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OPTIMIZATION OF R-FACTOR AT GRAPPA PARALLEL ACQUISITION TECHNIQUE ON THE IMAGE INFORMATION T2 AXIAL BRAIN MRI

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ABSTRACT

Background: *GRAPPA or Generalized Auto-calibrating Partially Parallel Acquisitions is a parallel acquisition technique which can reduce the scan time in MRI examination.*
Aims: *This study aims to investigate the effect of the R-factor variation of GRAPPA on image anatomical information quality and to determine the optimization value of GRAPPA e-factor to fasten the scan time with acceptable image information quality.*
Methods: *Eight respondents will perform T2 axial Brain MRI examination with various values of GRAPPA R-factor (1 to 7), evaluation was conducted with questionnaire which was given to 3 radiologists to assess the anatomical structure of the lateral ventricle, thalamus, caudate nucleus, lent form nucleus, internal capsule and background area. Data from respondents were then tested with Spearman test and Friedman test.*
Results: *Statistics test showed that there was significant effect of GRAPPA parallel acquisition technique on the anatomical image information quality of T2 axial Brain MRI (p value of 0,001<0,05) and the correlation direction was negative, in which the higher the value of r-factor GRAPPA used, the lower the quality of anatomical image information. Based on the result of mean rank, image with optimal image anatomical information quality was image with GRAPPA R-factor of 1 (mean rank = 6.01), but image anatomical information quality with GRAPPA R-factor of 3 was acceptable with fast scan time (opinion of 75 % of all radiologists).*
Conclusion: *R-factor at GRAPPA parallel acquisition technique could reduce scan time, but the higher the value of r-factor GRAPPA used, the lower the quality of image anatomical information.*

Keywords: *r-factor, GRAPPA, T2 Axial Brain MRI.*

INTRODUCTION

Magnetic resonance imaging or MRI is a medical diagnostic examination on medicine especially radiology with the use of high magnetic field and radiofrequency to analyze and visualize the soft tissues, blood flow, and function of the body's metabolism [1]. The application is high magnetic field of 0.064 Tesla - 1.5 Tesla (1 tesla=1000 Gauss) and resonance to hydrogen nuclei [2]. In addition to image quality, scan time is also a very important thing to be considered in MRI examination. MRI Scanner has limitation in the speed of scan time due to technical issues and functions related to the magnetic field gradient [3]. With parallel MRI, reduction in acquisition time can be achieved without the need to increase the performance of a magnetic field gradient [4].

Parallel magnetic resonance imaging (pMRI) is an advanced technique to improve MRI data acquisition speed by crossing some phase-encoding lines in the k-space while the encoding frequency direction is retained in full [5]. The idea of parallel MRI was introduced in the end of the 1980s,

however, in the 1990s it began to be used in MRI scanning. This technique has been used in many clinical settings since2000 and the development has been being conducted by experts. Parallel reconstruction technique can be used to improve image quality by increasing the signal to noise ratio, spatial resolution, reduced artifacts and temporal resolution of MRI scans [3].

Parallel imaging has the basic functions of a reduction in scan time and maintain image contrast without requiring a higher gradient performance system [6]. Due to faster image acquisition, parallel imaging in some cases can even significantly improve the image quality [4]. GRAPPA (Generalized Auto-calibrating Partially Parallel Acquisitions) is one method used to reconstruct the data by speeding up scan time by using a parallel MRI. The technique is based by finding correlations in the data obtained from a multi-coil MRI machine [7]. GRAPPA concept was introduced by Griswold in 2002 as a more general view of VD-SMASH AUTO and produced better image quality overall because of the increased artifactsupression [8].

GRAPPA is a more general implementation compared to VD-AUTO-SMASH. Although approach [9]. Even though those two techniques have the same acquisition, but there is a significant difference in the reconstruction of how to eliminate the k-space lines. The fundamental difference lies in the coil signal components which only have a single auto calibration signal and not the signal components thus lowering the linear weight to eliminate the k-space line in each coil component [4].

During preliminary study in Telogorejo Hospital, Semarang, the authors often found an TSE Brain Axial T2 MRI examination which used parallel acquisition technique og GRAPPA mode with R-factor of 2, while R-factor in GRAPPA parallel acquisition technique contained in MRI machine of Siemens MAGNETOM Avanto 1.5 Tesla is 1-7. From the above problems, the authors would like to find out the optimal use of GRAPPA application in order to obtain optimal image quality with fast scan time. This study is expected to be able to determine the effect of changes in GRAPPA R-factor on image anatomical information quality of Brain MRI of T2 TSE Axial sequence, as well as to determine the value of GRAPPA R-factor that can display the most optimal MRI image anatomical information.

METHODS

The type of research is a quasi-experimental employed posttest only control group design. This study was conducted with the following phases:

Preparation phase

Five respondents were chosen by non-randomization, with criteria: health respondent, man or woman in range 25-30 age, non claustrophobia, and agree to participant at research with signature on Informed Consent. Brain MRI examination of Axial slice with T2 TSE sequence was performed by using 1.5 Tesla MRI equipment at Telogorejo Hospital Semarang.

Implementation phase

Performed Brain MRI imaging of Axial slice with T2 TSE sequence. Respondents were in supine position, head first, used an array head coil and isocentre in the nation. Created T2 Axial slice with the changes in the variation of GRAPPA R-factor value of 1-7 with other parameters is fixed. Prepared and printed out the MRI image that would be observed by the radiologist, in the form of a single sheet of film that contained Axial slice Brain MRI image of T2 TSE sequence with R-factor variation of 1-7. From the image slice results, one image was selected to show the lateral ventricle, thalamus, caudate nucleus, the lentiform nucleus, and the internal capsule in one image, namely axial slice in the height of corpus callosum.

Assessment phase

A qualitative assessment has evaluated by 3 radiologist to evaluate in the form of general image contrast and observed the clarity of diagnostic information (the lateral ventricle, thalamus, caudate nucleus, lentiform nucleus, and internal capsule), and selected the image of the best (the most optimal) R-Factor variation. The radiologists have twenty-year experience evaluate MR image, especially Brain Imaging.

Data analysis

Data was analyzed by using Spearman correlation test in SPSS to determinethe effect of GRAPPA R-factor on theimage qualityof lateral ventricle, thalamus, caudate nucleus, the lentiform nucleus, and the internal capsule in one image, namely axial slice in the height of corpus callosum, to determine the effective value of R-factor to produce an optimal image (acceptable image quality with fast time scanning), Friedman test was conducted by looking at the highest mean rank value of each variation of R-factor used, as well as to determine the effective R-factor value to produce optimal images.

RESULTS

The effect of GRAPPA R-factor on the Brain MRI image anatomical information quality of Axial Slice of T2 TSE sequence

The effect of GRAPPA R-factor variation on anatomy above can be explained in the following table.

Table 1. Result of Spearman Correlation Test to explaineffect of GRAPPA R-factor variation on Brain MR image anatomical information

Tissue	*R* value	*P* value
Lateral ventricle	-0,854	< 0,001
Thalamus	-0,757	< 0,001
Caudate nucleus	-0,874	< 0,001
Lentiform nucleus	-0,835	< 0,001
Internal capsule	-0,851	< 0,001
Background	-0,83	< 0,001

The correlation test results obtained p value of each anatomy of 0.001 (p=0.001 <0.05), it can be concluded that Ho was rejected, then Ha was accepted. So in can be concluded that there was a significant relationship between the changes in the GRAPPA R-factor variation on the quality of Brain MRI image anatomical information of axial slice of T2 TSE sequence.

GRAPPA R-factor which can display the optimal quality of image anatomical information Based on the results of questionnaires from three observers (radiologists), all had the same opinion that the most optimal quality of Brain MRI image anatomical information of Axial slice of T2 TSE sequence contained in GRAPPA of 1 with a mean of 6.01, it was also supported by the statistical test results in the mean rank values as follow:

Table 2. Result of mean rank on Friedman Test to Optimization of GRAPPA R–factor on Brain MR image anatomical information

Variance R-Factor	Mean Rank	P value
R-factor of 1	6,01	<0,001
R-factor of 2	5,57	
R-factor of 3	5,21	
R-factor of 4	4,47	
R-factor of 5	2,80	
R-factor of 6	2,24	
R-factor of 7	1,70	

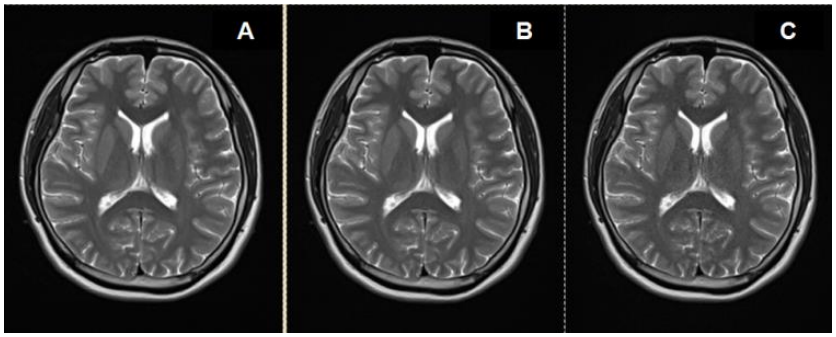


Figure 1. Brain MRI Image with GRAPPA R–factor of A = 1, B = 2, C = 3.

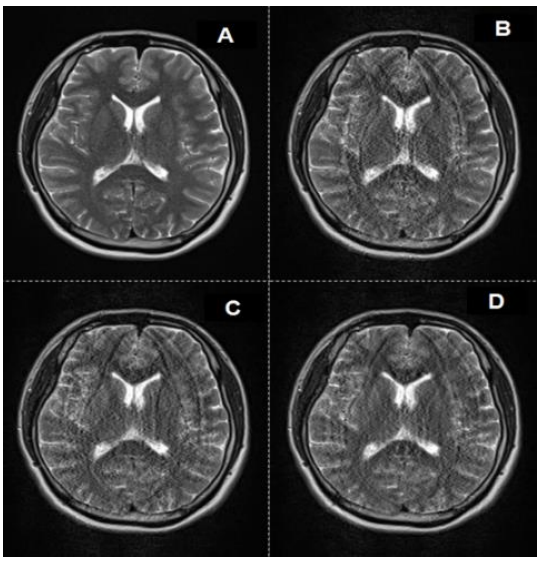
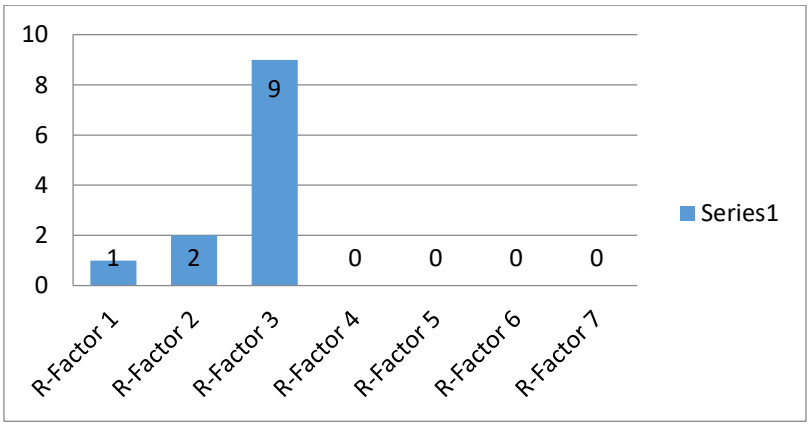


Figure 2. Brain MRI Image with GRAPPA R-factor of A = 4, B = 5, C = 6, D = 7

Based on the results of the questionnaire all observers tended to choose the image of A code in the image by using GRAPPA R-factor of 1, it is also supported by the total score on the Friedman test results with the highest mean rank in GRAPPA 1 of 6.01.

Based on the questions asked by the researchers to the observer it was stated that the use of GRAPPA R-factor of 3 could still display the optimal image anatomy quality with faster scan time so that the duration of MRI examination could also be reduced and would be efficient to time either on the patient or MRI operator. This is consistent with the results of the percentage of 4 (four) images with assessment from 3 (three) observers which indicated that 75% gave opinion that the use of GRAPPA R-factor 3 could still display the optimal image anatomy quality with faster scan time of just 2 minutes. The opinion of GRAPPA Observers with the acceptable image quality with faster time scanning can be explained in the following graph:



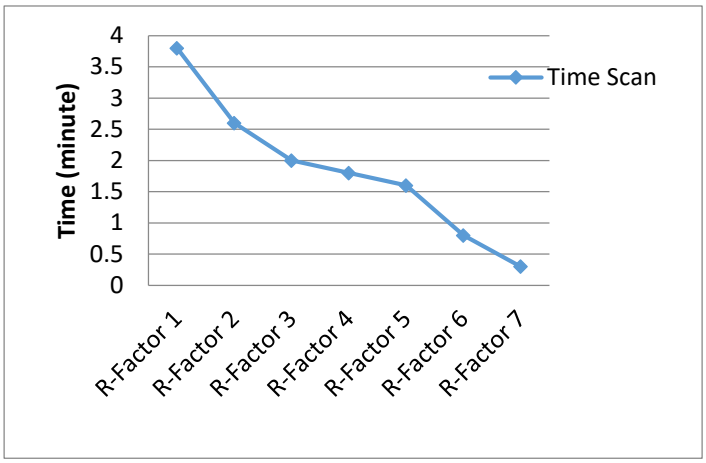
Graph 1. R-factor with optimal image quality with fast time (based opinion observer)

Based on the above explanation, the authors can conclude that using GRAPPA R–factor of 1 would get very good image quality with very fine detail, but with a longer scan time. MRI in patients with non-cooperative condition should reduce noise and artifacts due to the movement of the patients due to the scanning length of time it takes, so it can be fastened by using GRAPPA R-factor of 2 or 3 with similar results as by using GRAPPA R-factor of 1 but with faster scan time.

DISCUSSION

In GRAPPA parallel acquisition techniques there are special parameter called R-factor. This stated the number of coil elements of phased array coils that will affect the scan time [4]. Variations acceleration factor depends on the number of coil elements are used on each plane MRI. This study uses the MRI Siemens Magnetom Avanto 1.5 Tesla with 7 variations R-factor.

If the R-factor rise then the image quality will decline. This was due to the image obtained from the image in the under sampling acquisition by exploiting existing coil channel. So by increasing the R-factor, phase encoding step will be accelerated corresponding R-factor used for sampling are not full fill all of K-space. When the k-space is not fully charged then it will garner little spin echo encoding phase, there will be a reduction in linear data recorded in the image acquisition time, because time image acquisition and data collection is comparable with the number echo of phase encoding [12]. From the display on the monitor, it can be seen directly change the R-factors may affect the scan time. The larger the value of R-factor is used, then the scanning time will be reduced.



Graph 2. Influence R-factor changes to time scanning

In the research, it was found that the effect of R-factor on the quality of the image anatomical information was highly significant (p value = 0.001 <0.05) in each organ. Increased R-factor to the image anatomical information quality is negative, it is because the final image obtained is the result of a merger of the image in the acquisition of under sampling by exploiting existing coil channel. So by increasing the R-factor of then phase encoding steps will be accelerated according R-factor that is used for sampling that was not full fill all K-space (K-space under sampling). When the k-space is not fully filled then it would garner little spin echo encoding phase, there will be a reduction in linear data recorded in the image acquisition time, because time image acquisition and data collection is comparable with the number echo of phase encoding.

CONCLUSION

Statistical test result of the study received Ha which showed that there was a significant relationship between changes in the GRAPPA R-factor variation on the quality of Brain MRI image anatomical information of Axial slice of TSE T2 sequence (p=0.001<0.05) with r square in the lateral ventricle, thalamus, caudate nucleus, the lentiform nucleus, internal capsule and background of -0.854; -0.757; -0.874; -0.835; -0.851; -0.863, respecively; which mean that the quality of the anatomical information was caused by the GRAPPA R-factor. The correlation direction of the increase in GRAPPA R- factor on the quality of MRI image anatomical information was negative, which meant thatthe higher the value of r-factor GRAPPA used, the lower the quality of image anatomical information.

The friedman test results obtained the highest mean rank on the GRAPPA R-factor 1 of 6.01, indicated that the quality of anatomical information the most optimal image was by using GRAPPA R-factor of 1 but with a long scan time. Based on the questions from the researcher, the observers stated that GRAPPA R-factor of 3 could still display the optimal image anatomy quality with faster scan time so that the scan time could be reduced and might also be efficient towards time either on the patient or MRI operator.

The use of GRAPPA R-factor in MRI examination should still maintain optimal image quality and fast scan time. The use of GRAPPA R - factor of 3 can be applied in patients with non-cooperative conditions to reduce noise and artifacts due to the movement of the patients due to the scanning length of time it takes with similar results as by using GRAPPA R-factor of 1 but with faster scan time. This study can be developed by increasing the number of samples so that the results can be more objective.

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