



Research Article

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Effectiveness of GRAPPA-Assisted Head Immobilization in Enhancing Diagnostic Confidence and Interobserver Agreement in Routine Adult Brain MRI: A Prospective Paired Study

Fatima Ibrahim Assi^{1*}, Fezaa Shalal Neda¹, Abdullateef Ali Asghar Mustafa²¹Department of Physiology, College of Medicine, Mustansiriyah University, Baghdad, Iraq; ²Department of Medicine, Radiology Division, College of Medicine, Mustansiriyah University, Baghdad, Iraq

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Abstract

Background: Motion artifacts in brain MRI may reduce image interpretability and diagnostic confidence. Motion-reduction strategies should be evaluated using blinded radiologist assessment and interobserver agreement. **Objective:** To assess the effect of simple head immobilization combined with Generalized Autocalibrating Partially Parallel Acquisitions (GRAPPA) acceleration on motion artifact assessment, diagnostic confidence, and interobserver agreement in brain MRI. **Methods:** This prospective study included 38 adults who underwent standard and intervention diffusion-weighted imaging (DWI) and axial T2-weighted imaging during a single session. The intervention combined foam padding, forehead fixation, and GRAPPA acceleration. Two blinded radiologists assessed motion artifacts and diagnostic confidence. **Results:** The intervention significantly enhanced both sequences' image quality and diagnostic confidence as rated by the radiologists. In DWI, no-artifact ratings for Radiologist 1 increased from 0.0% to 55.3% and for Radiologist 2 from 5.3% to 60.5%, while very high diagnostic confidence increased from 10.5% to 63.2% and from 7.9% to 71.1% ($p=0.0001$). In axial T2-weighted imaging, no-artifact ratings increased from 2.6% to 63.2% and from 7.9% to 60.5%, while very high diagnostic confidence increased from 7.9% to 60.5% and from 26.3% to 73.7% ($p=0.0001$). These results indicate that the reduction in motion led to a clinically significant improvement in the consistency of image interpretation. Cohen's kappa for diagnostic confidence was almost perfect and remained stable in DWI (0.941 to 0.944) and increased in axial T2-weighted imaging (0.469 to 0.964). **Conclusions:** GRAPPA-assisted head immobilization improved image quality and diagnostic confidence in routine adult brain MRI, supporting strong diagnostic confidence and acceptable interobserver agreement.

Keywords: Brain MRI; Diagnostic confidence; GRAPPA.

فعالية تثبيت الحركة للرأس بمساعدة GRAPPA في تعزيز الثقة التشخيصية والاتفاق بين المراقبين في تصوير الدماغ المعتاد للبالغين: دراسة مستقبلية مزدوجة

الخلاصة

الخلفية: قد تقلل التشوهات الحركية في تصوير الرنين المغناطيسي للدماغ من قابلية تفسير الصورة والثقة التشخيصية. يجب تقييم استراتيجيات تقليل الحركة باستخدام تقييم مختص الأشعة الأعمى والاتفاق بين المراقبين. **الهدف:** تقييم تأثير تثبيت الحركة البسيط للرأس مع تسريع الاستحواذ المتوازي جزئياً المعمم (GRAPPA) على تقييم التشوش الحركي، والثقة التشخيصية، والاتفاق بين المراقبين في تصوير الدماغ بالرنين المغناطيسي. **الطرائق:** شملت هذه الدراسة المستقبلية 38 بالغاً خضعوا للتصوير القياسي والتصوير المرجح بالانتشار (DWI) والتصوير المرجح بمحورية T2 خلال جلسة واحدة. جمع التدخل بين الحشوة الرغوية، وتثبيت الجبهة، وتسريع GRAPPA. قام طبيباً أشعة بتقييم تشوهات الحركة والثقة التشخيصية. **النتائج:** عزز التدخل جودة صورة كلا التسلسلين وثقته التشخيصية كما تم تقييمهما من قبل أطباء الأشعة. في نظام DWI، ارتفعت تقييمات عدم وجود آثار لأخصائي الأشعة 1 من 0.0% إلى 55.3%، ولأخصائي 2 من 5.3% إلى 60.5%، بينما ارتفعت الثقة التشخيصية العالية جداً من 10.5% إلى 63.2% ومن 7.9% إلى 71.1% ($p=0.0001$). في التصوير المحوري المرجح بالسكري T2، ارتفعت تقييمات عدم وجود الآثار من 2.6% إلى 63.2% ومن 7.9% إلى 60.5%، بينما ارتفعت الثقة التشخيصية العالية جداً من 7.9% إلى 60.5% ومن 26.3% إلى 73.7% ($p=0.0001$). تشير هذه النتائج إلى أن انخفاض الحركة أدى إلى تحسن سريري مهم في اتساق تفسير الصور. كان كلاً من كوهين للثقة التشخيصية شبه مثالي وظل مستقرًا في نظام DWI (0.941 إلى 0.944) وارتفع في التصوير المحوري الموزون ب T2 (0.469 إلى 0.964). **الاستنتاجات:** حسن تثبيت الحركة للرأس بمساعدة GRAPPA جودة الصورة والثقة التشخيصية في التصوير بالرنين المغناطيسي الروتيني للدماغ البالغ، مما دعم الثقة التشخيصية القوية والاتفاق المقبول بين المراقبين.

***Corresponding author:** Fatima Ibrahim Assi, Department of Physiology, College of Medicine, Mustansiriyah University, Baghdad, Iraq;Email: fatimaibrahim@uomustansiriyah.edu.iq**Article citation:** Assi FI, Neda FS, Mustafa AAA. Effectiveness of GRAPPA-Assisted Head Immobilization in Enhancing Diagnostic Confidence and Interobserver Agreement in Routine Adult Brain MRI: A Prospective Paired Study. *Al-Rafidain J Med Sci.* 2026;11(2):46-52. doi: <https://doi.org/10.54133/ajms.v11i2.3156>© 2026 The Author(s). Published by Al-Rafidain University. This is an open access journal issued under the CC BY-NC-SA 4.0 license (<https://creativecommons.org/licenses/by-nc-sa/4.0/>).

INTRODUCTION

Brain MRI is highly sensitive to patient motion because image data are acquired sequentially over time, making even the smallest head movement capable of producing visible artifacts and reducing the clarity of the image [1]. This is a common practical problem in clinical MRI, as artifacts resulting from motion may degrade the quality of the diagnostic image, increase repeat imaging, and reduce workflow efficiency [2]. In brain MRI,

degradation due to motion can present as blurring, ghosting, or spatial distortion, which might obscure subtle findings and affect radiological interpretation [3]. Parallel imaging has been used to make MRI more efficient by decreasing the number of phase-encoding steps needed during image acquisition. Generalized Autocalibrating Partially Parallel Acquisitions (GRAPPA) is a well-known parallel imaging technique where undersampled k-space data is reconstructed using information from multi-channel receiver coils [4].

Recent studies on parallel MRI reconstruction also highlight the importance of sampling strategies and k-space reconstruction for image quality [5]. By reducing acquisition time, parallel imaging may decrease the chance for patient motion and thus contribute to better image quality in routine MRI examinations [6]. Simple head immobilization is another practical approach to decrease patient motion during brain MRI, as mechanical stabilization can restrict head displacement inside the coil [7]. Pre-scan preparation has been shown to decrease motion artifacts and improve head MRI quality [8]. Real-time monitoring of motion further supports the control of motion by enhancing the quality of MRI data and reducing the need for repeated imaging [9]. While objective image quality measures play a role, the value of strategies to reduce motion clinically also depends on the radiologist's confidence in reading the images. Confidence in making a diagnosis is based on the clarity of MRI images and may decrease in the presence of motion artifacts that obscure anatomical details or reduce image quality; studies of motion correction have demonstrated that reducing degradation related to motion can enhance clinical utility of MRI images [10]. Thus, the evaluation by blinded radiologists is essential to determine whether technical image improvement translates into interpretability that matters. Interobserver agreement is another important aspect of radiological research since it shows the reproducibility of image interpretation between different, independent readers. Cohen's kappa is most often used to assess the agreement beyond chance in categorical ratings, e.g., artifact severity and diagnostic confidence classification [11]. Kappa values have a well-defined interpretation that standardizes the description of the strength of agreement among observers [12]. The need for transparent assessment of observer variability in reader-based research is further underscored by the reliability and agreement reporting guidelines [13]. Despite the recognized importance of motion artifact reduction in brain MRI, many studies have focused mainly on technical image quality rather than reader-based clinical outcomes [14]. Limited attention has been given to whether combining simple head immobilization with GRAPPA acceleration can improve radiologist-rated motion artifact assessment, diagnostic confidence, and interobserver agreement in routine adult brain MRI. This study aimed to evaluate how effective GRAPPA-assisted head immobilization is in enhancing diagnostic confidence and interobserver agreement during blinded radiologist assessments.

METHODS

Study design and participants

This exploratory prospective within-subject paired study was conducted at the Institute of Radiology, Medical City, Baghdad, Iraq. Eligible adult participants were recruited consecutively during the defined study period.

The sample size reflected the exploratory nature of the study and the number of eligible participants who completed both imaging protocols during this period. A total of 38 participants, comprising 19 males and 19 females, completed both the standard and intervention protocols and were included in the final paired analysis. Each participant underwent both protocols during the same examination session and served as their own control, enabling directly matched within-participant comparisons and minimizing the influence of interindividual variability.

Inclusion and exclusion criteria

Eligible patients were adults aged 18 years or older requiring routine brain MRI with DWI and axial T2-weight imaging. Patients with severe agitation requiring sedation, inability to provide informed consent, or contraindications to extended MRI examination were excluded.

MRI protocols

All examinations were performed using the same 1.5-T MRI scanner (MAGNETOM Altea, Siemens Healthineers, Erlangen, Germany) equipped with a 20-channel head/neck coil. The same scanner and coil were used for all participants throughout the study. The standard protocol consisted of routine diffusion-weighted imaging (DWI) and axial T2-weighted imaging without additional head immobilization or GRAPPA acceleration. The intervention protocol consisted of the same routine DWI and axial T2-weighted sequences, with the addition of simple head immobilization and GRAPPA acceleration using a reduction factor of 2 ($R = 2$). Thus, GRAPPA was used to accelerate the routine sequences rather than replace them.

Selection of MRI Sequences

DWI and axial T2-weighted imaging were selected because they are routinely included in adult brain MRI protocols and provide complementary diagnostic information through distinct acquisition techniques. DWI, acquired using single-shot echo-planar imaging, is susceptible to motion-related signal inconsistencies and geometric distortion, whereas axial T2-weighted turbo spin-echo imaging provides detailed structural tissue contrast and may be degraded by motion-related blurring and ghosting. Including both sequences allowed the intervention to be evaluated across two clinically relevant routine acquisitions with different technical characteristics.

Blinded radiologist assessment

All MRI images were anonymized before assessment. Two specialists in diagnostic radiology, each with 10

years of clinical experience at the Institute of Radiology, Medical City, Baghdad, Iraq, independently reviewed the standard and intervention images in a blinded manner without knowledge of the imaging protocol. Both readers were diagnostic radiologists rather than formally subspecialized neuroradiologists. They independently assessed motion artifact severity and diagnostic confidence in DWI and axial T2-weighted images.

Motion artifact scoring

Motion artifacts were assessed independently by each radiologist for both MRI sequences using a four-point ordinal scale: 0, no motion artifact; 1, mild artifact without diagnostic impact; 2, moderate artifact with partial diagnostic impact; and 3, severe non-diagnostic artifact.

Diagnostic confidence scoring

Diagnostic confidence was assessed using a five-point Likert scale: 1, very low confidence; 2, low confidence; 3, moderate confidence; 4, high confidence; and 5, very high confidence. For interobserver agreement analysis, scores were grouped into low, moderate, and high confidence categories.

Interobserver agreement analysis

Interobserver agreement between the two radiologists was evaluated using Cohen's kappa after the categories were grouped. Motion artifact scores were dichotomized as no artifact versus artifact present, while diagnostic confidence scores were grouped into low, moderate, and high categories to support clinically meaningful agreement analysis.

Ethical considerations

Ethical approval was obtained from the Council of the College of Medicine, Al-Mustansiriyah University. The study was conducted at the Institute of Radiology, Medical City, Baghdad, Iraq, in accordance with the Declaration of Helsinki. Written informed consent was obtained from all participants. The intervention involved only simple non-invasive head immobilization and routine MRI acquisition.

Statistical analysis

Statistical analysis was performed using IBM SPSS Statistics, version 29.0. Categorical variables were summarized as frequencies and percentages. Paired ordinal outcomes were compared using the Wilcoxon signed-rank test. Interobserver agreement was assessed with Cohen's kappa after category grouping. A *p*-value < 0.05 was considered statistically significant.

RESULTS

A total of 38 adult participants completed both imaging protocols and were included in the paired analysis. The mean age was 45.1 ± 17.7 years, with an age range of 18–75 years. Sequence acquisition time decreased from 57 to 49 seconds for DWI and from 105 to 64 seconds for axial T2-weighted imaging. These values refer to the evaluated sequences rather than to the complete brain MRI examination. Because the acquisition times were fixed by the predefined protocol parameters, they are presented descriptively. Blinded radiologist assessment showed a shift toward lower motion artifact grades after the intervention in both DWI and axial T2-weighted imaging, as presented in Table 1.

Table 1: Blinded radiologist-rated motion artifact grades before and after GRAPPA-assisted head immobilization in DWI and Axial T2-weighted imaging (n= 38)

Sequence	Radiologist	Protocol	No artifact	Mild	Moderate	Severe	<i>p</i> -value
DWI	Radiologist 1	Standard	0(0.0)	23(60.5)	15(39.5)	0(0.0)	0.0001
DWI	Radiologist 1	Intervention	21(55.3)	15(39.5)	2(5.3)	0(0.0)	
DWI	Radiologist 2	Standard	2(5.3)	21(55.3)	15(39.5)	0(0.0)	0.0001
DWI	Radiologist 2	Intervention	23(60.5)	15(39.5)	0(0.0)	0(0.0)	
Axial T2	Radiologist 1	Standard	1(2.6)	34(89.5)	3(7.9)	0(0.0)	0.0001
Axial T2	Radiologist 1	Intervention	24(63.2)	13(34.2)	1(2.6)	0(0.0)	
Axial T2	Radiologist 2	Standard	3(7.9)	28(73.7)	7(18.4)	0(0.0)	0.0001
Axial T2	Radiologist 2	Intervention	23(60.5)	15(39.5)	0(0.0)	0(0.0)	

Values are presented as number (%). DWI, diffusion-weighted imaging; T2, T2-weighted imaging.

In DWI, no-artifact ratings increased from 0.0% to 55.3% for Radiologist 1 and from 5.3% to 60.5% for Radiologist 2, while moderate artifact ratings decreased from 39.5% to 5.3% and from 39.5% to 0.0%, respectively. In axial T2-weighted imaging, no-artifact ratings increased from 2.6% to 63.2% for Radiologist 1 and from 7.9% to 60.5% for Radiologist 2, while moderate artifact ratings decreased from 7.9% to 2.6% and from 18.4% to 0.0%, respectively. These changes were statistically significant for both radiologists in both

sequences ($p = 0.0001$). Diagnostic confidence improved after the intervention in both DWI and axial T2-weighted imaging, as summarized in Table 2. Very low or low confidence ratings were not recorded under either protocol. In DWI, very high confidence increased from 10.5% to 63.2% for Radiologist 1 and from 7.9% to 71.1% for Radiologist 2, while moderate confidence decreased from 36.8% to 5.3% and from 39.5% to 5.3%, respectively. These changes were statistically significant for both radiologists ($P = 0.0001$).

Table 2: Radiologist-rated diagnostic confidence before and after GRAPPA-assisted head immobilization in DWI and axial T2-weighted imaging (n=38)

Sequence	Radiologist	Protocol	Moderate confidence	High confidence	Very high confidence	p-value
DWI	Radiologist 1	Standard	14(36.8)	20(52.6)	4(10.5)	0.0001
DWI	Radiologist 1	Intervention	2(5.3)	12(31.6)	24(63.2)	
DWI	Radiologist 2	Standard	15(39.5)	20(52.6)	3(7.9)	0.0001
DWI	Radiologist 2	Intervention	2(5.3)	9(23.7)	27(71.1)	
Axial T2	Radiologist 1	Standard	6(15.8)	29(76.3)	3(7.9)	0.0001
Axial T2	Radiologist 1	Intervention	1(2.6)	14(36.8)	23(60.5)	
Axial T2	Radiologist 2	Standard	5(13.2)	23(60.5)	10(26.3)	0.0001
Axial T2	Radiologist 2	Intervention	2(5.3)	8(21.1)	28(73.7)	

Values are presented as frequency and percentage. DWI, diffusion-weighted imaging; T2, T2-weighted imaging.

Figure 1 presents the DWI diagnostic confidence scores assessed by Radiologist 2 before and after GRAPPA-assisted head immobilization. In axial T2-weighted imaging, very high confidence increased from 7.9% to 60.5% for Radiologist 1 and from 26.3% to 73.7% for Radiologist 2, while moderate confidence decreased from 15.8% to 2.6% and from 13.2% to 5.3%, respectively. These changes were statistically significant for both radiologists ($p=0.0001$).

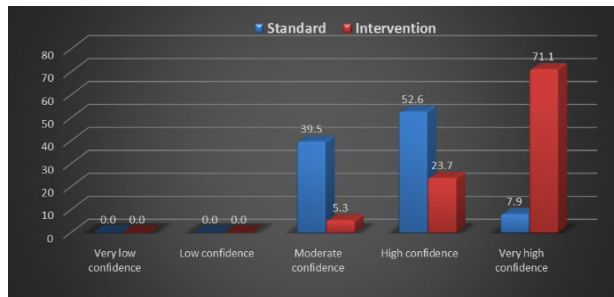
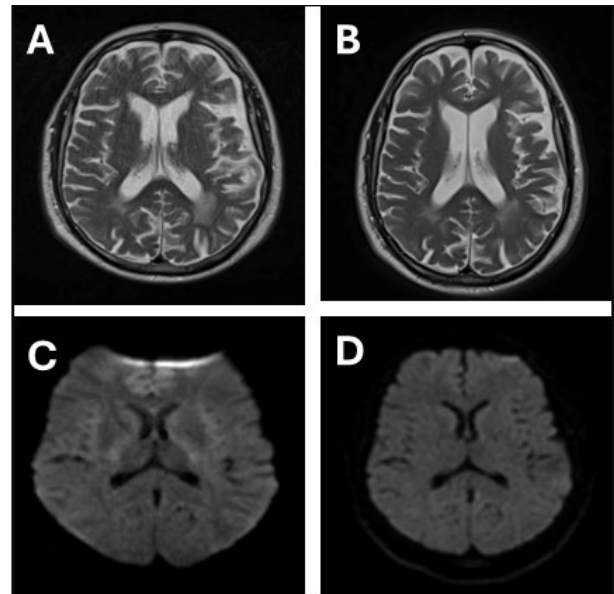
**Figure 1:** Diagnostic confidence assessment by radiologist 2 for DWI images.

Figure 2 presents the axial T2-weighted diagnostic confidence scores assessed by Radiologist 2 before and after GRAPPA-assisted head immobilization.

**Figure 2:** Axial T2-weighted diagnostic confidence scores for Radiologist 2 in the standard and intervention protocols.

Representative anonymized paired DWI and axial T2-weighted images acquired from the same study

participant under the standard and intervention protocols are presented in Figure 3. Interobserver agreement between the two radiologists was assessed using Cohen's kappa after category grouping, as presented in Table 3. Agreement for diagnostic confidence remained almost perfect in DWI under both protocols and improved from moderate to almost perfect in axial T2-weighted imaging after the intervention.

**Figure 3.** Representative paired brain MRI images obtained using the standard and intervention protocols. (A) Standard axial T2-weighted image. (B) Intervention axial T2-weighted image obtained with simple head immobilization and GRAPPA acceleration. (C) Standard diffusion-weighted image (DWI). (D) Intervention DWI obtained with simple head immobilization and GRAPPA acceleration.

For motion artifact assessment, post-intervention agreement was moderate in both sequences. Kappa was not calculated for standard DWI motion artifact assessment due to insufficient variability in the distribution of rating categories.

Table 3: Interobserver agreement between the two radiologists for motion artifact assessment and diagnostic confidence using Cohen's Kappa

Outcome	Sequence	Protocol	Category grouping	Cohen's kappa	Interpretation
Motion artifact score	DWI	Standard	No artifact vs. artifact	Not calculated	Insufficient variability
Motion artifact score	DWI	Intervention	No artifact vs. artifact	0.601	Moderate agreement
Motion artifact score	Axial T2	Standard	No artifact vs. artifact	0.959	Almost perfect agreement
Motion artifact score	Axial T2	Intervention	No artifact vs. artifact	0.607	Moderate agreement
Diagnostic confidence	DWI	Standard	Low/Moderate/High	0.941	Almost perfect agreement
Diagnostic confidence	DWI	Intervention	Low/Moderate/High	0.944	Almost perfect agreement
Diagnostic confidence	Axial T2	Standard	Low/Moderate/High	0.469	Moderate agreement
Diagnostic confidence	Axial T2	Intervention	Low/Moderate/High	0.964	Almost perfect agreement

DISCUSSION

The present prospective within-subject paired study showed that the combined application of simple head immobilization and GRAPPA acceleration ($R=2$) was associated with lower reader-rated motion artifact grades, higher diagnostic confidence, and shorter sequence acquisition times in routine DWI and axial T2-weighted imaging. The paired design allowed each participant to serve as their own control, thereby reducing the influence of interindividual variability. Because head immobilization and GRAPPA were introduced simultaneously, the findings represent the effect of the combined protocol and do not establish the independent contribution of either component. In addition, head movement was not measured directly; therefore, the improvement in reader-based assessments should not be interpreted as direct quantitative evidence of reduced head displacement. Published studies relevant to simple head-motion reduction have evaluated approaches that share some practical features with the present intervention but differ in their mechanisms and imaging settings. Krause *et al.* used medical tape across the forehead to provide tactile feedback and reported reductions in translational and rotational head motion during MRI [15]. Jolly *et al.* found that foam pillows combined with medical tape produced the greatest reduction in head motion during naturalistic fMRI, whereas customized headcases did not consistently outperform conventional support methods [16]. These studies provide context for low-resource head-motion reduction; however, their tape-based approaches relied partly on tactile feedback rather than mechanical immobilization and were evaluated primarily in functional MRI settings. In contrast, Mekiš *et al.* found no significant difference in motion artifacts or overall image quality between mask immobilization and standard diagnostic positioning during intracranial MRI for radiotherapy planning [17]. Their study used different coils, immobilization methods, imaging objectives, and sequences, including contrast-enhanced 3D T1-weighted imaging and T2-FLAIR. These differences indicate that the effectiveness of head immobilization may depend on the fixation method, imaging sequence, examination setting, and expected pattern of patient movement. GRAPPA represented the acceleration component of the present protocol. In diffusion-weighted MRI, GRAPPA-based parallel imaging can reduce the amount of phase-encoding data required and shorten acquisition; however, its performance depends on the acceleration factor, coil configuration, calibration data, and reconstruction parameters. Laib *et al.* demonstrated through theoretical modeling that GRAPPA and system parameters influence the estimation quality of diffusion MRI measurements [18]. Rabanillo *et al.* further demonstrated that GRAPPA reconstruction can produce spatially variable noise amplification characterized by

the geometry factor [19]. These studies support the need to balance acquisition efficiency against potential noise-related limitations when selecting an acceleration factor. In the present protocol, GRAPPA at $R=2$ with a 20-channel head/neck coil shortened acquisition time in both evaluated sequences. Shorter acquisition windows may reduce the opportunity for patient motion and improve workflow efficiency. These findings apply to the evaluated DWI and axial T2-weighted sequences rather than to the complete brain MRI examination. Because the acquisition-time differences were determined by the predefined sequence parameters, they were interpreted descriptively. Nevertheless, the observed improvement cannot be attributed to GRAPPA alone because acceleration and immobilization were applied together. The present intervention differs technically from advanced perspective motion-correction methods. Aranovitch *et al.* used head-mounted NMR markers to estimate head position and prospectively update imaging coordinates without altering the design of the standard imaging sequences [20]. Tisdall *et al.* used volumetric navigators to track head position during acquisition and demonstrated reductions in motion-induced bias and variance in brain morphometry [21]. Such methods can directly detect and correct motion but may require dedicated markers, tracking components, navigator integration, calibration, or additional technical expertise. In contrast, the present combined protocol is simpler and can be implemented using routine clinical MRI equipment without a dedicated motion-tracking system. However, this simplicity is also a limitation because the protocol may restrict movement and shorten the acquisition window but cannot identify or correct residual or abrupt motion in real time. Therefore, the present intervention should be regarded as a preventive motion-reduction strategy rather than a direct motion-correction technique. Interobserver agreement provided additional information regarding the consistency of the reader-based assessments. Agreement for diagnostic confidence was almost perfect in DWI under both protocols and improved from moderate to almost perfect in axial T2-weighted imaging after the intervention. In contrast, post-intervention agreement for motion artifact assessment was moderate in both sequences, indicating that some variability in artifact grading remained between the two radiologists. Kappa could not be calculated for standard DWI motion artifact assessment because of insufficient variability in the distribution of the grouped rating categories. Cohen's kappa is a chance-corrected measure commonly used to evaluate agreement for categorical radiological assessments [22,23]. However, its value may be influenced by category prevalence and marginal distributions, particularly when ratings are concentrated within one dominant category [23,24]. Consequently, the kappa findings should be interpreted together with the complete distribution of motion artifact and diagnostic

confidence ratings rather than as isolated indicators of agreement [25]. The moderate post-intervention interobserver agreement for motion artifact assessment in both sequences indicates that some variability in artifact grading remained between the two radiologists. Nevertheless, the concurrent improvement in diagnostic confidence supports better perceived image interpretability following GRAPPA-assisted head immobilization. This finding should not be interpreted as direct evidence of improved diagnostic accuracy because lesion-detection performance, diagnostic sensitivity, and clinical outcomes were not evaluated. The principal practical advantages of the combined protocol are its non-invasive and low-resource nature, compatibility with routine MRI equipment, absence of specialized motion-tracking hardware, and shorter acquisition times for the evaluated DWI and axial T2-weighted sequences. Its principal technical limitations include the inability to separate the individual effects of immobilization and GRAPPA, the absence of quantitative motion tracking, and the inability to correct residual movement after it occurs. Direct comparison with the cited literature remains limited because these studies evaluated immobilization or GRAPPA-based acceleration separately and used different sequences, imaging objectives, or examination settings. Future studies should compare immobilization alone, GRAPPA alone, and their combined application while incorporating objective motion measurements and a broader range of routine brain MRI sequences.

Strength and Limitations

A strength of the present study is its prospective paired design, in which both the standard and intervention protocols were carried out in the same examination session by each participant. With this design, inter-patient variability was minimized, and a direct within-subject comparison was made possible. Blinded radiologist assessment added to the reliability of the reader-based outcomes. This is in line with the recommendation that the proper use of agreement and reliability measures is important when observer-based ordinal assessments are used in clinical research. On the whole, it seems that GRAPPA-assisted head immobilization is a practical and clinically feasible strategy to boost radiologist diagnostic confidence and ensure reliable interobserver agreement in routine adult brain MRI. The intervention is simple, low-cost, non-invasive, and easily applicable within the regular workflow of a clinical setting. This will help boost confidence and agreement among readers during image interpretation and may thus contribute to more reliable diagnostic assessment in routine brain MRI practice. Findings of this study should be interpreted in light of some limitations. It was a single-center study with 38 adult patients, which may confine the generalizability of its findings to other institutions or MRI systems. However, the prospective paired design, where each

patient was his or her control, helped minimize variability between patients and thereby enhanced the comparison between the two protocols. Second, the analysis was restricted to DWI and axial T2-weighted sequences in routine brain MRI; hence, findings may not be generalizable to all other MRI sequences. The intervention comprised basic head immobilization along with GRAPPA acceleration, thus precluding the assessment of the individual effect of each component. However, the study reflects how the new protocol would actually be used in practice within a regular clinical workflow. Lastly, motion was evaluated using radiologist-rated image quality rather than direct motion tracking. Nonetheless, this is the approach that mimics the practical diagnostic impact of motion artifacts in the routine interpretation of clinical images.

Conclusion

GRAPPA-Assisted Head Immobilization Improves Image Quality and Diagnostic Confidence in Routine Adult Brain MRIs. The method further reduced the problems of image degradation due to motion by shortening the acquisition time and limiting head displacement. The method also demonstrated strong agreement in diagnostic confidence and acceptable interobserver agreement for artifact assessment, confirming its practical, non-invasive, and low-cost clinical value in routine practice.

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Conflict of interests

The authors declared no conflict of interest.

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Data sharing statement

The data that supports the findings of this study are available from the corresponding author upon a reasonable request.

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