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The Review Evaluation of Factors and their Effects on Image Quality of Magnetic Resonance Imaging at 1.5T for Pediatric Brain Imaging

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Abstract

Background: Magnetic Resonance Imaging (MRI) plays a vital role in the evaluation of pediatric brain disorders due to its superior soft tissue contrast and non-ionizing nature. In clinical practice, most routine examinations are performed at 1.5 Tesla, which is widely available and considered the standard field strength across many institutions. However, achieving optimal image quality in pediatric brain MRI at 1.5T presents unique challenges compared to adult imaging.

Methods: Pediatric patients undergoing routine brain MRI at 1.5T were included. Image quality was independently rated by two radiologists based on clarity, contrast, and artifact levels. Inter-rater agreement was assessed using Cohen's kappa statistics, and the effects of technical and patient-related variables on image quality were analysed.

Results: 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. The kappa 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. 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.

Conclusion: Multiple technical and patient-related factors influence image quality in pediatric brain MRI at 1.5T, with patient motion being the most significant contributor. Optimizing protocols and patient preparation can enhance diagnostic confidence and reduce the need for repeat scans.

1. Introduction

Several factors influence image quality in pediatric MRI. These include technical parameters such as magnetic field strength, pulse sequence selection, coil configuration, acquisition time, and signal-to-noise ratio (SNR). In addition, patient-related factors—including younger age, inability to remain still, motion artifacts, and the frequent need for sedation or anesthesia—directly affect diagnostic image quality. Motion, in particular, remains a significant limitation in pediatric brain imaging, often leading to repeat scans, increased examination time, and potential diagnostic uncertainty.

Image quality improvement in MR imaging and the factors affecting it is an important part for the quality services in a radiology department. Providing radiography with superior quality MR imaging to provide better pathology analysis and justice to the diagnosis and all after appropriate treatment to the patient. Also other important factors like, reduce

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MRI scan repetition due to missed out pathology or poor image quality or may be due to artifacts. Using several factors and by manipulating them at a specific manner and certain limits, to improve image quality of MR imaging. The aim of this research is to provide radiology services to ensure superior MR image quality for the betterment of medical and radiology services.

2. Method & Material

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 individual's 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.

All were subjected to MRI scan investigation in routine manner. The data has been collected over a period of 8 months. All those having any systemic disease were not included in the study. Data were collected from the entire population, i.e. randomly selected patient and their vital signs and other medical details, clinical history were recorded and used as data for the above-mentioned research.

3. 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 ($\kappa = 0.38$), fair agreement for overall image quality. The kappa 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. 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 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.

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 Quality is 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:

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

a) 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%**

b) 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

c) 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 = 0.76

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.

4. 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. The kappa 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.

5. 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.