To Assess the Factors Effecting Image Quality in Magnetic Resonance Imaging at 1.5T

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DOI:10.37648/ijrmst.v17i01.007

[1]*Received: 22 April 2024; Accepted: 18 June 2024; Published: 26 June 2024*

ABSTRACT

Background: Good image quality is essential for accurate diagnosis in magnetic resonance imaging (MRI) examinations. This study aimed to investigate how image quality can be improved by implementing improvement strategies on factors that effects the MRI parameters instead of relying solely on conventional techniques.

Method: This research employs a Comparative study design to compare the image quality in routine brain Magnetic Resonance Imaging (MRI) scans at 1.5T before and after implementing image quality improvement strategies. The study involved 37 individuals participant’s data (20 females and 17 males) aged 15-70 years who underwent MRI scans. Participants with any systemic disease, acute trauma, pregnancy and participants with absolute contraindications were excluded from the study.

Result: The study found that several factors can effects MRI image quality and can be improved by implementing improvement strategies on these factors by manual adjustments. By identifying factors affecting image quality and evaluating improvement strategies, we seek to optimize MRI protocols and enhance the diagnostic utility of routine brain imaging. For instance, increasing the number of Excitation (NEX) values improved image quality. By increasing the echo time (TE) value a 50% images shows improvement in image quality. The volume of shimming showed better image quality than the other two modes (difficult mode and auto mode). Decreasing the flip angle and voxel size also improved image quality

Conclusion: In conclusion, image quality can be improved by implementing improvement strategies on factors that effects the MRI parameters in comparison with the conventional techniques.

Keywords: *MRI; image quality; number of Excitation (NEX); echo time; Flip angel; Voxel; Pixel*

INTRODUCTION

Magnetic Resonance Imaging (MRI) is a non-invasive and versatile imaging modality widely used in clinical practice for the evaluation of various medical conditions. In routine imaging, the quality of MRI images plays a critical role in facilitating accurate diagnosis and guiding patient management decisions. Hence, effort to assess the factors effecting image quality in magnetic resonance imaging at 1.5T will enhance clinical outcomes and patient care.[1]

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[1] *How to cite the article:* Jyoti, Meena B.K., Phogat D.S., Dahiya M.K. (June 2024); To Assess the Factors Effecting Image Quality in Magnetic Resonance Imaging at 1.5T; *International Journal of Research in Medical Sciences and Technology;* Vol 17, 40-50, DOI: http://doi.org/10.37648/ijrmst.v17i01.007

This research focuses on "to assess the factors effecting image quality in magnetic resonance imaging at 1.5T" The study aims to address the specific challenges and opportunities associated with MRI performed at 1.5T, a standard field strength used in clinical settings.[2] By identifying factors affecting image quality and evaluating improvement strategies, seeking to optimize MRI protocols and enhance the diagnostic utility of routine MR imaging.

The importance of this research lies in its potential to impact clinical practice significantly. Improved image quality can lead to more precise identification and characterization of pathologies, aiding clinicians in making accurate and timely diagnoses. Moreover, optimized MRI protocols can potentially reduce examination times, enhance patient comfort, and optimize resource utilization in healthcare settings.

The research will employ a data collection approach, involving patients undergoing routine MRI at 1.5T image quality metrics will be assessed and compared. The study will also explore the effectiveness of various improvement strategies to enhance image quality.

The key findings from the research are expected to identify factors effecting image quality in routine MRI at 1.5T. The study will provide insights into areas for improvement and propose strategies to enhance image quality, leading to improved diagnostic accuracy and better clinical outcomes.

METHODS

STUDY DESIGN: Comparative study.

STUDY POPULATION: Patients who will undergo for routine MR examination in the radiology department.

STUDY AREA: The data was collected from the MRI room of radiology departments in SGT Hospital and Research Institute, Gurugram, Haryana.

INCLUSION CRITERIA:

- Subjects of either sex will be recruited with the age from 15 to 70 years.
- Patient those who are coming for routine MR scan.
- Only patients who are willing to participate in the study would be selected.

EXCLUSION CRITERIA:

- Patients with acute trauma.
- Pregnant patients
- Patient below the age of 15 and elderly patients above the age of 70.
- Patients who are not willing to participate in the study would be not selected.

Patients with absolute MRI contraindications[3] such as

- Cardiac Pacemaker.
- Implanted cardiac defibrillator.
- Internal pacing wires.
- Clips such as cerebral, carotid, or aortic aneurysm.
- Cochlear implants.
- Any implant with non compatibility to MR magnet.
- Swan-Ganz catheter. for MRI.
- Incomplete Imaging Sequences: MRI scans with incomplete imaging sequences, missing essential sequences, or significant motion artifacts will be excluded.

METHOD OF DATA COLLECTION:

This research employs a Comparative study design to compare the image quality in routine Magnetic Resonance Imaging (MRI) scans at 1.5T before and after implementing image quality improvement strategies. The study aims to assess the factors effecting image quality in magnetic resonance imaging at 1.5T. Comparative research attempts to establish cause–effect relationships among the variables in the study.[4] The data used in the current study was obtained from the MRI room of radiology department. The research is carried out is at the Philips Multiva 1.5Tesla MR machine.

SAMPLING TECHNIQUE:

Preferred sampling technique.

SAMPLE SIZE:

Total 37 number of MRI patients took part in this study.

STATISTICAL ANALYSIS:

The data collected was compiled, tabulated, graphical, analyzed, and subjected to statistical tests. Analysis was done using Excel.

RESULTS

The study found that several factors can effects MRI image quality and can be improved by implementing improvement strategies on these factors by manual adjustments. By identifying factors affecting image quality and evaluating improvement strategies, we seek to optimize MRI protocols and enhance the diagnostic utility of routine brain imaging and the result has been shown below.

NEX/NSA:- Number of excitations (NEX) or number of signal averages/acquisitions (NSA) is a measurement parameter. It is used to represent the number of times each line of k-space data is acquired and is primarily used to improve signal-to-noise (SNR) ratio.[5]

TABLE NO. 1:- Table showing result increased of no. of excitation (NSA)

Serial no.	Patient ID	MR Exam	NSA (Before)	NSA (after)	Artifacts	Image Quality	Sequence
1	RC007	MR BRAIN	3	1	YES	POOR	T2W_TRA
2	RC008	MR PELVIS	4	2	YES	POOR	T2W_TSE_TRA
3	RC012	MR PELVIS	1	2	NO	GOOD	T2W_TSE
4	RC013	MR BRAIN	1	2	NO	GOOD	T2W_ COR
5	RC018	L.S.SPINE	1	2	NO	FINE	T2W_TSE_COR
6	RC027	L.S.SPINE	1	2	YES	FINE	STIR_SAG

[redacted]

Fig.1:- (a) NSA 1 & (b) NSA 2

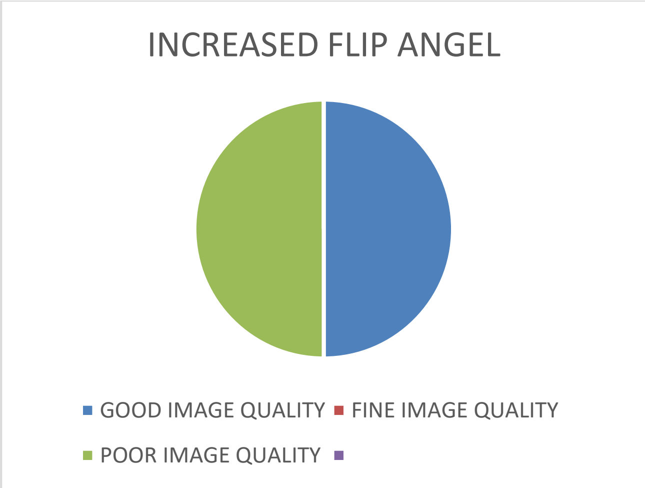
FLIP ANGLE: flip angle is also called tip angle is the amount of rotation the net magnetization experiences during application of a radiofrequency (RF) pulse. It can be measured in degrees.[6]

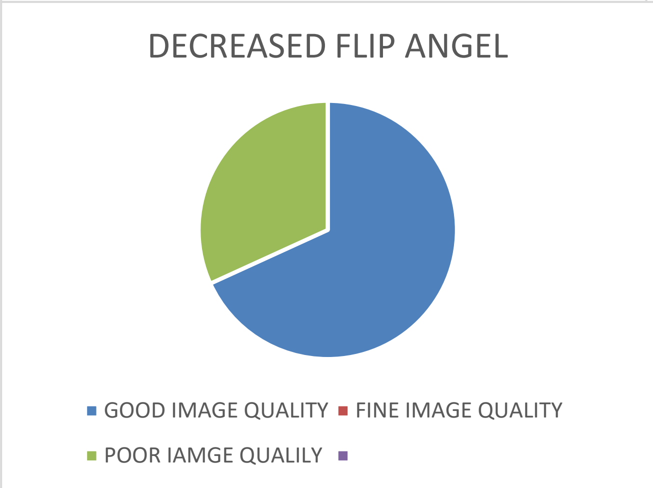
TABLE NO. 2:- Table Showing Changed Flip Angle increased.

Serial No.	Patient ID	MR Exam	flip angel (Before)	flip angel (after)	Artifacts	Image Quality	Sequence with increased flip angel
1	RC005	MR BRAIN	90	180	YES	POOR	T2W_SE_SAG
2	RC011	MR BRAIN	90	120	NO	GOOD	T2W_TSE_COR

TABLE NO. 3:- Table Showing Changed Flip Angle decreased

Serial No.	Patient ID	MR Exam	flip angel (Before)	flip angel (after)	Artifacts	Image Quality	Sequence with decreased flip angel
1	RC001	MR BRAIN	90	45	YES	POOR	T2W_TSE_TRA
2	RC012	MR PELVIS	90	45	NO	GOOD	T2W_TSE_SAG
3	RC013	MR BRAIN	90	45	NO	GOOD	T2W_TRA_PL
4	RC019	L.S. SPINE	90	60	NO	GOOD	T1W_TSE_TRA





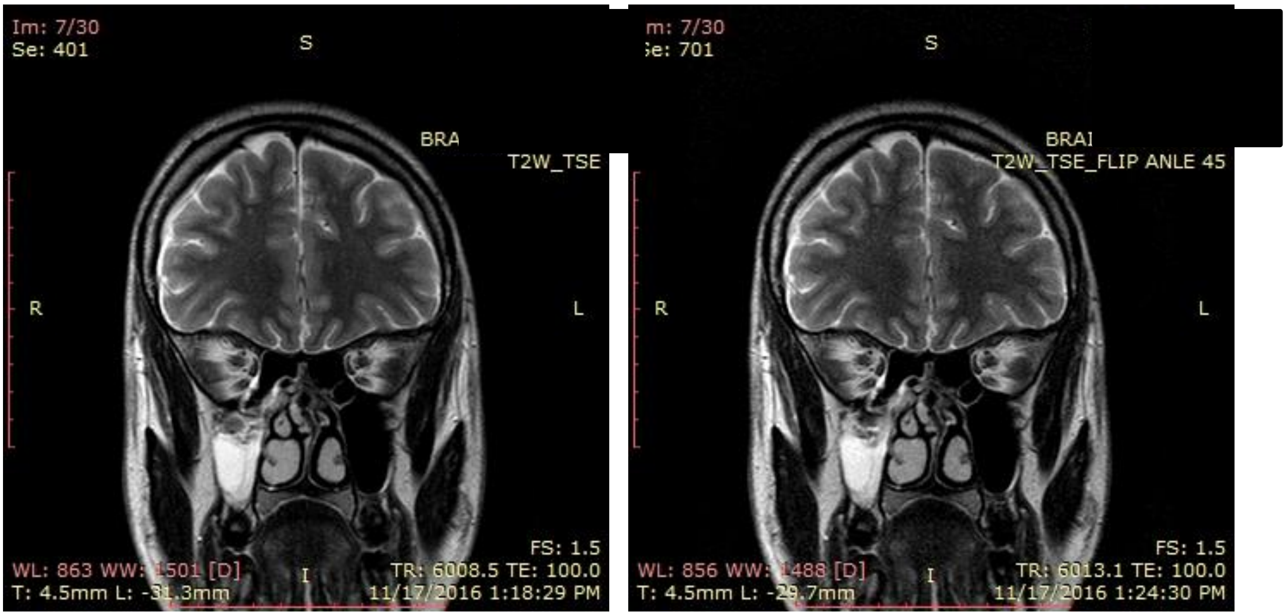


Fig.2:- (a) flip angel 90 degree & (b) flip angel 45 degree

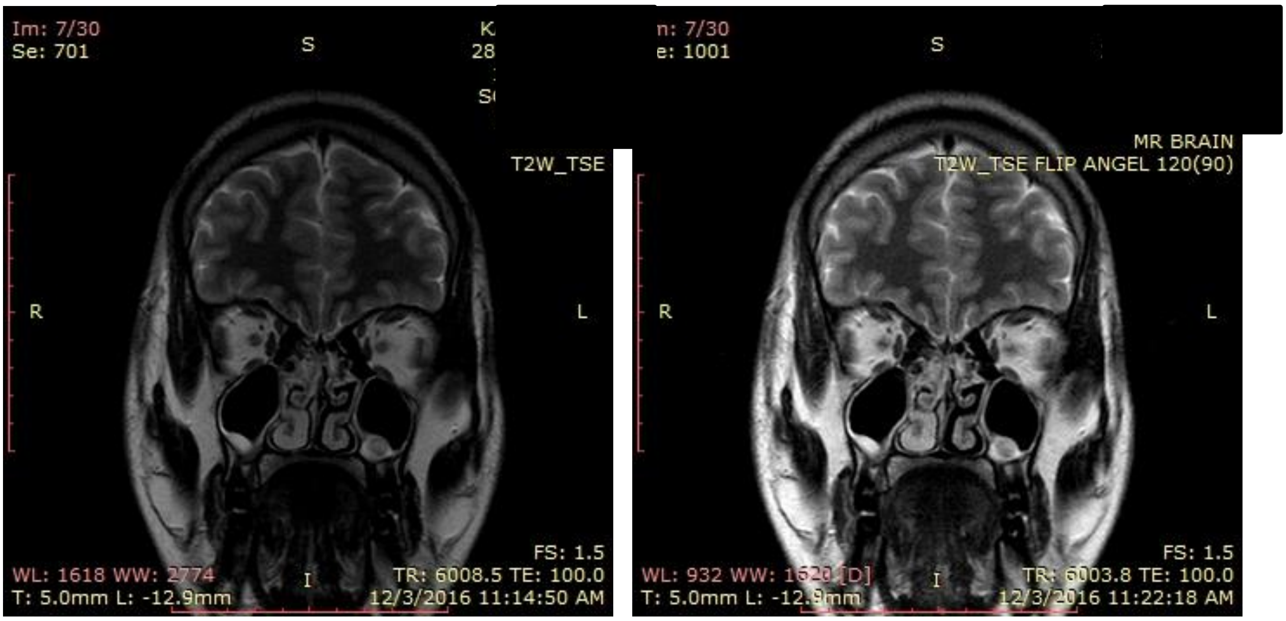


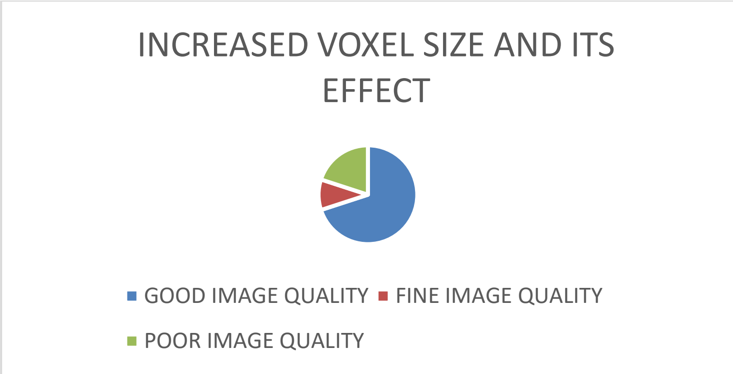
Fig.3:- (a) flip angel 90 degree & flip angel 180

<u>VOXEL</u> : A voxel is a unit of graphic information that defines a point in three-dimensional space. Since a pixel (picture element) defines a point in two dimensional space with its x and y coordinates , a third z coordinate is needed. In 3-D space, each of the coordinates is defined in terms of its position, color, and density. Think of a cube where any point on an outer side is expressed with an x , y coordinate and the third, z coordinate defines a location into the cube from that side, its density, and its color.[7]

TABLE NO. 4: Table Showing Changing Voxel Size.

Serial no.	Patient ID	MR Exam	VOXEL (Before)	VOXEL (after)	Artifacts	Image Quality	Sequence
1	RC003	MR PELVIS	1	2	Yes	Poor	T2W_TSE_COR
2	RC009	L.S. SPINE	1	2	Yes	Poor	T2W_TSE_
3	RC010	MR BRAIN	1	2	No	Good	T1W_SE_HST
4	RC013	MR BRAIN	1	2	No	Good	T2W_TSE_COR
5	RC018	L.S. SPINE	0.99	1.5	No	Good	STIR_LONG_TE
6	RC019	L.S.SPINE	0.99	1.5	No	Good	STIR_LONG_TE
7	RC021	L.S. SPINE	0.99	1.5	No	Good	STIR_LONG_TE
8	RC023	SHOULDER	2	4	Yes	Good	T1W_TSE_MSK
9	RC027	L.S. SPINE	0.99	1.5	Yes	Fine	STIR_LONG_TE
10	RC032	D.L. SPINE	0.99	1.5	No	Good	STIR_LONG_TE

(IJRMST) 2024, Vol. No. 17, Jan-Jun **e-ISSN: 2455-5134 p-ISSN: 2455-9059**



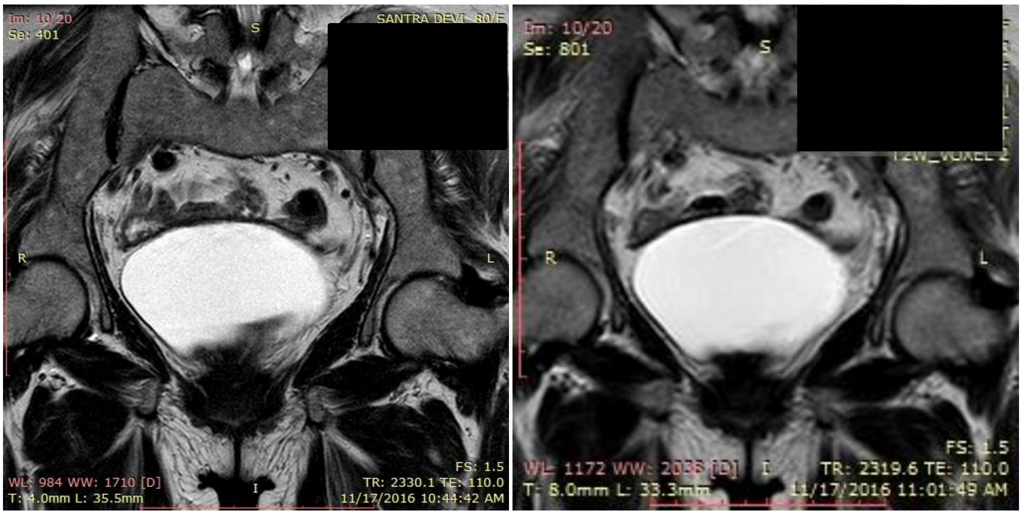


Fig. 4:- (a) voxel size1.5mm & (b) voxel size 0.99mm

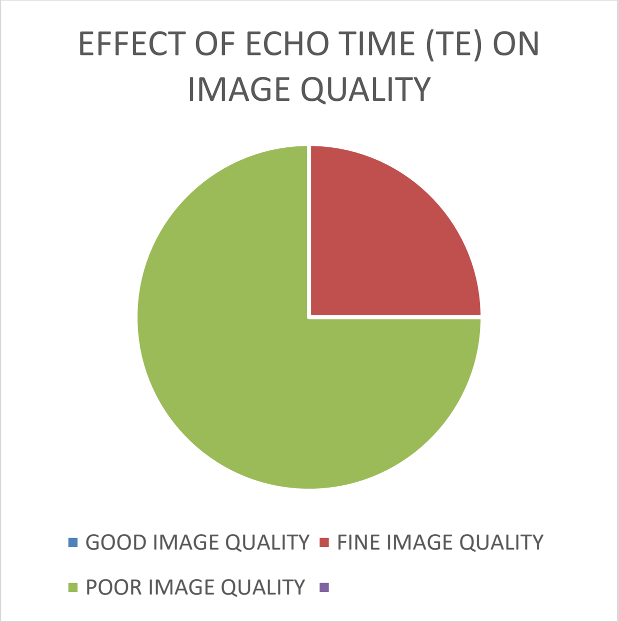
<u>TE&TR</u>: TE: - Time to echo having peak time when signal received. And **TR**: - time to repeat or repeating time. The contrast on the MR image can be manipulated by changing the pulse sequence parameters. A pulse sequence sets the specific number, strength, and timing of the RF and gradient pulses. The two most important parameters are the repetition time (TR) and the echo time (TE). The TR is the time between the first 90° RF pulse or excitation pulse and second 180° RF pulse or refocusing pulse. The TE is the time between the initial 90° RF pulse and the echo.[8]

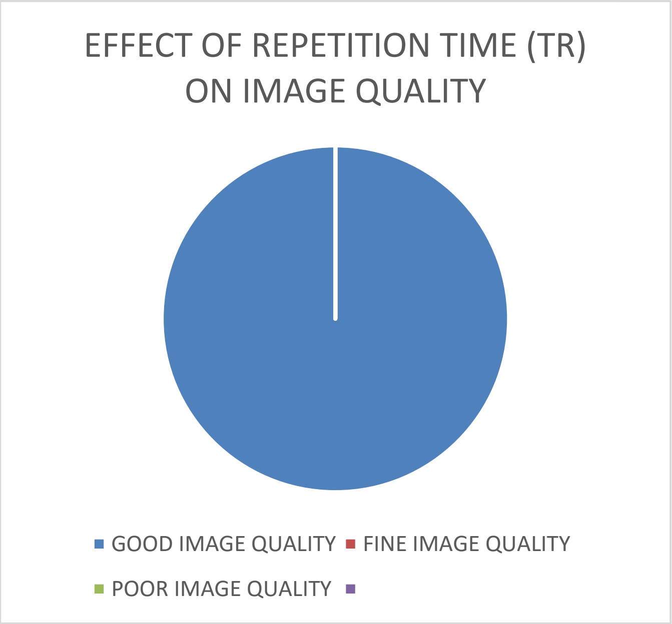
TABLE NO. 5:- table showing increased echo time (TE)

Serial no.	Patient ID	MR Exam	TE (Before)	TE (after)	Artifacts	Image Quality	Sequence
1	RC002	MR L.S. SPINE	100	200	YES	POOR	T2W_TSE_SAG)
2	RC005	MR BRAIN	10	20	YES	POOR	T2W_TSE_COR
3	RC006	MR L.S.SPINE	120	140	YES	POOR	T2W_TSE_SAG
6	RC026	L.S. SPINE	8	15	NO	FINE	T2W_TSE_SAG

TABLE NO. 6:- table showing change increased repetition time(TR)

Serial no.	Patient ID	MR Exam	TR (Before)	TR (after)	Artifacts	Image Quality	Sequence
4	RC013	MR BRAIN	4000	8000	NO	GOOD	T2W_TRA_PL
5	RC017	L.S. SPINE	400	800	NO	GOOD	T1W_TSE_SAG





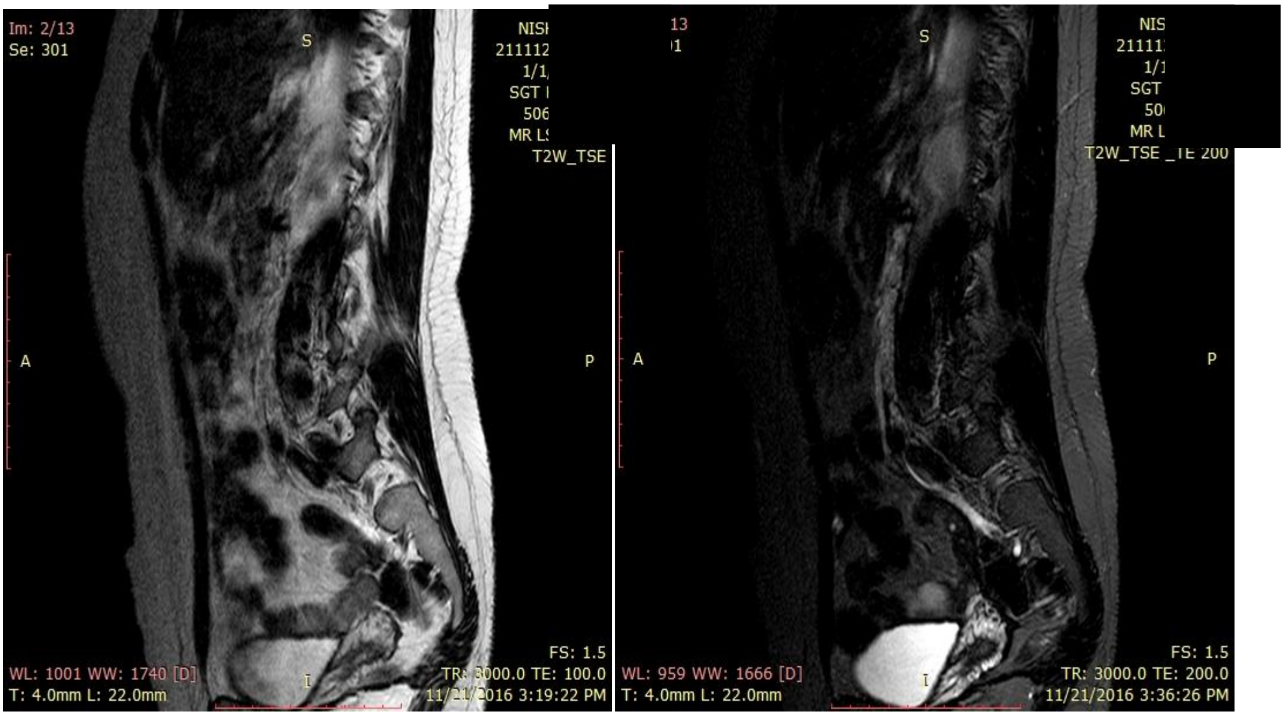


FIG.5:- (a) TE 100 & (b) TE 200

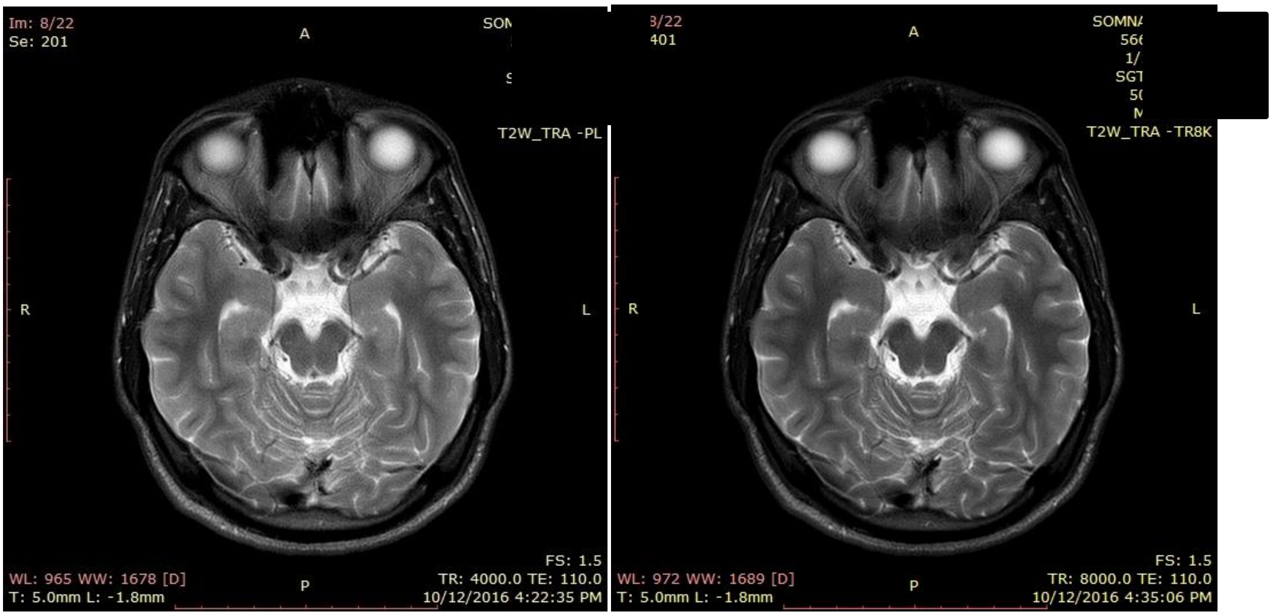


FIG. 6:- TR 4000 & (b) TR 8000-

SHIMMING: Shimming involves a preparation phase in which small gradients in the subject are measured and corrected to optimize magnetic field homogeneity β_0. It is used for optimal fat suppression, the homogeneity should be significantly better than 3.4 ppm (frequency different water/fat) over the volume of interest. The parameter is different in MR imaging and MR spectroscopy.[9]

Options for shimming in MR*

(*NOTE: Options for shimming in MR can varies in manufacturing companies.)

1. Difficult mode:- Automatic shimming will performed in scans utilizing.

2. Auto mode:- auto stands for automatic shimming is done over the whole value representing the stacks in the scan.
3. Volume mode:- volume shimming allows a user defined volume to be drawn targeting first order optimization to that region no matter how many stacks are defined.

TABLE NO. 7: Shows change in shimming (difficult mode) to volume mode

SERIAL NO.	Patient ID	MR Exam	SHIMMING		Artifacts	Image Quality	Sequence
1	RC001	MR BRAIN	difficult mode	volume mode	YES	POOR	T2W_TSE_COR
2	RC005	MR BRAIN	difficult mode	volume mode	YES	POOR	T1W_TSE_TRA
3	RC013	MR BRAIN	difficult mode	volume mode	NO	GOOD	T2W_ TRA_PL
4	RC024	RT. FOOT	difficult mode	volume mode	NO	GOOG	T1W_TSE_SAG
5	RC027	L.S. SPINE	difficult mode	volume mode	YES	FINE	T1W_TSE

FIG. 7:-(a) shimming difficult & (b) shimming volume

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