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Evaluation Of Image Quality Enhancement In 1.5T Magnetic Resonance Brain Imaging: An Exploratory Study

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ABSTRACT

Background: *Magnetic Resonance Imaging (MRI) is one of the most valuable techniques in neuroimaging because of its excellent soft-tissue contrast, non-invasive nature, and ability to produce multiplanar anatomical information [1,3]. Improving image quality at 1.5T isessential to maximize its diagnostic value as 1.5 Tesla MRI systems remain the standard in most clinical environments due to their affordability, widespread availability, and proven diagnostic reliability.*

Methods: *A comparative study was conducted on 41 patients undergoing routine brain MRI at 1.5T. Conventional images (pre-intervention) were compared with optimized images (post-intervention), incorporating protocol adjustments. Two independent skilled and senior radiologists, blinded to acquisition status, assessed image overall image quality using a 5-point Likert scale. Inter-rater agreement was measured with Cohen's kappa test.*

Results: *A total of 53 patients underwent brain MRI at 1.5T during the study period. Of these, 12 cases were excluded according to the predefined exclusion criteria. The final analysis was therefore conducted on 41 patients, which met the sample size requirement for this exploratory study. Where male candidates are 35 and females were 18 only (randomly selected)*

Two independent radiologists evaluatedoverall image quality. Inter-rater agreement for the overall image quality was found to be moderate, with a Cohen's kappa (κ) value of 0.53. Agreement demonstrated fair concordance between raters.

Overall, post-optimization images were consistently rated higher than conventional images across all quality domains. Comparative assessment indicated improvements in sharpness and contrast, with a noticeable reduction in artifacts as well following the application of optimization strategies.

Conclusion: *Image optimization strategies can substantially improve diagnostic quality in 1.5T brain MRI, with measurable gains in clarity, and artifact reduction. These findings highlight the potential for protocol refinement and image processing techniques to enhance routine neuroimaging practice at 1.5T. Further large-scale studies are recommended to validate these preliminary observations.*

Keywords: *Brain MRI, 1.5 Tesla, image quality, artifacts, optimization, exploratory study*

INTRODUCTION

Magnetic Resonance Imaging (MRI) plays a critical role in the evaluation of brain disorders, offering high-resolution visualization of anatomical structures without ionizing radiation. Among available systems, 1.5 Tesla scanners remain widely used in clinical practice due to their accessibility, cost-effectiveness, and reliable diagnostic performance[1].

The present exploratory study aims to assess and compare the diagnostic quality of conventional and optimized brain MRI at 1.5 T, with a focus on clarity, contrast, artifact reduction, and overall image quality. This evaluation may contribute to improved imaging practices in the health care sector for the betterment of effective diagnostic services[2,3].

METHODOLOGY:

Data collection: 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 aims to assess the inter-rater agreement using Cohen's Kappa statistics.

The target population for this study comprises routine brain MRI scans performed at a 1.5T MRI system. A convenience sampling method will be employed to select the MRI scans from patients who underwent routine brain imaging during a specified period. The data collection process will span a defined timeframe to ensure an adequate sample size.

Specific image quality improvement strategies for routine brain MRI at 1.5T will be identified and implemented during the study. These strategies may include protocol optimization, hardware adjustments,. The details of each strategy and the rationale behind their selection will be documented.

Two trained radiologists will independently and blindly rate the image quality of each MRI scan before and after implementing the image quality improvement strategies.. Prior to the rating process, the raters will undergo a comprehensive training session to ensure consistent and reliable assessments.

Patient data and confidentiality will be handled in compliance with ethical guidelines.

TECHNIQUE:

To estimate the sample size needed for an exploratory assessment of inter-rater agreement using Cohen's Kappa.

Formula for Sample Size for Estimating Cohen's Kappa

$n=Z2\cdot P\cdot(1-P)E2n=E2Z2\cdot P\cdot(1-P)$

Where:

- n: required sample size (number of MRI scans)
- ZZ: Z-score corresponding to the desired confidence level

(for 95% confidence, $Z=1.96Z=1.96$)

- PP: expected proportion of agreement (i.e., expected Kappa value)
- EE: desired precision (margin of error around the estimate)

Calculation

- moderate agreement: $P=0.6P=0.6$
- 95% confidence level: $Z=1.96Z=1.96$
- margin of error of ±0.15: $E=0.15E=0.15$

formula:

$n=(1.96)2\cdot0.6\cdot(1-0.6)(0.15)2n=(0.15)2(1.96)2\cdot0.6\cdot(1-0.6)$

$n=3.8416\cdot0.6\cdot0.40.0225=3.8416\cdot0.240.0225=0.9219840.0225n=0.02253.8416\cdot0.6\cdot0.4$

$=0.02253.8416\cdot0.24=0.02250.921984n\approx41n\approx41$

Hence, required exploratory sample size = 41 MRI scans

This will give you a 95% confidence interval for Cohen's Kappa with a ±0.15 margin of error around an expected Kappa of 0.6.

SELECTION CRITERIA OF PATIENTS

INCLUSION CRITERIA:

- Patient those who are coming for routine brain scan.
- Subjects of either sex will be recruited with the age from 18 to 60 years.
- 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 18 and elderly patients above the age of 60.
- Patients who are not willing to participate in the study would be not selected.
- Patients with absolute contraindications.
- Incomplete Imaging Sequences: MRI scans with incomplete imaging sequences, missing essential sequences, or significant motion artifacts will be excluded.

Cohen's Kappa Analysis:

Cohen's Kappa statistics will be calculated to evaluate the inter-rater agreement between the two radiologists. This analysis will measure the level of agreement beyond what is expected by chance, and it will provide insights into the consistency and reliability of image quality assessment before and after implementing the improvement strategies[9].

Data analysis according to patients age group:

The current exploratorystudy a total 41 patient's data has been assessed (the actual total 53 patient's data has been assessed where, 12 were excluded (as per exclusion criteria) and total 41 as per sample size has been selected).

Total Age Range

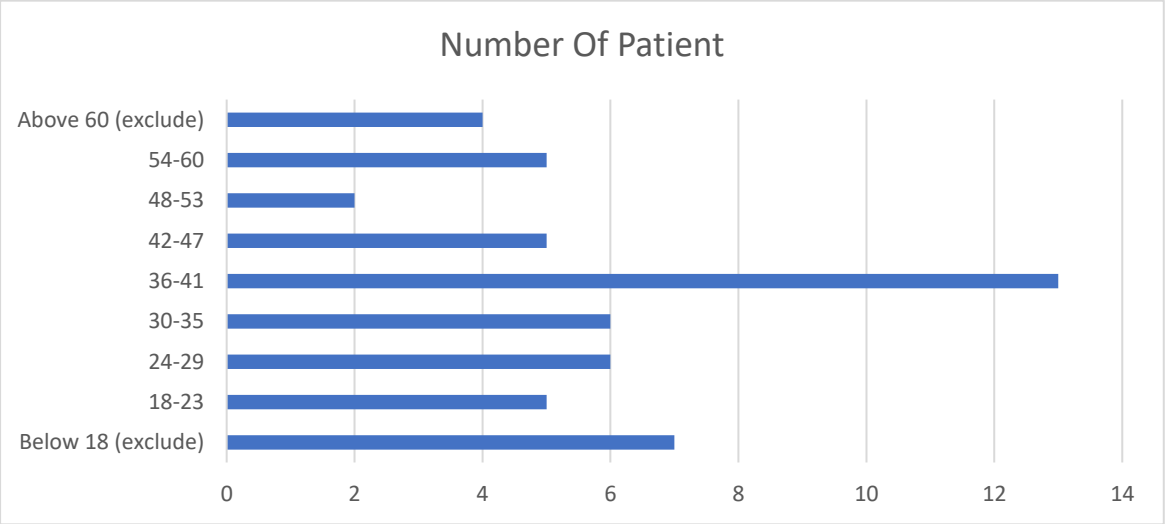
- Minimum age = 18
- Maximum age = 60
- Total range = 60 − 18 = 42 years

Divide into 7 Equal Intervals

- 42 years ÷ 7 groups = 6 years per group

Age Group	Number Of Patient	No of Excluded patients
Below 18 (exclude)	7	7
18-23	5	-
24-29	6	-
30-35	6	-
36-41	13	1
42-47	5	-
48-53	2	-
54-60	5	-
Above 60 (exclude)	4	4
7 age groups	53	12(11age factor + 1artifact)

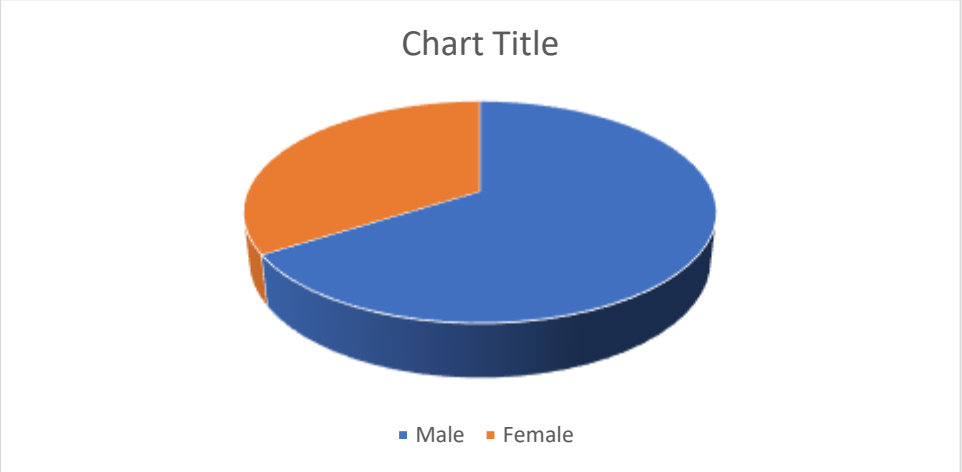
Table no 4.1 showing data of patients according to age group



Graph 4.1 shows the ratio of age group to the number of patients who underwent for MRI scan

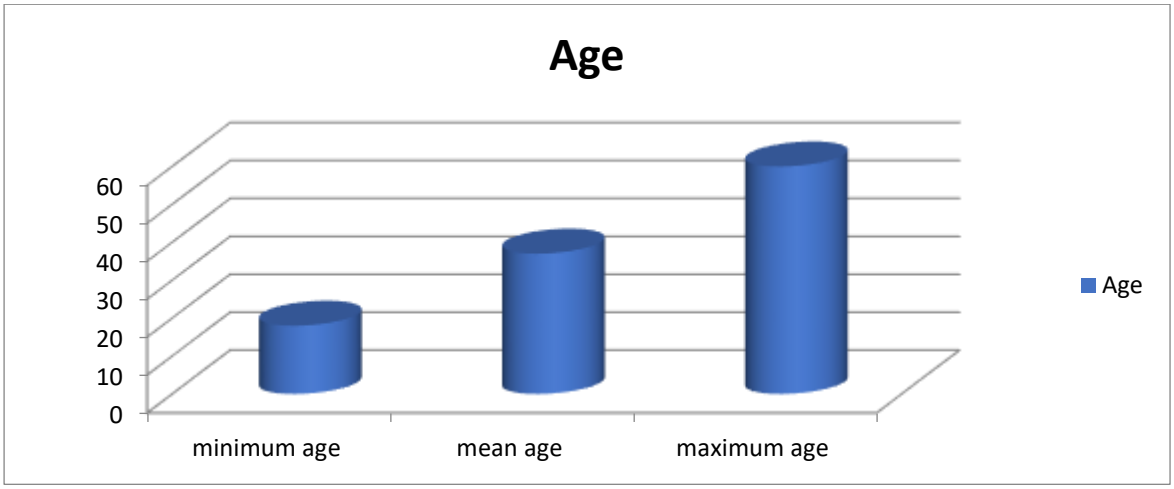
Gender	Number of patient
Male	35
Female	18
TOTAL	53

Table 4.2 shows the ratio of gender to the number of patients who underwent for MRI scan.



Age Group	AGE
Minimum age	18
Mean age	39
Maximum age	60

Graph 4.2 shows the ratio of gender to the number of patients who underwent for MRI scan
Table 4.3 shows the ratio of age range to the number of patients who underwent for MRI scan



Graph 4.3 shows the ratio of gender to the number of patients who underwent for MRI scan

Kappa Statics

Reliability is an important part of any research study. The static of kappa coherences assessment is the inter-rater reliability of 2 raters in a particular sample.

Kappa concurrence is a degree of calculation of accuracy and reliability, agreements. The agreement is measurement is measured between 2 raters (judges). Both the 2 raters separately and blindly judge the MRI Image data both pre and post image improvement strategies and rate the in various categories like image contrast, clarity, artifact and overall quality.

$$k = \frac{p_o - p_e}{1 - p_e}$$

Where P_o is the relative observed agreement among raters and P_e is the hypothetical probability of chance agreement. It can be measured in two ways. First is Inter – rater reliability: it is to evaluate the degree of agreement between the choices made by two (or more independent judges). On the other hand, second is Intra rater reliability: it is to evaluate the degree of agreement presented by the same person at a distance of time.

Interpret the kappa statics

Kappa should always less than or equal to 1. It can be negative as well that happens when both observers agreed less than that would be expected by the chance.

The following point that are necessary for kappa calculation for 2 raters are: -

- Both judges agree to include
- Both judges agree to exclude
- Only the first judge wants to include
- Only the second judge wants to include[9]

RESULT: Calculating Kappa coherence statistics: -

Both the 2 raters separately and blindly judge the MRI Image data, both pre and post image improvement strategies and rate the image in various categories as follow: -

1. Overall MR Image Quality: -

In this study both the 2 raters separately and blindly judge the MR Image data for both the pre and the post image improvement strategies and rated the image on the basis of its Overall Quality of image for both before and after application of image quality improvement strategies. The rating criteria includes rating scale where 1= Poor; 2= Fair; 3= Good; 4= Very Good and 5=Excellent. Which is later classified in to two categories i.e. “YES” and “NO”

Where, YES: The “after image quality improvement strategies” image is recorded as improved (and denoted as “YES”) only if the rater has given more rates to the image in compare to the before application of image quality improvement strategies.

NO: The “after image quality improvement strategies” image is recorded as not improved (and denoted as “NO”) only if the rater has given equal or less rates to the image in compare to the “before application of image quality improvement strategies” Image.

Calculating Kappa coherence statistics for MR image Overall Image Quality.

1. “Rater 1” finds that 37 out of 41 patients image data have YES or improved image quality.
2. “Raters 1” finds that 04 out of 41 patients image data have NO or same or not improved image quality.
3. “Rater 2” finds that 38 out of 41 patients image data have YES or improved image quality.
4. “Raters 2” finds that 03 out of 41 patients image data have NO or same or not improved image quality.
5. Both the radiologist (Rater 1 and Rater 2) agreed that 36 out of the 41 patients image data have YES or improved image quality
6. (leaving 01 patient where the doctors disagreed from each other in a peaceful manner).

7. Both the radiologist (Rater 1 and Rater 2) agreed that 02 out of the 41 patients image data have NO or same or not improved image quality.
8. (leaving 02 patients where the doctors disagreed from each other in a peaceful manner).

The Kappa statistic is calculated using the following formula:

$$\frac{\text{Observed agreement - chance agreement}}{\text{1-chance agreement}}$$

1. **First step: -**
filling 2 X 2 table as follows:

		R1		
		Yes	No	total
R2	Yes	36	02	38
	No	01	02	03
	total	37	04	41

The observed agreement is: (X + Y) / N
Where, "X" = both the raters (radiologist) agreed to include the patients as a positive find.
And, "Y" = both the raters (radiologist) disagreed to include the patients as a positive find or agreed to exclude the patient as negative finding.
N = total no of observation (Patients)
= (36 + 02) / 41
The observed agreement is = 0.92
The observed agreement percentage is: [(a + d) / N] x 100
= 0.78 x 100 = 92.68%

2. **Second step**: -
To calculate the chance agreement: -
note that "R1" found 37/41 patients to have improved image quality and 04/41 to not have improved image quality
And "R2" found 38/41 patients to have improved image quality and 03/41 to not have improved image quality.
formula for "chance of agreement": - $Pe=[(a+b)/N\times(a+c)N] + [(c+d)/N\times(b+d)/N]$
Where,

		R1		
		Yes	No	total
R2	Yes	a	c	a+c
	No	b	d	b+d
	total	a+b	c+d	N

First term = expected Yes agreement
Second term = expected No agreement
i.e $Pe = [(a+b)/N\times(a+c)N] + [(c+d)/N\times(b+d)/N]$
$Pe = [37/41\times38/41] + [04/41\times03/41]$
Pe= 0.84

3. **Third step**: - To find the value of Cohen's Kappa and to calculate the formula is as follow:

$$\frac{\text{Observed agreement Po - chance agreement Pe}}{\text{1-chance agreement Pe}}$$

i.e.
The observed agreement is Po = 0.92

and the chance of agreement is Pe = 0.84
Hence,

$$\text{Kappa} = \frac{0.92 - 0.84}{1-0.84}$$

Kappa= **0.53** Kappa= 0.53
95% confidence interval: From 0.068 to 0.997
A kappa value of 0.53 indicates moderate agreement between observers.

As, the kappa test analyses value can be classified as: -

- 0.01 – 0.20 slight agreement
- 0.21 – 0.40 good agreement
- **0.41 – 0.60 moderate agreement**
- 0.61 – 0.80 substantial agreement
- 0.81 – 1.00 almost perfect or perfect agreement

kappa is always less than or equal to 1. A value of 1 implies perfect agreement and values less than 1 imply less than perfect agreement.It's possible that kappa is negative. This means that the two observers agreed less than would be expected just by chance.
The result for the above study shows a good kappa value, which is as follow:
For the overall imagequality of routine brain MRI have shown moderate level of kappa value i.e. 0.53 which stays in the moderate agreement level of kappa values scale.
The artifact also shows helps in improving image quality as in the total 41 case data 17% data shoes artifact according to R1 and 10% according to R2.
however, many of these cases improved after quality strategies shows 86% of artifact cases improved according to R1 75% of artifact cases improved As per R2.

DISCUSSION:

This study aimed to evaluate inter-rater agreement on MRI image quality parameters—Mainly overall image quality in terms of assessing the impact of artifact-reducing via applied strategies and image contrast and clarity. The findings demonstrate agreement between the two raters, with Cohen's Kappa values indicating moderate agreement for overall image quality (κ = 0.53). Thekappa values suggest that subjective interpretation plays a role in evaluating specific image characteristics, especially contrast, where lower agreement may reflect personal variation in visual perception or diagnostic experience.This outcome underscores the effectiveness of intervention protocols aimed at optimizing image quality in clinical MRI practice.
This exploratory study suggests that protocol adjustments and post-processing refinements can lead to measurable improvements in the quality of brain MRI performed at 1.5 Tesla. Gains were observed in clarity, contrast, and artifact reduction, which may translate into greater diagnostic reliability.

CONCLUSION:

The investigation demonstrates that refining imaging protocols and applying post-processing adjustments can noticeably improve brain MRI quality at 1.5 Tesla. Enhancements were evident in sharpness, contrast, and artifact suppression, thereby supporting greater diagnostic confidence. The study indicates that substantial improvements are possible with existing 1.5T systems, without requiring expensive technological upgrades. Although limited by a small cohort, these initial results lay the groundwork for future research. Larger, multi-institutional studies using objective image quality measures and advanced reconstruction techniques, including artificial intelligence, are needed to confirm and expand upon these findings.

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