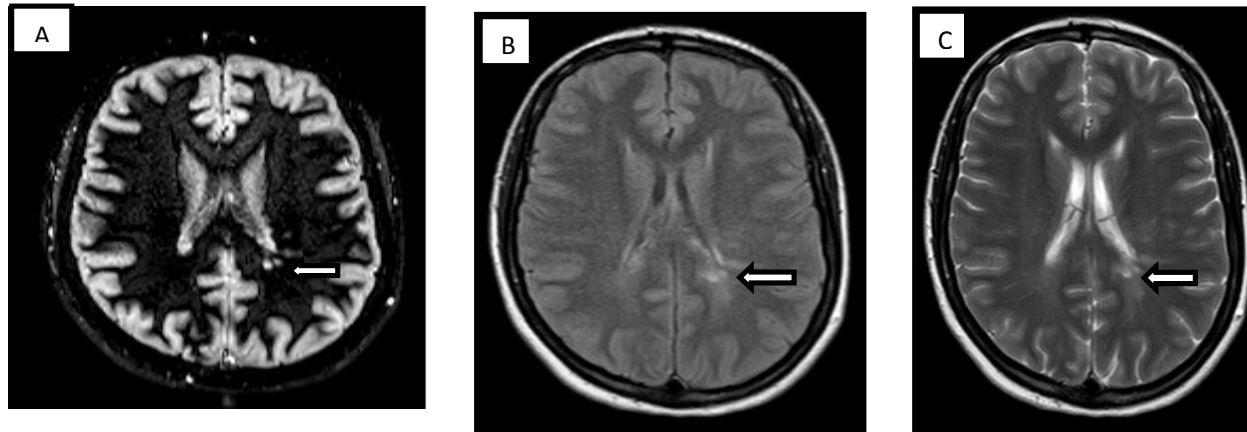


Fig. 1. A female case of 31 years old admitted with blurring of visualization and was diagnosed with relapsing remitting multiple sclerosis (RRMS)
Axial DIR (A) FLAIR (B) and T2WI (C) display multiple left parietal periventricular plaques hyperintense in 3 pulse sequences
Note the better delineation of MS plaques seen in DIR images

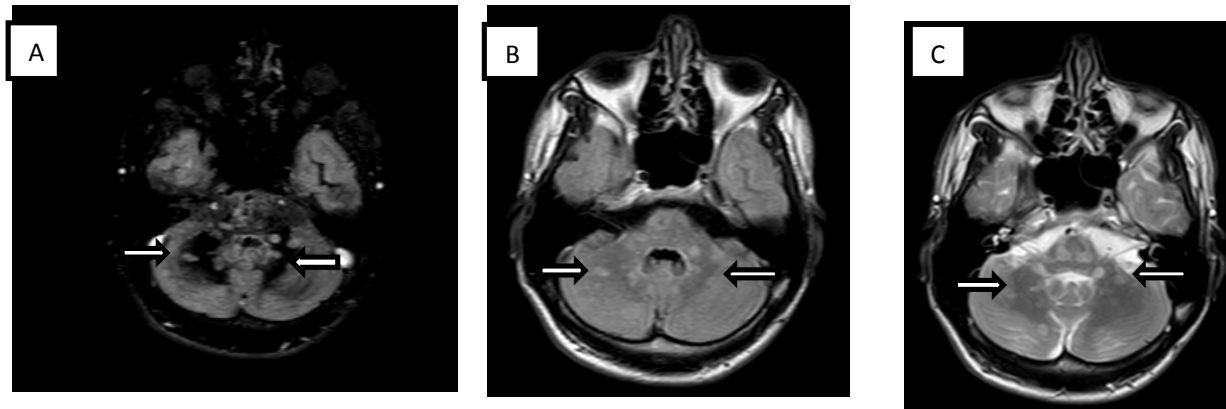


Fig. 2. A female case of 35 years old presented with blurring of vision and ataxia and was diagnosed as having secondary progressive multiple sclerosis (SPMS)

*Axial DIR (A) FLAIR (B) and T2WI (C) display showing multiple plaques seen in both cerebellar hemispheres hyperintense in 3 pulse sequences
Note the better delineation of MS plaques seen in DIR images*

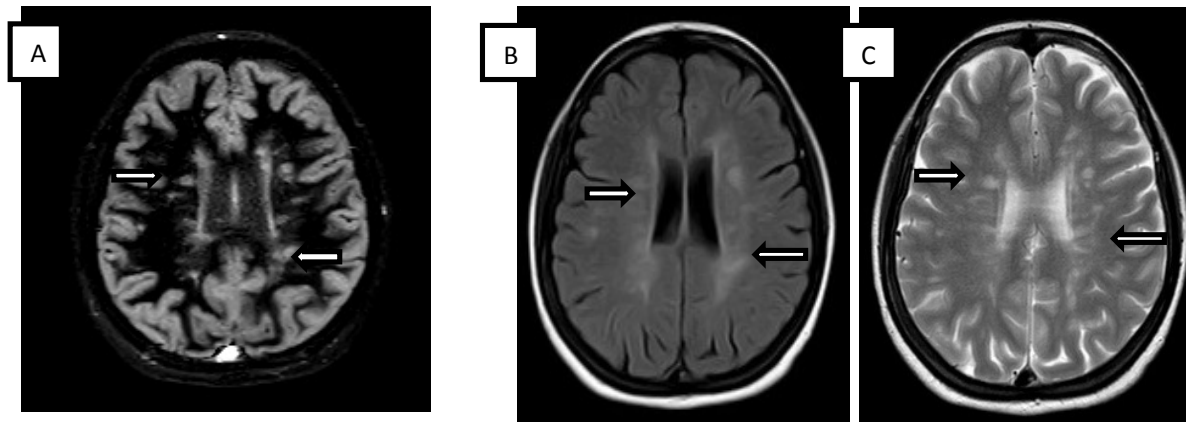


Fig. 3. A female case of 33 years old presented with numbness of lower limbs and ataxia and was diagnosed as having secondary progressive multiple sclerosis (SPMS)

Axial DIR (A) FLAIR (B) and T2WI (C) display showing multiple plaques seen in periventricular region in both cerebellar hemispheres hyperintense in 3 pulse sequences. Note the better delineation of MS plaques seen in DIR images

Table 3. Analyzing of the lesions load measuring and relative comparison of DIR vs. FLAIR sequence

Region	FLAIR	DIR	p-value	Relative ratio of DIR/FLAIR (%)
PVWM	12.3±4.3 8.7 (0-36)	12.7 ± 3.8 10.6 (0-40)	0.930	6%
DWM	10±3.2 9.1 (0-33)	9.9 ± 8.10 8.9(1.0-33)	0.600	-1%
Mixed W-GM	7.1±2.0 6.1(1.0-22)	9.2 ± 3 8.1 (0-25)	0.009*	28%
JC	9.4 ± 2.1 6.0 (0-21)	9.1 ± 2.6 6.0 (0-22)	0.622	-2%
Cortical	0.8±0.2 0 (0-7.0)	1.7±0.8 1 (0-9.0)	0.004*	85%
IT	1.2±0.3 1.0 (0-8.0)	1.9±0.5 2.0 (0-15.0)	0.002*	63%
Total	38.7±12.4 33.5 (4-114)	41.9±13.4 54 (6-121)	0.041*	9%

4. DISCUSSION

Multiple sclerosis (MS) is the greatest chronically inflammation and demyelinating disease of the CNS that was identified by the existence of multifocal inflammation demyelinating signs spread in space and in time Simon et al [7].

MS was typically defined by a white matters disorders Frischer et al. [8], but within the few earlier yrs., an improved consideration was going to involve of gray matters in the patho-physiology of MS Geurts et al. [9].

The acknowledgments of gray matters involvements in MS have going to the combination of cortical/juxta-cortical lesion in the late 2017 reviewed McDonald's diagnosing principles for MS Thompson et al. [10].

The principal aim of the current work was to assess the added values of DIR sequences in comparison to FLAIR and T2W-TSE in detecting the cortical and white matters MS plaques.

We studied 42 cases with a mean aging of 32.05 ± 6.58-yrs.that was nearly the same as of Abidi et al. [11] which was including 50 cases with mean aging of 34.7 ± 6.8-yrs.. The ages were lower in the report of Elnekeidy et al. [12] which involved 15 cases with mean aging of 26 ± 3.2-yrs.

Our results revealed that an increase detecting rates of ICLs by DIR sequences was found. DIR detect significantly more ICLs in comparison to T2W and FLAIR images.

In accordance to our results, Geurts et al. [9] reported higher numbers of ICLs with DIR in comparison to FLAIR and T2WI. Furthermore, Elnekeidy et al. [12] concluded similar result.

In addition to the improved sensitivities to ICLs, we recorded an additional main advantage of DIR imaging that was its superficial potential for improved differentiation among mixed white-grey-matters lesion and juxta-cortical lesions.

This is approved by the observations of a decreased number of juxta-cortical lesions scoring on DIR image in comparison to T2 (P = 0.696 relative losing about 1%) and FLAIR (P = 0.622, relative losing about 2%). It's significant to detect that the maximum number of juxta-cortical lesions was noticed with FLAIR and that the lowermost number was found with DIR with non-significant change among DIR and FLAIR or T2.

In contrast, a significant rise was found in mixed white -grey matters lesions detecting on DIR at the expenses of T2WI (P-value < 0.001 relative gaining about 48%) and FLAIR (P-value = 0.009, relative gaining about 28%).

The satisfactory explaining for these varied detecting ratings in the juxta-cortical lesion and mixed white -grey matters lesion is the sharp definition among grey & white matters on DIR, that was allowing strict differentiating among pure juxta-cortical lesion and lesion touching the cortical zone.

In regard to the juxta-cortical lesions, the present work agrees with the results of Wattjes et al. [13] who concluded that the maximum lesions number were diagnosed with FLAIR with non-significant change among DIR and FLAIR or T2WI. But, the current study results were not agree with the results of Geurts et al. [9] who detected the maximum lesions number with T2WI compared with FLAIR and DIR.

According to mixed white-grey matters lesion, our results were in accordance to Vural et al. [14] who found significantly higher lesions with DIR as compared to T2WI and FLAIR.

Additional advantage of DIR according to our results was its capability of detecting periventricular white matters (PVWM) lesion. DIR detecting significantly higher lesions as compared to T2WI ($P = 0.039$, relative gain about 35%). Not amazingly, DIR detecting lesions with a slightly high change as compared to FLAIR, this change was below the statistically significant (P -value = 0.930, relative gain about 6%).

We reported almost an identical detecting rates regarding deep white matters (DWM) lesion by all sequences, with non-significant change among them. Our findings were in accordance to that of Abidi et al. [11], but, not agree with the findings of Elnekeidy et al. [12] who found higher lesions number by DIR as compared with T2 and FLAIR in whole anatomic sites, Elnekeidy et al. [12] included his investigation on 15 cases only not agree with our results which demonstrated on 42 cases, that might propose the unmatched results.

One more significant benefit of DIR in our results was its capability of detecting infra-tentorial lesion. In the current work, DIR detected significantly greater lesions as compared with FLAIR (P -value = 0.002, relative gain about 63%). However, it was worthier of consideration that DIR detecting greater number of lesions even in comparison to the T2, that was reported as the "gold-standard" in the infra-tentorial area (P -value = 0.025, relative gain about 45%).

The present results were in agreement with that of Abidi et al. [11] and [12]. but not agree with that of Moraal et al. [15] who reported that more detecting with FLAIR in comparison to DIR and clarified that as fractional suppressing of WM lesions (because of the mixture of the two inversion pulses of the 3D-DIR sequences) and

decreased intensities of fractional size influences around lesion.

Based on the previous results of diagnosing accuracies of DIR in various anatomic sites as compared to T2 and FLAIR, we reported that the improved rates of WMLs detecting with FLAIR than DIR doesn't come at the cost of reduced number of WMLs estimated.

5. CONCLUSION

Conventional MRI has a significant role in diagnosing, characterizing and following-up of MS. Finally, we concluded that DIR can be used as an addition to or even as an alternate for standardized T2W and FLAIR. Therefore, we intensely recommended adding a DIR sequences in the every-day MR protocols of MS cases.

CONSENT AND ETHICAL APPROVAL

The current work protocol was permitted Tanta Medical research ethics committee, agreement of the directors of the hospitals in which the work was performed, all participants give an agreement to be involved in this work, personal privacy was appreciated in all stages of this work and recorded data will not be employed for any other aim.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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