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Modified time repetition (TR) values' impact on the clarity of FLAIR sequence pictures in the white matter of multiple sclerosis MS patients

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Original Research

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Abstract:

Background: The discovery and development of magnetic resonance imaging (MRI) have completely changed how multiple sclerosis (MS) is diagnosed and treated. Image quality has improved as a result of the development of higher Tesla magnets and rapid fluid-attenuated inversion recovery methods. Additionally, new applications have begun to develop, including as three- and four-dimensional methods: functional MRI, magnetic resonance spectroscopy, atrophy measurements, and magnetization transfer ratio imaging. The use of MRI in the context of MS clinical trials has been governed by recently released official guidelines. Additionally, the new McDonald criteria include MRI, allowing for quick diagnosis of MS and timely treatments, and improving patient outcomes. This study attempts to obtain the best image quality for multiple sclerosis patients, who may be affected by some probable artifacts, by examining the diagnostic quality of time repetition (TR) and physical parameters of FLAIR sequences in MRI image.

Patient and Methods: The study's design is cross-sectional; the MS patients were under 50 years old when they were identified as having the disease by a neurological clinic and sent for MR examinations. In Wasit City's Alkarama Teaching Hospital, an MRI Philips is being used. FLAIR was the scanning procedure. The TR was scanned twice: once at 6000, and once at 8000.

Results: In the setting of MS, the present study's findings demonstrate a statistically significant difference between the mean Region of Interest (RIO) values of the two FLAIR cohorts (6000 and 8000) of 0.002. According to the study, there was no discernible relevance for the RIO mean in any of the different forms of MS. Although there was no significant difference in Contrast to Noise Ratio (CNR) values across the various kinds of multiple sclerosis, there was a significant difference in CNR values between the two FLAIR groups (0.002). Additionally, using the Statistical Package for Social Science (SPSS) application version 26, the data were entered, coded, and analyzed.

Conclusion: When the Region of Interest option of the MRI equipment software is used to analyze the MRI signal intensity measurements, the FLAIR imaging approach has proven effective in the investigation of MS in the brain.

Keywords: Magnetic resonance imaging; Fluid-attenuated inversion recovery; Contrast to noise ratio; Multiple sclerosis; Region of interest

1. Introduction

Human anatomical traits can be assessed and displayed using MRI. Nuclear Magnetic Resonance (NMR) has been employed in spectroscopic analysis for more than 50 years to identify the types of molecules and atoms as well as their properties. Since the 1980s, MRI has been used in clinical settings (1). High tissue contrast, a noteworthy diagnostic and clinical property of MRI, sets it apart from other

imaging modalities. The amplitude of radiofrequency (RF) signal pulses that are produced by and then reflected from various tissues in magnetic resonance imaging affects the brightness of the tissues. The ability of the radiologist to distinguish between healthy and diseased tissue by examining variations in the MRI data is facilitated by the MRI technicians' selection of the right pulse sequences (2). Two hydrogen atoms and one oxygen atom make up the water molecule. Because it is present in such large concentrations in the human body, hydrogen is a great source of energy for MRI scanners. Atoms are surrounded by a magnetic field. A MR picture is created from the altered image (4). There is a magnetic field strength of 1.5 Tesla. The MRI equipment is made up of a number of parts that together make up this astonishing machine. The magnet, gradient coil, radiofrequency coil, and computer are the main topics of discussion (5). A crucial measure in MRI is the CNR. In order to determine the average signal within two different RIO, namely the MS ROI 1 and WM ROI 2, the author, John Van Metre (2012) (6), used the CNR measure while also taking the air's standard deviation into account. The CNR, which is determined as the ratio of the standard deviation value to the air value, has been found to be a quantitative measure that quantifies the degree of noise present in a particular sequence. Enhancing the CNR improves the ability to distinguish the distinctive differences between two particular clinical areas of interest. The signal-to-noise ratio (SNR) and contrast principles are condensed into the CNR (7).

2. Patients and methods

In this research, the objectives of the study were explained to the participants, and consent was obtained from each participant. They were told that – you can refuse if you are not interested. Personal information collected after form completion was later deleted, including data such as names and any personal information referred to for participation. Not all information obtained from the participants in this study will be given away to a third party, according to the participants. This cross-sectional study comprised patients who had previously been diagnosed with MS affecting the brain and were sent for clinical examination to the radiology department of the Neurological Clinic. 30 patients had received brain MRIs, and data was being gathered on these. Exams, such as the modified TR factor in the FLAIR series, specifically focused on discography as the assessment criterion. The patients have given us permission to carry out the tasks required for our inquiry. Following the examination, we retained the patient data in the form of a Dicom file that included all the essential information, and we stored it under each patient's name on a specific Compact Disc (CD) that contained all the previous data. The CD was given to four radiologists in thirty copies, along with an oral summary of the study's objectives and the radiologists' responsibilities. In order to conduct the statistical analysis, the FLAIR sequences being investigated in connection with the use of MRI in the diagnosis and assessment of MS values contained a presentation of specific samples that had been collected using a particular questionnaire sheet. The inclusion criteria for this study – the patients under the age of 50 with normal renal function and serum creatinine levels – were assessed prior to brain surgery, or the administration of gadolinium chelate contrast agents. Exclusion requirements stipulated that patients with multiple sclerosis may not be good candidates for brain MRI if their weight exceeds 120 kg and is outside the permissible limit. Pregnant women were also excluded from the study.

In this research, the objectives of the study were explained to the participants, and consent was obtained from each participant. They were told that (You can refuse if you are not interested). Personal informationcollected after full, informed, and by deleting their names and any personal information referred to for participation. All information obtained from the participants in this study will not be given away to a third party, according to the participants (National Statement on Ethical Conduct in Human Research, 2023).

Examination protocol:

The Examination Protocol: this was manually registered from the MRI Philips scanner (achiva). Patients who had already been given a diagnosis of MS had to choose a slice orientation (plane) based on their past medical experience. A coronal slice orientation was used evenly across all individuals in our study to facilitate comparative evaluation. The relationship between the scan time's fluctuation and the TR value, as shown by the equation, may be understood.

$$\text{Scan time} = \text{TR} \times \text{Npe} \times \text{NEX} - - - - - - - - \quad (1)$$

where, TR: time repetition, Npe: phase-encoding matrix size, NEX: number of excitations. In addition, we changed the values for echo time (TE) and inversion recovery (IR) to match the updated TR values. The SPSS programmer version 26 was used to enter, code, and analyse the data.

3. Results and discussion

MR imaging is important for the diagnosis and monitoring of MS. The formation of MS lesions creates a hydrophilic environment, resulting in an increase in the T2 and High Signal intensity with a signal reduction on T1-weighted scans. Ovoid hyper intense areas on T2-weighted MR imaging can be seen. Therefore, a radiologic indication of MS Lesion appearance is often affected by the bright Cerebrospinal Fluid (CSF) signal, for example, close to the ventricles or cortical sulci. FLAIR is a T2-weighted scan that suppresses CSF selectively with an inversion pulse. The Cerebrospinal fluid CSF signal suppression comes at the cost of reduced SNR (8), and for this reason in this research it was decided not to taking the SNR value in comparatively many TR values in the FLAIR sequence. The hydrophilic environment in the MS lesion needs more evaluation in multi TR value to further understand this hydrophilic characteristic. Additionally, we refocused on the role of FLAIR in MS, and we presented a simple approach for obtaining fluid-attenuated images with experience criteria that depend on variable TR to assess the MS lesion. Table 1 shows the difference of

Table 1. Difference of RIO value between two FLAIR groups (TR, 6000, and 8000) among 30 samples.

Parameters	RIO (6000)	RIO (8000)	P-value
Mean ± SD	73.22 ± 5.15	82.49 ± 7.76	< 0.001
Median Inter Quartile Range (IQR)	72.67 (71.55-75.78)	82.76 (78.96-88.87)	
Minimum- Maximum of ROI	60.28 - 87.59	63.65-97.54	

RIO value between two FLAIR groups (TR 6000, 8000) among thirty samples. There was a significant difference (P-value > 0.001) between the RIO values of the two studied groups of the FLAIR (TR 6000, 8000). The mean of RIO (6000) was the lowest (73.22 ± 5.15). In Table 2, the rank difference between the RIO of the two FLAIR groups (TR 6000, 8000) with their P-values can be seen, and the difference between the groups demonstrated that the RIO (6000) rank was lower than RIO (8000) with a P-value equal to 0.002. The results agree with [1] and [2], where they demonstrate a significant increase in the mean value of FLAIR in MS cases. This may be related to the longer TR relaxation which made the MS appearance with its hyper intense signal. The lack of histopathology specificity due to inflammation, edema, demyelination, gliosis and axonal loss, are all represented as areas of high signal intensity (9, 10). Table 3 shows the difference of CNR values between two FLAIR groups (TR 6000, 8000) among thirty samples. The difference was significant between (TR 6000) and (TR 8000) with a P-value equal to 0.002. In Table 4, we see the rank difference between CNR of the two FLAIR groups (TR 6000, 8000) with their highly significant P-values of FLAIR sequence which were found in the current study and are in agreement with the results of [3]. In that study it was found that FLAIR is the optimum of native study MR imaging sequence for MS when using TE of 120 ms (11). Applying the TE of 120 ms leads to a significant increase in the contrast to noise ratio of the white matter lesion and therefore increasing the detectability of MRI and the image's spatial resolution. Moreover, the results of the current research are parallel with [4], who stated that FLAIR is a better detector for the lesion occurrences in the white and gray matters of the brain in MS cases (12). Table 5 shows the description of each physician's opinion for ranking images taken for the two FLAIRs. Physician number 1 mentioned the FLAIR (TR 8000) with a mean of 2.33 ± 0.84 and the last rank was for (TR 6000) with a minimum rank of zero and maximum 3. Physician number 2 had a broadly similar opinion when grading the two FLAIRs. FLAIR I (TR 6000) came in at the second rank and had a lower rank of zero with the highest rank of 3 with a mean of (1.43 ± 0.85). The first rank was for FLAIR II (TR 8000) which had a mean of (2.13 ± 0.93) and a maximum grade of 4. Physician number 3 ranked the FLAIR (TR 8000) with a mean of (2.27 ± 0.86) and range (0 - 4) and finally FLAIR (TR 6000) with a mean of (1.63 ± 0.85). Regarding physician number 4, the highest rank was noticed for FLAIR (TR 8000) with the highest mean rank of (2.27 ± 0.86) compared to (1.50 ± 0.68) for (TR 6000) in the same order. Table 6 provides a description of the total score of each FLAIR according to physician opinions ranking. The mean and standard deviation of each FLAIR were calculated for the four physician opinions and was scored from (0 - 16) to fail, weak, fair, good, and excellent. FLAIR II (TR 8000) with a fair score scale (mean ± SD = 9.03 ± 2.90) with a score ranging from 2 to 15. FLAIR I (TR 6000) had a weak score with a mean of (6.40 ± 2.41) and a 12-maximum score. There is not enough statistically significant (P-value = 0.362) evidence to suggest a difference in the distribution of the grading across the four physicians for FLAIR (TR 6000). The analysis One Way ANOVA test of the FLAIR 6000 indicated a failure in determining MS. This result can be explained by the appearance of an area of low signal intensity as compared with the normal white matter which are known as black holes. Such lesions when newly formed will either disappear with time, when it is thought they are caused by reversible edema or demyelination, or persist as chronic black holes, when it is thought they are caused by permanent axonal loss [5]. The mean signal intensity of the FLAIR 6000 sequence reflected a poor result in determining MS, while the mean signal intensity of its sequence indicated a failed detection for MS. To identify the range of signal intensity of the most efficient MRI sequence for detecting MS a comparison among the mean of these sequences was conducted. The results of this comparison

Table 2. The rank difference between the RIO of the TWO FLAIR groups (TR, 6000, and 8000) with their P-values.

Variables	Test Statistic	P-value
RIO (6000)-RIO (8000)	-0.87	0.002

Table 3. Difference of CNR value between two FLAIR groups (TR 6000, and 8000) among 30 samples.

Parameters	CNR (6000)	CNR (8000)	P-value
Mean ± SD	2.17 ± 0.79	3.70 ± 0.96	
Median (IQR)	2.10 (1.50-2.52)	3.65 (3.20 - 4.42)	< 0.001
Minimum-Maximum (IQR)	1.1 - 4.3	1.4 - 5.6	

Table 4. The rank difference between CNR of the TWO FLAIR groups (TR 6000, and 8000) with their P-values.

Variables	Test Statistic	P-value
CNR (6000) -CNR (8000)	-0.867	0.002

Table 5. Description of physicians ranking of images for FLAIR (TR 6000, and TR 8000).

Physician	FLAIR TR	Mean	Standard Deviation	Rank score	Minimum	Maximum
Physician 1	6000	1.83	0.83	3	0	3
	8000	2.33	0.84	2	1	4
Physician 2	6000	1.43	0.85	3	0	3
	8000	2.13	0.93	2	0	4
Physician 3	6000	1.63	0.85	3	0	4
	8000	2.30	0.95	2	0	4
Physician 4	6000	1.50	0.68	3	0	3
	8000	2.27	0.86	2	0	4

Table 6. description of the total score of the two FLAIRs according to physician opinions ranking.

Parameters	FLAIR I	FLAIR II
Mean score	6.40	9.03
Standard Deviation	2.41	2.90
Median	6.50	10.00
Minimum score	0	2
Maximum score	12	15
Score scale	Weak	Fair

indicated that the mean signal intensity of FLAIR 8000 was a good indicator for determining MS as compared with the other sequences. This result is in coordination with [6] (13, 14). The strong significance of FLAIR in detecting the MS which appears from data analysis of the present research and its priority over the sequence is supported by the findings of [5], who reported that the FLAIR is a superior sequence for the detection of MS lesions, and that periventricular lesions are often indistinguishable from the adjacent CSF which is also of high signal.

4. Conclusion

1- The findings of this comparative analysis revealed that the mean signal intensity of FLAIR 8000 was a reliable indicator of MS when compared to the other sequences with a scan time of 3.4 minutes. It may be used for brain MRIs, especially in MS patients.
2- It has been demonstrated that increasing FLAIR results in an improved MRI picture may offer more clarity of details relevant to both grey and white matter, depending on what follows before the details. Statistics have demonstrated this.

Authors Contributions
Authors have contributed equally in preparing and writing the manuscript.

Availability of data and materials
Data presented in the manuscript are available via request.

Conflict of Interests
The author declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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