The Optimization of Magnetic Resonance Imaging Pulse Sequences in Order to Better Detection of Multiple Sclerosis Plaques

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ABSTRACT

Background and objective: Magnetic resonance imaging (MRI) is the most sensitive technique to detect multiple sclerosis (MS) plaques in central nervous system. In some cases, the patients who were suspected to MS, Whereas MRI images are normal, but whether patients don't have MS plaques or MRI images are not enough optimized enough in order to show MS plaques? The aim of the current study is evaluating the efficiency of different MRI sequences in order to better detection of MS plaques.

Materials and methods: In this cross-sectional study which was performed at Shohada-E Tajrish in Tehran - Iran hospital between October, 2011 to April, 2012, included 20 patients who suspected to MS disease were selected by the method of random sampling and underwent routine brain Pulse sequences (Axial T2w, Axial T1w, Coronal T2w, Sagittal T1w, Axial FLAIR) by Siemens, Avanto, 1.5 Tesla system. If any lesion which is suspected to the MS disease was observed, additional sequences such as: Sagittal FLAIR Fat Sat, Sagittal PDw-fat Sat, Sagittal PDw-water sat was also performed.

Results: This study was performed in about 52 lesions and the results in more than 19 lesions showed that, for the Subcortical and Infratentorial areas, PDWw sequence with fat suppression is the best choice, And in nearly 33 plaques located in Periventricular area, FLAIR Fat Sat was the most effective sequence than both PDw fat and water suppression pulse sequences.

Conclusion: Although large plaques may visible in all images, but important problem in patients with suspected MS is screening the tiny MS plaques. This study showed that for revealing the MS plaques located in the Subcortical and Infratentorial areas, PDw-fat sat is the most effective sequence, and for MS plaques in the periventricular area, FLAIR fat Sat is the best choice.

Keywords

Multiple Sclerosis, MRI, PDW fat suppression, PDW water suppression, FLAIR

Introduction

MS is an inflammatory demyelinating disease of the central nervous system (CNS) [1]. It is the most common demyelinating disease after vascular- and age-related demyelination [2]. MS is characterized by multiple "plaques" of demyelination in the white matter of the brain and spinal cord [1]. The primary lesions are found in

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the perivascular spaces along penetrating veins [3]. Though the etiology of MS is not fully understood, the destruction of myelin is most likely caused by an autoimmune process [4]. Initial symptoms can sometimes be triggered by Initial symptoms, but a convincing link to the disease has not been made [5]. The clinical course of MS is highly variable. The age of symptom onset in MS is usually between 18 and 40 years; onset is uncommon in childhood and after the age of 50 years [6]. Initial symptoms may include numbness, dysesthesia, double vision, or problems with balance and coordination [7]. Loss of motor function is also a frequent initial presentation. Less commonly, spinal-cord-related symptoms constitute the initial presentation of MS. There is a female/male ratio of 3:2 [8, 9].

Diagnostic Criteria

No single clinical or laboratory test is pathognomonic for MS [10]. For this reason, diagnostic criteria have been developed to assess the relative probability of MS. In 2001, an international panel convened by the National Multiple Sclerosis Society of North America and chaired by Ian Mc Donald recommended revised diagnostic criteria for MS [11]. They replace the older Poser Criteria and have become known as the "McDonald criteria," after their lead author [12]. These new criteria integrate MRI image assessment with clinical and other clinical methods in drawing diagnostic conclusions [13]. The McDonald criteria take into account the high sensitivity of MRI in detecting lesions. In 2005, a revision to the "McDonald criteria" [14, 15] was proposed to clarify the exact definition of terms such as "attack," "dissemination," a "positive MRI" etc. It is now widely accepted that MRI plays an important role as a noninvasive diagnostic test to establish the diagnosis of MS lesions, showing demyelinating lesions in the brain and spinal cord [16]. Because of its greater sensitivity, compared with clinical measures, MRI can be used to measure subclinical disease. Moreover, MRI outcome measures are routinely used in clinical trials of MS patients, and MRI has become the method of choice for patient follow-up and treatment monitoring[8, 17].

MRI Appearance of MS

The characteristic abnormalities of MS in the brain consist of multiple white-matter lesions with a high SI on FLAIR, PDW-WI, and T2-WI and low SI on T1-WI [18]. Lesions are found predominantly in a Periventricular distribution, centrum semiovale, and the callososeptal interface. Additional sites of involvement include other parts of the cerebral white matter such as the subcortical white matter, optic nerves, corpus callosum, internal capsule,

cerebellar peduncles, brainstem, and spinal cord [8, 19].

Background and objective

Magnetic Resonance Imaging (MRI) is the most sensitive technique for detecting multiple sclerosis (MS) plaques in central nervous system [20]. In some cases, , the patients who suspected to MS, Whereas MRI images are normal [21], but whether patients don't have MS plaques or MRI images are not enough optimized enough in order to show MS plaques? The aim of the current study is evaluating the efficiency of different MRI pulse sequences in order to better detection of MS plaques [22].

Methods

In this cross-sectional study which was performed at Shohada-E Tajrish hospital between October, 2011 until April, 2012, included 20 patients who suspected to MS disease were selected by the method of random sampling and underwent routine brain Pulse sequences (Axial T2w, Axial T1w, Coronal T2w, Sagittal T1w, Axial FLAIR) by Siemens, Avanto, 1.5 Tesla system. If any lesions which suspected to the MS disease, observed, additional sequences such as: Sagittal FLAIR Fat Sat, Sag-

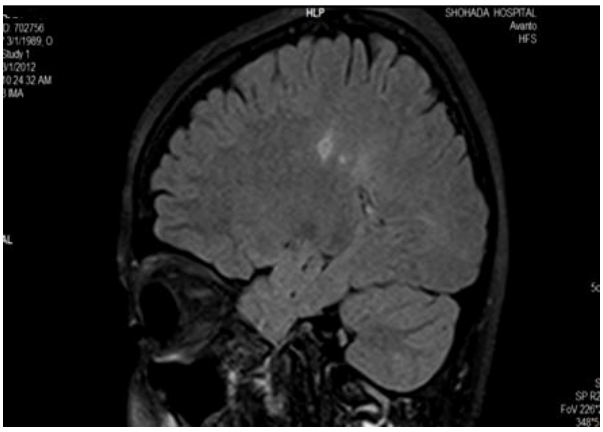
ittal PDw-fat Sat, Sagittal PDw-water sat have been taken; then the images related to additional sequences were evaluated by two neuroradiologists and the number of the observed MS plaques in each sequences in three areas of brain: periventricular, subcortical white matter and infratentorial region, were noted (Figures 1-3).

Results

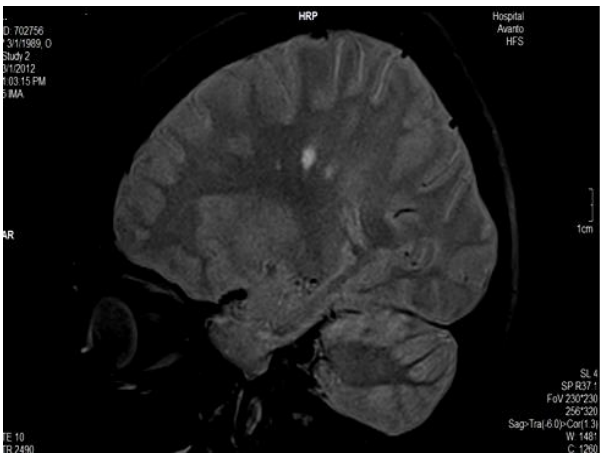
This study was performed in about 50 lesions and the results in more than 17 lesions showed that, for the Subcortical and Infratentorial areas. The comparison of observed MS plaques in three different MRI Pulse sequences was done by ANOVA test ($p<0.05$), and the amount of agreement between two neuroradiologists has been done with Kappa statistic (Table 1). The result of our study showed that, PDw sequence with fat suppression with sensitivity and specificity = 100% is the best choice for detection of MS lesion in sub cortical and infratentorial area of brain comparison with FLAIR and PDW water sat. (Figure 1 and 3) (P value <0/05). And then, PDW water sat with sensitivity of 88% and FLAIR with 77% sensitivity and specificity about 33-77% (Table 1). In 30 plaques located in periventricular area, FLAIR Fat Sat was the most effective sequence than both PDw fat and water suppression pulse sequences (Figure 2) (p value<0/05) and Kappa statistics sensitivity and specificity= 100% (Table 1).

Discussion

MS is an inflammatory demyelinating disease of the CNS which is characterized by multiple "plaques" of demyelination in the white matter of the brain and spinal cord[8, 9]. Although MRI is the most sensitive technique for detecting MS plaques in CNS [20], in some cases, however, the patient has symptoms in which MS is suspected, MRI images are normal; or maybe patient has symptoms that are related to specific area of the brain but MRI images don't show the MS plaques in the



A



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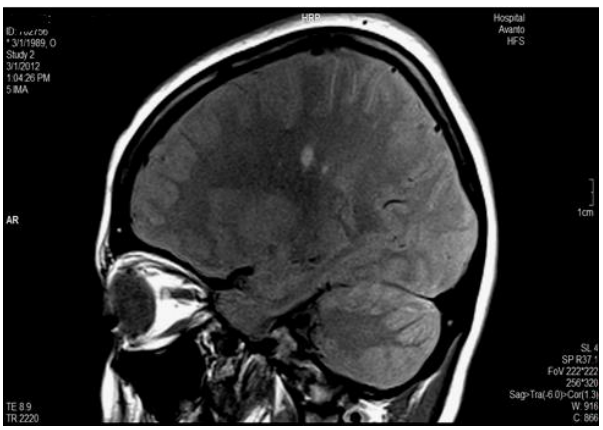
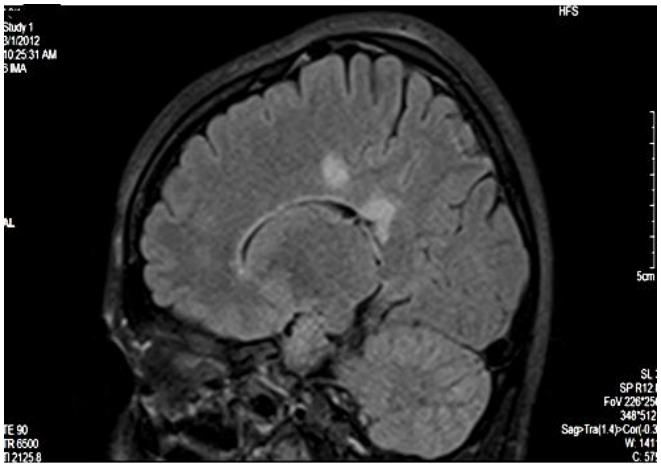


C

Figure 1: These images show the MS plaques in subcortical white matter area with three MRI pulse sequence: A is FLAIR, B is PDW-Fat sat and C is PDW-Water sat.



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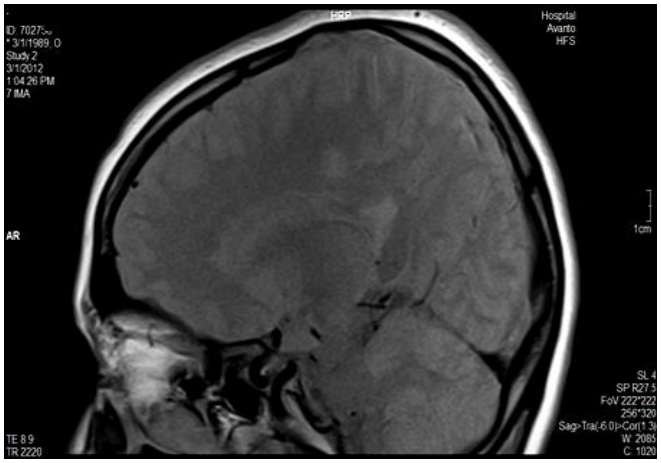
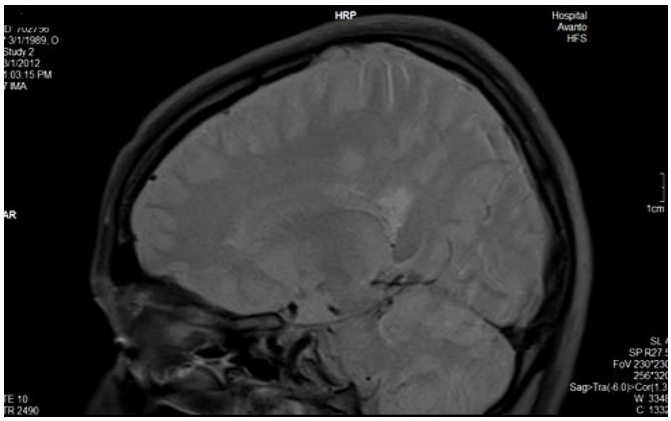
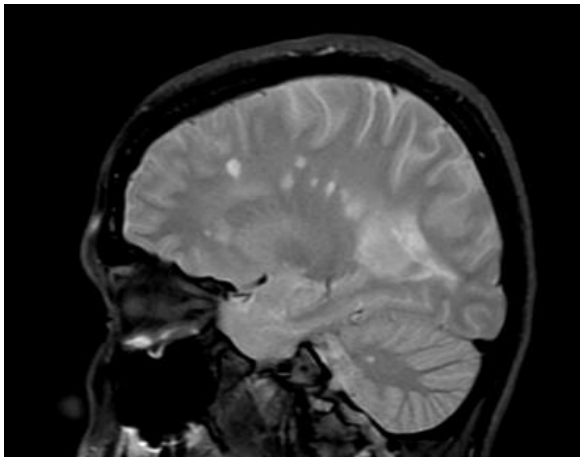


B

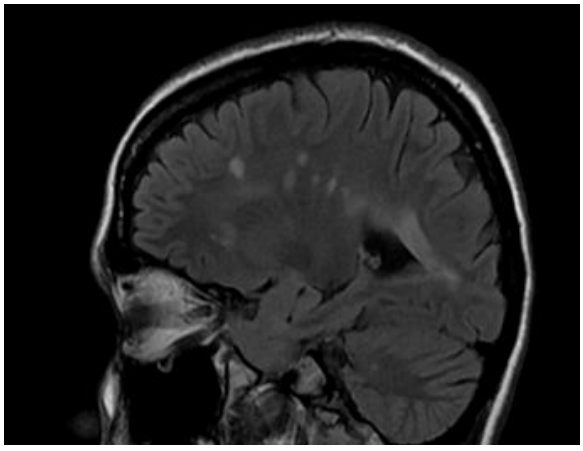


C

Figure 2: These images show the MS plaques in periventricular area with three MRI pulse sequence: A is FLAIR, B is PDW-Water sat and C is PDW-Fat sat.



A



B

Figure 3: These images show the MS plaques in infratentorial region with two MRI pulse sequence: A is PDW-Fat sat, B is FLAIR. Note: in this patient system had error and couldn't do PDW-Water sat.

given area [21]; Therefore in this situation we cannot surely say the patient doesn't have MS plaques because in some cases it is due to poor optimization of MRI pulse sequences. So in this investigation we have evaluated some different MRI pulse sequences to asses which of them is the most efficient to detect MS plaques in the brain. For this reason we got additional MRI pulse sequences rather than doing only routine brain MRI as described earlier in method section. Finally we found that for MS plaques which are located in subcortical and infratentorial regions, proton density sequence with fat suppression technique is the

Table 1: The result of accuracy of selected pulse sequences in detection of MS lesion in three area.

Sequences Accuracy	FLAIR fat sat	PDW fat sat	PDW water sat
Sub cortical	77%	100%	88%
Infratentorial	77%	100%	88%
periventricular	100	82%	88%

best choice, but the FLAIR sequence is the most efficient MRI pulse sequence to detect MS plaques in periventricular area [23, 24].

Conclusion

Although large plaques may visible in all images, but important problem in patients with suspected MS is screening the tiny MS plaques. This study showed that for revealing the MS plaques located in the Subcortical and Infratentorial areas, So far, studies showed that, FLAIR sequences were accepted in detecting MS lesions [25]., it seems not to be enough alone to assess MS plaque. Because FLAIR has some imaging problems including low contrast in the cerebellum and juxta-cortical as well as artifacts motion [26, 27]. In addition FLAIR sequence, other sequences such as PDW and T2 can be helpful especially if it is used pre saturation fat sat pulses fat sat [28] PDW fat saturation has the superior contrast than FLAIR in posterior fossa and also, juxta-cortical area and, in our study, is the most effective sequence and for MS plaques in the periventricular area, FLAIR fat sat is the best choice. However, new research has shown that the 3D Double Inversion Recovery sequence has a very high diagnostic accuracy in displaying of MS plaques especially in juxta-cortical. [29, 30]. Finally, it seems that, in order to better detection of brain MS lesions, it is necessary to use some related sensitive sequences otherwise, some tiny MS plaque may be missed.

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Conflict of Interest

None

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