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To Evaluate The Image Quality In Pediatric Magnetic Resonance Brain Imaging At 1.5t

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Abstract

Background: This research study titled "To Evaluate the Image Quality in Pediatric Magnetic Resonance Brain Imaging at 1.5T" aims to evaluate and enhance the diagnostic quality of pediatric MRI brain imaging acquired at 1.5 Tesla. This exploratory researchstudy focuses on optimizing imaging protocols and assessing key image quality parameters such as clarity, contrast, and the presence of artifacts in both the pre (conventional MR image) and post (after image quality improvement strategies application) in terms of overall image quality. Through a systematic and comparative review of images, the study seeks to identify potential improvements in clinical imaging practices, particularly in standard pediatric brain MRI.

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 21individualpediatric participant's data (06 females and 15 males) aged 0-17 years 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 = 0.38), fair agreement 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.

Keywords: *MRI, image quality, Pediatric MRI Brain, MRI contrast, MRI artifacts, MR image clarity.'*

INTRODUCTION

Magnetic Resonance Imaging (MRI) is one of the most valuable imaging modalities for the evaluation of pediatric brain disorders because of its superior soft tissue contrast, multiplanar capabilities, and non-ionizing nature. It plays a critical role in diagnosing a wide spectrum of neurological conditions in children, including congenital malformations, neoplastic lesions, infections, and developmental abnormalities.[1]

1.5 Tesla (1.5T), MRI remains the most widely available and clinically utilized field strength, offering a balance between accessibility, cost-effectiveness, and diagnostic capability. Also, optimizing image quality in pediatric brain imaging at 1.5T requires careful consideration of sequence selection, patient preparation, and artifact minimization strategies. This research focuses on "to evaluate the image quality in pediatric magnetic resonance brain 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.

This study is designed to evaluate the image quality in pediatric magnetic resonance brain imaging at 1.5T by assessing key imaging parameters such as clarity, contrast, resolution, and artifacts. Through this evaluation, the study aims to highlight the strengths and limitations of 1.5T imaging in pediatric neuroimaging and to provide insights for protocol optimization, ultimately contributing to enhanced diagnostic accuracy and patient management.

The research will employ a data collection approach, involving pediatric 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 pediatric MRI brain at 1.5T. Overall, the research aims to inform and standardize pediatric MRI brain scans at 1.5T, enhancing diagnostic integrity and propose strategies to enhance image quality, leading to improved diagnostic accuracy and better clinical outcomes.

METHODS

STUDY DESIGN: Comparative study.

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

INCLUSION CRITERIA:

- Subjects of either sex will be recruited with the age from 0 to 17years.
- Patient those who are coming for pediatric MRI Brain scan.

EXCLUSION CRITERIA:

- Patients with acute trauma.
- Patient above the age of 17.
- Patients or their guardianwho are not willing to participate in the study would be not selected.

Patients with absolute MRI contraindications[3]

METHODOFDATACOLLECTION:

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.Comparative research attempts to establish cause–effect relationships among the variables in the study.[4]

The target population for this study comprises pediatric MRI brain scans performed at a 1.5T MRI system. A convenience sampling method will be employed to select the MRI scans from the pediatric 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 pediatric MRI brain 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 skilled senior radiologists will independently and blindly rate the image quality of each MRI scan before and after implementing the image quality improvement strategies, ensuring consistent and reliable assessments.

SAMPLING TECHNIQUE:

Preferred sampling technique.

SAMPLESIZE: ***Total21 number ofpediatricpatientstookpartinthisExploratorystudy.***

STATISTICALANALYSIS:

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 **15** out of 21 patients image data have YES or improved image quality.
2. "Raters 1" finds that **06** out of 21 patients image data have NO or same or not improved image quality.
3. "Rater 2" finds that **16**out of 21 patients image data have YES or improved image quality.
4. "Raters 2" finds that **05**out of 21 patients image data have NO or same or not improved image quality.
5. Both the radiologist (Rater 1 and Rater 2) agreed that **13** out of the 21 patients image data have YES or improved image quality
6. (leaving **03**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 21 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:

Observed agreement - chance agreement 1-chance agreement

1. First step: -

filling 2 X 2 table as follows:

R1

Yes No total

R2	Yes	13	03	16
	No	02	03	05
	total	15	06	21

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)
= (13 + 03) / 21

The observed agreement is= 0.7619
The observed agreement percentage is: [(a + d) / N] x 100
= 0.7619 x 100 = **76.19%**

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 = [15/21×16/21] + [06/21×05/21]
Pe= 0.61

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

<u>Observed agreement Po - chance agreement Pe</u> 1-chance agreement Pe

i.e. The observed agreement is Po = 0.76
and the chance of agreement is Pe = 0.61

Hence,

$$\text{Kappa} = \frac{0.76 - 0.61}{1-0.61}$$

Kappa= 0.386

Kappa= 0.38

95% confidence interval: From -0.054 to 0.826

A kappa value of **0.38** 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.[11]
The result for the above study shows a good kappa value, which is as follow:
For the "overall MR image quality" kappa value is 0.38 which shows good agreement between both the raters.

DISCUSSION:

This study aimed to evaluate inter-rater agreement on MRI overall image quality. The findings demonstrate varied levels of agreement between the two raters, with Cohen's Kappa values indicating **good agreement** for overall image quality. 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.The observed good agreement on overall image quality, compared to lower agreement on specific features, suggests that raters may align more closely when evaluating composite quality rather than isolated parameters. This might indicate the need for clearer standardization or training in assessing individual image features.

CONCLUSION:

The results of this study demonstrate that while inter-rater agreement varies across different MRI image quality parameters, the application of targeted image quality improvement strategies can significantly reduce artifacts and enhance diagnostic image quality. The moderate kappa value for overall image quality suggests a reasonable level of agreement between raters, supporting the consistency of overall evaluations. However, the need for more standardized evaluation criteria or rater calibration.Furthermore, the high percentage of improvement in artifact cases after intervention reinforces the value of continuous quality monitoring and corrective measures in MRI imaging workflows. Future studies with larger sample sizes and automated evaluation tools (e.g., AI-based assessments) may help improve consistency and objectivity in radiological image quality assessments. The findings suggest the importance of:

- Continuous quality assurance protocols,
- Training for image evaluators, and
- Potential integration of objective tools or AI to improve consistency.[10]

Further research with larger datasets and objective measures could reinforce these findings and contribute to more standardized image quality evaluation in clinical practice.

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