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The Influence of Number of Signal Average Variation to the Scan Time and Anatomic Information of Lumbar MRI on Sagittal Slice with Stir Sequence

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ABSTRACT
Background: *The number of signal averages (NSA) parameters is one of the parameters that can affect the quality of the MRI image making the selection of accurate parameters is necessary to produce an optimal image produced and a short imaging time.*
Objectives: *The purpose of this study was to determine the effect of variations in the value of the NSA to scan time and get a lumbar MRI anatomical image on sagittal STIR sequences and NSA that generate value anatomic information with an optimal scan time on lumbar MRI sagittal STIR sequences.*
Method: *This research is a quantitative research experiment conducted with a 1.5 Tesla MRI at the Kasih Ibu Hospitals Denpasar. Data are in the form of 50 image sagittal STIR sequences MRI lumbar of the 10 volunteers with five NSA variations (1, 2, 3, 4 and 5). The assessment is performed by 3 people regarding information generated imagery and data were analyzed by using Friedman test.*
Result: *The results showed that there was the influence of variations in the value of the NSA to scan time and a lumbar MRI anatomical image slices sagittal with STIR sequences with a significance level of p value <0.05. Based on an assessment of the respondents, the value of the NSA which produce good anatomical information at the lumbar spine MRI sagittal slice with STIR sequences is NSA 5. And the NSA optimal value is based on the standard of NSA 2 relative value of SNR and scan time.*
Conclusion: *there was the influence of variations in the value of the NSA to scan time and get a lumbar MRI anatomical image slices sagittal with STIR sequences with a significance level of p value <0.05. The value of the NSA which produced good anatomical information at the lumbar spine MRI sagittal slice with STIR sequences is NSA 5. And the NSA optimal value is based on the standard of NSA 2 relative value of SNR and scan time*
Keyword: *NSA, Information Anatomy, STIR.*

Introduction

Magnetic Resonance Imaging (MRI) is a cross-sectional body imaging techniques based on the principles of nuclear magnetic resonance of hydrogen atoms. The tool has the ability to create an image of pieces of coronal, sagittal, axial and oblique without manipulating the patient's body.

MRI imaging technique is relatively complex because the image generated depends on many parameters. When selecting the proper parameters, the quality of the image detail of the human body will become evident, so that the anatomy and pathology of tissue can be evaluated accurately (Notosiswoyo and Suswati, 2004).

There are two parameters in MRI which affect the quality of the image: the primary parameter and secondary parameter. The primary parameter is the Time Repetition (TR), Echo Time (TE), Inversion Time (TI) and Flip Angle (FA) which affect the image contrast. Slice thickness and interslice gap affects the local area examined (coverage). Field of View (FOV), frequency encoding and phase encoding will affect resolution and SNR. While the Number of Signals averaged (NSA) / Number of Excitation (NEX) and bandwidth affect the Signal to Noise Ratio (SNR). Secondary parameters consist of SNR, the scanning time, coverage, resolution and image contrast (Hashemi 2004)

According to Westbrook, Kaut and Talbot (2011) to obtain an MRI image quality, there are four things that must be considered: the signal to noise ratio (SNR), contrast-to-noise ratio (CNR), spatial resolution and scan time. SNR, CNR, and spatial resolution, can be obtained by optimizing the parameters of MRI. Consequently, scan time will change according to parameters optimization has been done.

A number of Signal Average (NSA) is defined as the number of times the scan is repeated. According to Mc Robbie et.al (2006) to produce a high SNR is to increase the NSA, but it also resulted in increasing the scanning time. Therefore, by increasing the NSA to obtain optimal image information, one should consider the state of the patient due to the time taken is relatively longer.

MRI examination of the lumbar spine is often used for a variety of clinical examination including the examination of the nervous system as well as to evaluate the degenerative changes, abnormalities, for example, spinal disc herniation (HNP), spondylosis, lumbar compression, tumors and others. A more useful in evaluating imaging the lumbar spine is the sagittal slice (Westbrook, 2008).

Lumbar spine area is surrounded by fat and fluids that require the addition of sequences Short Tau Inversion Recovery (STIR) to strengthen the picture on the corpus, CSF, spinal cord, discus and bone marrow (Woordward and William, 1997).

Short Tau Inversion Recovery (STIR) is a fat suppression technique that is useful to suppress the fat signal in general MR imaging (Westbrook, et.al, 2011). The normal fat signal intensity in the marrow of the vertebral body is generally high, even with the long Echo Time (TE). For that reason, the pathology of the bone marrow, such as tumors, bruises or broken bones, may not be adequately visualized on T1 and T2 sequences Fast Spin Echo (FSE) Weighting. STIR sequences sagittal slices can be used to visualize the bone marrow abnormalities properly (Westbrook, 2008). The use value of the NSA on STIR should be appropriate to get optimal image information as though in the sequences of T1W-FSE and T2W-FSE are enough with the standard value of the NSA but in STIR sequence aimed at showing images of bone marrow corpus, spinal cord, intervertebral, CSF is required more optimal since those anatomical parts are evaluated by sagittal pieces (Westbrook, 2008).

According to Elmouglu (2012), NSA 4 is used for MRI lumbar spine with STIR sequences. Meanwhile, George et. al (2010) in a routine protocol lumbar spine MRI sagittal with STIR sequences uses the parameter of NSA 2, and research conducted by Rochmayanti (2007) concluded that the optimum SNR is NSA 3.

Based on the observations of researchers for carrying out field work in hospitals, for example, in the hospital Kasih Ibu Denpasar, Indonesia, the value of NSA used is 2, but in hospital Hardjo Lukito Yogyakarta, the value of the NSA 3 with the strong and the same magnetic field type is used. Furthermore, in some other hospitals, the MRI plane with different brands but with the same magnetic field of 1.5 Tesla, NSA used is varied in the range of 1 to 4. Few radiographers who will perform parameter settings of NSA MRI lumbar vertebrae to gain faster scanning time with good image quality as they simply apply the value of the parameters based on the existing protocols making MRI examination takes more time and may cause the artifacts due to movement of the patient. Varying the value of the NSA will get a picture with a variety of image quality and scan time information, as well as the known value of the NSA that would produce the best image with the optimal required imaging time.

The purpose of this study is to determine the effect of variations in the Number of Signal Average (NSA) to the scan time and lumbar MRI anatomical information on sagittal slices with STIR sequences. In addition, it aims to determine the proper use of the NSA to produce anatomical information with optimal scan time in lumbar spine MRI sagittal with STIR sequences.

MATERIAL & METHOD

This is a quantitative research with an experimental approach. The independent variable is the variation of Number of Signal Average (NSA) while the dependent variable is the scan time and MRI anatomical information of the lumbar spine with the controlled variable: time repetition, time echo, a field of view, slice thickness, flip angle, slice interval, bandwidth, matrix, and coil. This research was conducted from October to December 2016 in the radiology installation of Kasih Ibu Hospital Denpasar. The population in this study were all patients of MRI lumbar sagittal piece and samples in this study were 10 volunteers experiencing the sagittal slices lumbar MRI examinations.

The procedures are:

1. Lumbar MRI imaging sagittal slices were performed in 10 volunteers.
2. Each volunteer was scanned with STIR sequences sagittal slices with the variation of NSA 1, NSA 2, NSA 3, NSA 4, and NSA
3. Sequencing must consider the controlled variables of TR = 4720.0 ms, TE = 35 ms, slice thickness = 4.0 mm, inter slice / gap = 1.0 ml, phase encoding = AP / PH, matrix = 256×192, flip angle = 150^o, TI = 170, and FOV = 24 cm.
4. Fifty sagittal slice image with varied NSA is obtained. During the sequencing, the researchers noted the appeared Rel.SNR value and scan time at every change in the value of the NSA.
5. Imaging is only performed on the 6th slice from each value of the NSA as it is considered the informative slices of lumbar sagittal slices, then printed to proceed with filling in the questionnaires.
6. The completed questionnaire from each respondent is recapitulated then analyzed by using SPSS.

Data obtained is the assessment score image by a radiologist in form of an ordinal data type. This data is converted into interval data using the method of successive intervals.

The first statistical testing performed was the Kappa test to determine the rating agreement given by the two respondents.

The next statistical test is the test of the influence of the independent variables to the dependent variable. Each volunteer was treated in accordance with the five groups of variables studied generating paired data so that the statistical method used is linear regression to assess the presence or absence of any significant influence between independent variables and the dependent variable. The linear regression test requires ratio data normally distributed. If the data obtained is not normally distributed, the Friedman Test is applied.

Friedman statistical test aims to determine the difference and mean rank of NSA imagery on which one has the highest value of the variation of the NSA against Lumbar MRI anatomical information STIR sequences sagittal slices.

The level of significance is used to infer the relationship between independent and dependent variables. If the result of p -value < 0.05 then Ho is rejected, meaning that there is influence NSA variation on MRI anatomical information Lumbar sagittal slice with STIR sequences. Meanwhile, if the p- value> 0.05 then Ho is accepted meaning that there is no influence of variation NSA against MRI anatomical information Lumbar sagittal slices with STIR sequences. The results are then becoming the basis for making conclusions.

RESULT

The study was conducted on ten (10) male and female volunteers aged between 23 years to 40 years with four categories of body mass index (BMI): underweight, normal, overweight, and obese. Here are the volunteer characteristics:

Table 1. Description of the sample by gender

Sex	Total	Percentage
Male	3	30%
Female	7	70%
Total	**10**	**100%**

Table 2. Characteristics of Volunteer based age and BMI

Category	Classification	Total	Percentage
age	21 – 30	5	50%
	31 – 40	5	50%
	Total	**10**	**100%**
The Body Mass Index	*Underweight*	1	10%
	Normal	4	40%
	Overweight	4	40%
	Obese	1	10%
	Total	**10**	**100%**

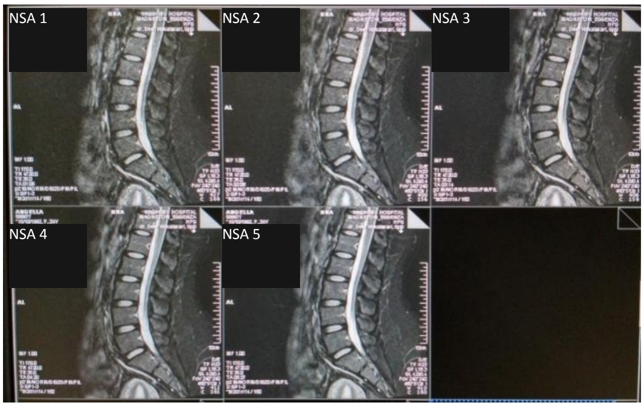

Figure 1. Results of the MRI image of the lumbar sagittal STIR piece 6th of 11 total images each sequence with variation of the NSA

Of the ten volunteers were obtained anatomical information MRI lumbar vertebra with five variations of NSA values. Each variation of the NSA values produced 11 sliced images, then selected one image that could reveal the anatomy of MRI Vertebra Lumbar i,e bone marrow, intervertebral disc, spinal cord and cerebra-spinal fluid in one slice (sixth slice). The total number of images used for the research is 50 images.

One of parameters that affect the quality of the image is a scanning/imaging time, optimization of the MRI which is to get a good image during a short time. This research resulted in 50 images of 10 Volunteer, between Volunteer 1 Volunteer 2 Volunteer 3 to Volunteer 10 each carried five variations of the NSA. The fifth NSA used variation used between volunteer entirely causes the change scanning time as follows:

Table 3. Scan Time of each change in the value of the NSA

No	NSA's Value	*Scan Time*
1	1	1 minute 17 seconds
2	2	2 minute 18 seconds
3	3	3 minute 24 seconds
4	4	4 minute 31 seconds
5	5	5 minute 37 seconds

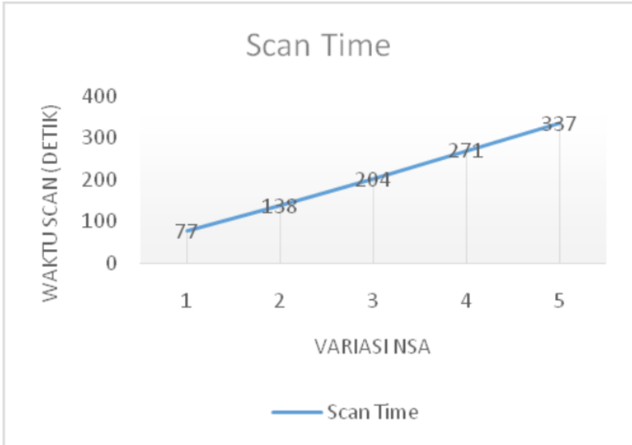

Figure 2. Graph Scan Time with NSA variations

Table 3 and Figure 2. above shows the effect of NSA value changes on the change of scanning time, the greater the NSA value used, the scanning time will increase as well. The scan time can be viewed directly on the computer display which will change whenever the NSA parameter is changed.

Prior to statistical tests to determine whether or not the effect of variation of Number of Signal Average (NSA) on the anatomical information of MRI Lumbal with STIR sequence and to know what is the NSA variation that can display optimal anatomical information, Kappa test is done to know the suitability or similarity of respondents ' perception in the questionnaire assessment. Results of Kappa test against 3 respondents are as follows:

Table 4. Kappa Test Results in Respondents' Assessment

Respondents	Kappa *Value*	P -*Value*	Description
R1 and R2	0.877	<0.001	Good Reliability
R2 and R3	0.841	<0.001	Good Reliability
R1 and R3	0.719	<0.001	Good Reliability

Table 4 shows the Kappa Test results from the three respondents. The value of kappa between Respondent 1 and Respondent 2 is 0.877, Respondent 2 and Respondent 3 is 0.841 and between Respondent 1 and Respondent 3 is 0.719 with a p- value <0.05. These results indicate that there is a correspondence or similar perception among the three respondents in assessing the anatomical information of the lumbar vertebrae of both the NSA variation in the Sagittal STIR sequence.

From the Kappa test to assess whether there is influence NSA variation on STIR sequences against Lumbar MRI anatomical information is then performed Linear Regression Testing and Test Friedman uses only the data from the questionnaire respondents 1, Senior Radiologist experienced interpreted the results of MRI image.

To find a normal distribution of data, it is necessary to test the normality of the residual value of the data. The following is data normality test results for NSA variation to MRI Lumbar anatomical information:

Table 5. Data Normality Test Results for NSA Variation against MRI Lumbar Anatomical Information

Anatomical information	Saphiro-Wilk		
	Statistic	Df	Sig.
Bone marrow	.964	50	.131
Discus	.907	50	.001
Spinal cord	.944	50	.019
CSF	.955	50	.053

The data is normally distributed if the p-value > 0.05. Based on the table 5, 2 data have a significant value of p < 0.05, which means that the distribution of these respondents' assessment of data distribution is not normal, so the linear regression test can not be performed. Since the data is not normally distributed, the Friedman test is then performed.

Table 6. Friedman Test Results Number of Signal Average (NSA) Variation

No.	NSA Value	*Mean Rank*	*p Value*	Description
1.	NSA 1	1.67	ρ < 0.001	Different
2.	NSA 2	1.99		
3.	NSA 3	3.27		
4.	NSA 4	3.82		
5.	NSA 5	4.26		

Results of Friedman test on NSA variation in lumbar MRI anatomical information indicates the ρ value <0.001 which means there is a difference / influence on each variation for the entire device. Judging from the mean rank for the best possible outcome picture based on the overall Friedman test is the NSA 5 or the fifth variation whereas the lowest result is the first variation or NSA 1.

After Friedman test on the variation of the Number of Signal Average (NSA), the similar test is then performed on each organ to find out the difference NSA variation to information on any anatomy lumbar sagittal slice organ. The results of the Friedman test on each organ are as follows:

Table 7. Friedman Test Results In Variation Number of Signal Average (NSA)

No.	Organ Anatomy	NSA Variant	*Mean Rank*	*p-Value*	Description
1.	*Bone marrow*	NSA 1	1.55	ρ < 0.001	Different
		NSA 2	1.85		
		NSA 3	3.10		
		NSA 4	3.90		
		NSA 5	4.60		
2.	*Discus*	NSA 1	1.40	ρ < 0.001	Different
		NSA 2	1.70		
		NSA 3	3.45		
		NSA 4	4.00		
		NSA 5	4.45		
3.	*Spinal cord*	NSA 1	2.15	0.009	Different
		NSA 2	2.35		
		NSA 3	3.35		
		NSA 4	3.40		
		NSA 5	3.75		
4.	*CSF*	NSA 1	1.65	<0.001	Different
		NSA 2	2.10		
		NSA 3	3.10		
		NSA 4	3.85		
		NSA 5	4.30		

The Friedman test results on Table 7 showed a significant difference between the image of the anatomy of the lumbar with 5 variations of NSA with ρ value <0.001. Judging from the mean rank, the highest value in the lumbar anatomy image is NSA 5 value which is an average 4.60 in the bone marrow corpus, 4.45 to discus, 3.75 for the spinal cord, and 4.30 for the CSF.

One trades off in image quality considered is the value of SNR images. To determine the use of the NSA producing an optimal SNR with relatively short scanning time, it can be seen from the Rel.SNR. Rel.SNR is the software contained on the Siemens 1.5 Tesla MRI. This software has the advantage to know the optimal SNR value on the formation of the overall image, in this case, the image of lumbar MRI with T2 STIR weighing. With that software, researchers are capable of determining the optimal SNR at relatively short scanning time. From the results, The research generated the Rel.SNR value and the scanning time as follows:

Table 8. Results of the optimum SNR measurement

NSA	Rel. SNR	Scan Time	Standard Rel. SNR	Conclusion
1	70 %	1 minute 17 seconds	100 %	<100%
2	100 %	2 minute 18 seconds	100 %	=100 %
3	122 %	3 minute 24 seconds	100 %	>100 %
4	141 %	4 minute 31 seconds	100 %	>100 %
5	158 %	5 minute 37 seconds	100 %	>100 %

From Table 8, it is concluded that by using the NSA 1, SNR produced less than optimal because Rel.SNR value is less than 100%. Then by using the NSA 2 equals to reference standard protocols. While using 3 NSA, NSA 4, and NSA 5 will produce optimal Rel.SNR because the value is more than 100%.

CONCLUSION

Variation of NSA used changes affect the time of scanning. From the data generated, it can be seen that the higher the NSA used the longer the scanning time will be. Using NSA 1 to 2 causes the scanning time becomes twice longer. This is consistent with existing literature that by increasing the SNR produced NSA will also increase but the scanning time will increase/grow longer.

The results of Friedman test on variation Number of Signal Average (NSA) for the anatomical information MRI lumbar slices sagittal with STIR sequences indicate that there is significant difference in the variation of the use of NSA 1, NSA 2, NSA 3, NSA 4 and NSA 5.

NSA greatest value in imaging the anatomy of MRI lumbar with Siemens 1.5 Tesla is the NSA 5 because it has the highest mean rank. Then the most optimal anatomical information is using NSA 2 with a scan time of 02:18 as it is in accordance with the standards of Rel. SNR (100%) and produces a faster inspection time compared to the NSA3, NSA 4 and NSA 5.

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