Evaluation Of Image Quality In Magnetic Resonance Brain Imaging Of Elderly Patients At 1.5Tesla An Exploratory Study

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ABSTRACT
Background

Magnetic resonance imaging (MRI) is an essential tool in neuroimaging, offering excellent soft-tissue contrast and multiplanar capabilities without ionizing radiation. The 1.5 Tesla (T) MRI system remains the most widely used worldwide, primarily because of its accessibility, lower cost, and reduced susceptibility to certain artifacts when compared to higher-field systems such as 3Tesla[1].

Brain imaging in elderly patients, however, presents unique challenges. Normal aging is often accompanied by cerebral atrophy, ventricular enlargement, and white matter changes, all of which may influence image interpretation[2]. In addition, vascular alterations, including cerebral small vessel disease, are common in older adults and are best demonstrated on T2-weighted and FLAIR sequences[3]. Elderly patients are also more prone to motion during scans, related to discomfort, tremors, or cognitive decline, which can further compromise image quality [4].High-quality imaging is crucial in this population because MRI plays a central role in diagnosing conditions such as dementia, cerebrovascular disease, and Parkinson's disease [5]. Therefore, evaluation of image quality at 1.5 T in elderly patients remains highly relevant for clinical practice.

Despite the extensive use of 1.5 T scanners, few studies have systematically assessed brain image quality in elderly individuals. An exploratory evaluation can provide preliminary insights into common limitations, support protocol refinement, and ultimately improve diagnostic confidence in this rapidly growing patient population.

Method: This Exploratoryresearch 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 23individualpediatric participant's data (10 females and 13males) aged above 60years who underwent MRI scans. Participants with any systemic disease, acute traumaand participants with absolute contraindications were excluded from the study.

As part of the research methodology, independent image quality evaluations are conducted by two expert raters to ensure objectivity and consistency in analysis. Their assessments form the basis for statistical analysis of inter-rater agreement of kappa coherence statistics and contribute significantly to the study's findings on image quality standards and improvements.

Result: This study aimed to evaluate inter-rater agreement on MRI image overall quality. The findings demonstrate the agreement between the two raters, with Cohen's Kappa values indicating fair agreement for image clarity (κ = 0.49),moderateagreement for overall image quality. Thekappa values suggest that subjective interpretation plays a role in evaluating specific image characteristics. This outcome underscores the effectiveness of intervention protocols aimed at optimizing image quality in clinical MRI practice.

INTRODUCTION

Magnetic Resonance Imaging (MRI) is a cornerstone of neuroimaging, providing excellent soft-tissue contrast and multiplanar capability without ionizing radiation exposure[7]. In the elderly population, MRI assumes greater clinical significance due to the higher burden of cerebrovascular disorders, neurodegenerative diseases, and age-related structural brain changes[8]. Reliable imaging in this age group is crucial for timely diagnosis, effective clinical management, and longitudinal monitoring of neurological conditions.

Although 1.5 Tesla (T) MRI scanners remain widely used globally owing to their availability and lower cost, they present limitations when compared to higher field strengths such as 3T. These include reduced signal-to-noise ratio (SNR), lower spatial resolution, and greater susceptibility to image-degrading factors[9]. In elderly patients, these challenges are further accentuated by brain atrophy, vascular calcifications, and increased likelihood of motion during scanning, all of which can compromise diagnostic accuracy[10].

Image quality can be assessed through both subjective and objective measures. Subjective evaluation typically involves expert assessment of clarity, contrast, and artifact burden, while objective methods employ quantitative indices such as SNR and contrast-to-noise ratio (CNR)[11]. Moreover, inter-rater reliability, often expressed using Cohen's kappa statistic, provides insight into the consistency of image quality ratings between independent evaluators[12].This exploratory study aims to assess the quality of routine brain MRI performed at 1.5T in patients over 60 years of age. Specifically, it evaluates image clarity, contrast, and artifact presence, as well as inter-rater agreement, with the goal of identifying potential limitations and guiding optimization strategies for elderly neuroimaging.

METHODS

METHODOFDATACOLLECTION:
STUDY DESIGN: Comparative study.
INCLUSION CRITERIA:
*   Subjects of either sex will be recruited with the age above 60years.
*   Patient those who are coming for pediatric MRI Brain scan.
EXCLUSION CRITERIA:
*   Patients with acute trauma.
*   Patient below the age of 60.
*   Patientswho are not willing to participate in the study would be not selected.
*   Patients with incomplete MRI scan data.
*   Patients with absolute MRI contraindications[3]

This research adopts a comparative study design to evaluate the quality of routine brain magnetic resonance imaging (MRI) scans acquired at 1.5 Tesla before and after the implementation of image quality improvement strategies. The primary aim is to assess the level of agreement between two independent raters, using Cohen's Kappa statistics. Comparative research is well-suited for identifying possible cause–effect relationships between applied interventions and observed outcomes[4].

The study population will consist of elderly patients aged over 60 years who have undergone routine brain MRI examinations using a 1.5 T system. A convenience sampling method will be employed to select MRI scans from this patient group within a defined study period. This sampling approach will allow the inclusion of an adequate number of cases for analysis while reflecting typical clinical practice.

A series of image quality optimization measures tailored to brain MRI in elderly patients at 1.5T will be identified and applied. These strategies may include adjustments in imaging protocols, optimization of sequence parameters, and potential hardware-related modifications.

MRI scans will be collected across two phases: before and after the application of image quality improvement strategies. Each scan will be independently and blindly evaluated by two experienced

radiologists. Assessments will focus on predetermined image quality parameters, including clarity, contrast, artifact levels, and overall diagnostic adequacy. Independent double review ensures reliability, and inter-rater consistency will be quantified using Cohen's Kappa. Preferred sampling technique is employed in this study with sample size of a total 23 number of elderly patients aged over 60 years who have undergone routine brain MRI examinations using a 1.5T system tookpartinthisexploratory study.The data collected was compiled, tabulated, graphical, analyzed, and subjected to statistical tests. Analysis was done using kappa coherence statistical analysis.

RESULTS

Calculating Kappa coherence statistics for MR image Overall Image Quality: -
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: -

Overall, 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.

MR Image Overall Image Qualityis the sharpness, detail, and diagnostic visibility of anatomical structures in magnetic resonance imaging (MRI). High image clarity is essential for accurate diagnosis, particularly in brain imaging. Echo time (TE), repetition time (TR), Slice thickness, voxel size, etc. are some factors that affect 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 **MR image Overall Image Quality**for both before and after application of image quality improvement strategies.

Calculating Kappa coherence statistics for MR image Clarity.

1.   "Rater 1" finds that **19** out of 23 patients image data have YES or improved image quality.
2.   "Raters 1" finds that **04** out of 23 patients image data have NO or same or not improved image quality.
3.   "Rater 2" finds that **17**out of 23 patients image data have YES or improved image quality.
4.   "Raters 2" finds that **06**out of 23 patients image data have NO or same or not improved image quality.
5.   Both the radiologist (Rater 1 and Rater 2) agreed that **16**out of the 23 patients image data have YES or improved image quality
6.   (leaving **01** patients where the doctors disagreed from each other in a peaceful manner).
7.   Both the radiologist (Rater 1 and Rater 2) agreed that **03** out of the 23 patients image data have NO or same or not improved image quality.
8.   (leaving **03**patients where the doctors disagreed from each other in a peaceful manner).

The Kappa statistic is calculated using the following formula:

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

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

R1

	Yes	No	total

R2	Yes	16	01	16
	No	03	03	06
	total	19	04	4

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)
= (16 + 03) / 23
The observed agreement is= 0.826
The observed agreement percentage is: [(a + d) / N] x 100
= 0.7619 x 100 = **82.60%**

2. **Second step: -**
To calculate the chance agreement: -
note that "R1" found 15/21 patients to have improved image quality and 06/21 to not have improved image quality
And "R2" found 16/21 patients to have improved image quality and 05/21 to not have improved image quality.
formula for "chance of agreement": - Pe=[(a+b)/N×(a+c)N] + [(c+d)/N×(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×(a+c)N] + [(c+d)/N×(b+d)/N]
Pe = [19/23×17/23] + [04/23×06/23]
Pe = [0.61]+[0.04]
Pe= 0.65

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 = **82.61%**
and the chance of agreement is Pe = **65.60%**

Hence,

$$Kappa = \frac{0.82 - 0.65}{1 - 0.65}$$

Kappa= 0.38   Kappa= 0.495

95% confidence interval: From -0.076to 0.913

A kappa value of **0.49**indicates good 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.[13]

The result for the above study shows a good kappa value, which is as follow:

For the "overall MR image quality" kappa value is 0.49 which shows good agreement between both the raters.

DISCUSSION:

Furthermore, the variability in rater agreement highlights the importance of training and calibration among radiologists and technologists involved in quality evaluation. The development of objective, automated image quality assessment tools, potentially leveraging artificial intelligence, could also reduce subjectivity and improve reliability in future studies.

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CONCLUSION:

This exploratory study demonstrated that routine brain MRI performed at 1.5T in elderly patients yields images of acceptable diagnostic quality, with inter-rater agreement reaching a moderate level (κ = 0.49). While this suggests that 1.5T scanners can provide clinically useful information, variability in subjective assessments highlights the influence of artifacts, motion, and age-related changes on image interpretation. Standardization of evaluation criteria and the integration of quantitative quality measures may improve consistency across raters. Future research with larger sample sizes, multi-observer designs, and advanced imaging protocols is warranted to optimize brain MRI quality in this growing patient population.

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