



DIFFERENCE OF ANATOMY INFORMATION MRI KNEE JOINT ON VARIATION OF TIME REPETITION SEQUENCES STIR IN SAGITTAL SLICES

PERBEDAAN INFORMASI ANATOMI MRI SENDI LUTUT PADA VARIASI TIME REPETITION SEKUENS STIR IRISAN SAGITAL

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ABSTRACT

Background: Time Repetition (TR) is one of the main parameters of Inversion Recovery. **Purpose:** The purpose of this study is to determine the differences in anatomical MRI information on the variation of the knee joint TR sequences of STIR Sagittal slices. **Method:** The type of the current research is experimental study. The study was conducted with MRI 1.5 tesla. The data were in the form of 42 image sequences of STIR MRI knee joint with TR 3500, 4000, 4500, 5000, 5500, 6000, and 6500 ms. Anatomical assessments on the anterior cruciate ligament, posterior cruciate ligament, articular cartilage, and meniscus were performed by a radiologist. Data were analyzed using Friedman and Wilcoxon test. **Result:** The results showed that there were differences in the MRI anatomical information of the knee joint of the STIR sagittas slice in the TR variation with p -value < 0.001 . There is a difference in anatomical information between TR 5000 and 6000 ms (p -value = 0.034), TR 5000 and 6500 ms (p -value = 0.024), TR 5500 and 6500 ms (p -value = 0.038). There is no difference in anatomical information between TR 4500 and 5000 ms (p -value = 0.395), TR 4500 and 5500 ms (p -value = 0.131), TR 4500 and 6000 ms (p -value = 0.078), TR 4500 and 6500 ms (p -value = 0.066), TR 5000 and 5500 ms (p -value = 0.414), TR 5500 and 6000 ms (p -value = 0.102), TR 6000 and 6500 ms (p -value = 0.083). **Conclusion:** The optimal value to produce anatomical information of the knee joint sagittal MRI sequences STIR is TR 4500 ms.

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ABSTRAK

Latar belakang: Time Repetition (TR) adalah salah satu parameter utama dari Inversion Recovery. **Tujuan:** Tujuan penelitian ini untuk mengetahui perbedaan informasi anatomi MRI sendi lutut pada variasi sekuens TR sekuens STIR irisan Sagital. **Metode:** Jenis penelitian adalah eksperimental. Penelitian dilakukan dengan MRI 1.5 tesla. Data berupa 42 citra MRI sendi lutut sekuens STIR dengan TR 3500, 4000, 4500, 5000, 5500, 6000, dan 6500 ms. Penilaian anatomis pada *ligamentum cruciatum anterior*, *ligamentum cruciatum posterior*, *kartilago artikular* dan *meniskus* dilakukan oleh dokter spesialis radiologi. Data dianalisis dengan uji Friedman dan Wilcoxon. Hasil: Hasil penelitian menunjukkan bahwa terdapat perbedaan informasi anatomis MRI sendi lutut irisan sagital sekuens STIR pada variasi TR dengan p -value $< 0,001$. Terdapat perbedaan informasi anatomi antara TR 5000 dan 6000 ms (p -value = 0,034), TR 5000 dan 6500 ms (p -value = 0,024), TR 5500 dan 6500 ms (p -value = 0,038). Tidak terdapat perbedaan informasi anatomis antara TR 4500 dan 5000 ms (p -value = 0,395), TR 4500 dan 5500 ms (p -value = 0,131), TR 4500 dan 6000 ms (p -value = 0,078), TR 4500 dan 6500 ms (p -value = 0,066), TR 5000 dan 5500 ms (p -value = 0,414), TR 5500 dan 6000 ms (p -value = 0,102), TR 6000 dan 6500 ms (p -value = 0,083). **Kesimpulan:** Nilai optimal untuk menghasilkan informasi anatomis MRI sendi lutut irisan sagital sekuens STIR adalah TR 4500 ms.

Kata kunci:
Time repetition, Knee joint, MRI, STIR

INTRODUCTION

Magnetic Resonance Imaging (MRI) is a cross-sectional body imaging technique based on the principle of magnetic resonance of hydrogen nuclei. MRI imaging techniques are relatively complex because the image generated depends on many parameters. The tool can create a picture of the coronal, sagittal, axial, and oblique slice without manipulating the patient's body (Notosiswoyo and Suswaty, 2004).

In the MRI imaging, there is a term known as pulse sequences. The pulse sequence is a series of events that include radiofrequency pulses, gradient activation, and signal collection undertaken to produce an MRI picture (Moeller and Reif, 2003). Several types of sequences are often used in clinical diagnostics including sequences spin echo, fast spin echo, gradient echo, inversion recovery, echo planar imaging and magnetic resonance angiography. Each sequence has different parameters that are also vary. Weighting contrast in each sequence has certain characteristics that can be used to assess a pathological process (Bitar et al., 2006).

The inversion recovery sequence is one that is often used in clinical diagnostics in inversion recovery pulse 90°. Inversion recovery consists of a Short Tau Inversion Recovery (STIR) and Fluid Attenuated Inversion Recovery (FLAIR) (Bitar et al., 2006).

Short Tau Inversion Recovery is a pulse inversion recovery sequence that uses Time Inversion (TI) short to suppress fat signals. When the excitation pulse application 90° and the vector fatback through 90° to 180° with full saturation, then the signal in the fat disappears. STIR sequences are typically used in the musculoskeletal example in the knee joint. Overview STIR has a very low-fat signal, but the signal fluid (fluid) is so high that STIR is also called fat-suppressed pathology imaging techniques (Westbrook et al., 2011).

In some cases, an MRI exam has difficulty in distinguishing the fat picture and surrounding soft tissues. There are a lot of fat around anatomical structures but they are not well constrained. On some networks, fat is a molecular component of the hydrogen atoms in the liquid. To overcome these problems, a technique called fat suppression was developed (Wu et al., 2012). Sagittal fat suppression sequences were designed to image the meniscus. ACL, PCL and cartilage are also well visualized with this sequence (Freitas, 2016). The knee joint is a synovial joint type with complex types. It has three compartments, namely the medial, lateral, and patellofemoral. There are four major ligaments in the knee joint, (anterior and posterior cruciate ligaments), and on the inside and the outside of the knee (medial and lateral collateral ligaments) that serve to stabilize the joint together with the capsule (R. and V., 2013)

According to (McRobbie et al., 2006), conventional X-ray examination of the knee joint can only show a fracture or effusion in large numbers, and this is

sometimes not very helpful in clinical diagnosis. The ability of MRI in displaying soft tissue, tendons, ligaments, and meniscus was very helpful in assessing knee joint pathology.

According to (Bitar et al., 2006), the main parameters of the pulse is inversion recovery Time Repetition (TR), Time Echo (TE) and TI. Time repetition is the time from application to application RF pulse next to each slice and is measured in milliseconds (ms). Time Repetition determines the amount of longitudinal relaxation between RF pulses RF to the next. Thus, Time Repetition determines the number of T1 relaxation that has occurred when the signal is read ((Westbrook et al., 2011).

According to (Westbrook et al., 2011) in the TR, the value is 4000 ms + STIR. Meanwhile, according to (Moeller and Reif, 2003), TR optimal value varies according to the strength of the magnetic field. On systems with 1.5 tesla magnetic field on the optimal value, TR STIR is 6500 ms, at 1.0 tesla value TR 1500 ms and at 0.5 tesla TR optimal value is 2000 ms. Based on the information that the author obtained in Haji Hospital Surabaya, the value TR used on STIR sequences is 3500 ms.

MATERIAL AND METHOD

This type of research is a quantitative research experiment. Variables used in the study are the independent variable which is the variation of the TR, and the dependent variable is anatomical information STIR sequence MRI of the knee joint which is the controlled variable TE, FOV, slice thickness and NSA. The study was conducted in October-November 2016 in Radiology Hospital Haji Surabaya. The population in this study was an examination of the knee joint MRI Radiology at Hospital Haji Surabaya. Meanwhile, the study sample consisted of 42 images of MRI of the knee joint sequences STIR with the use of seven variations of TR (TR 3500 ms, TR 4000 ms, TR 4500 ms, TR 5000 ms, TR 5500 ms, TR 6000 ms, TR 6500 ms) of 3 volunteers with samples of the right and left knee joint with sagittal slices.

Of each variation, TR has 4 slices of images that reveal anatomical information from MRI of the knee joint in sagittal slices with the criteria looked Anterior Cruciate Ligament (ACL), Posterior Cruciate Ligament (PCL), articular cartilage, and meniscus. From the results of that image, the evaluation was conducted by the two respondents. Respondents were specialist radiology which have the ability in the expertise field of MRI over 5 years. The results of this study showed statistical tests using SPSS software. Before conducting a statistical test to determine the differences in anatomical MRI of the knee joint information on the variation of the TR on STIR sequences, a Kappa test was conducted a prior test to

If there is a difference, then it was continued with the Wilcoxon test.

Wilcoxon test is a test for the continuation of the friedman test that aims to understand the difference between the variation of the TR. A further test was conducted to assess the optimal TR in producing good image quality. Good image quality is determined based on the total score of each anatomical assessed. To do the wilcoxon test, the results of the respondents' assessment is summed with the criteria of the sum with a value (4-8 = poor, 9-12 = good). The test is performed on the image quality is good information (9-12) because it is used to determine the optimal value TR. Therefore, the image was included in unfavorable criteria that were not included in the wilcoxon test. As for meeting, the criteria was not good which was TR 3500 ms and 4000 ms because it had a total of 4 ratings scoring - 8. Meanwhile, the value of TR that meets both criteria (total score 9-12) was TR 4500 ms, TR 5000 ms, TR 5500 ms, TR 6000 ms, TR 6500 ms. If the criteria has good results, then the testing was conducted.

Ethical clearance in this study was obtained from the Health Research Ethics Committee (KEPK) Health Polytechnic Semarang.

RESULT

The results of this study described the characteristics of the study sample based on gender and age, as well as the results of the respondent's conformity test to determine the similarities in the perception of radiologist in assessing the clarity of image information. The results of testing differences in anatomical information were presented in two stages which were the difference test in the clarity of anatomical information on the overall TR variation using the continued friedman test and the Wilcoxon test. To determine the most optimal TR value in producing anatomical information on the knee joint MRI, the STIR sequence was determined based on the mean rank.

The characteristics of the study volunteers are shown in Tables 1 and 2.

Table 1. Volunteers characteristics base on sex

Sex	Frequency	Percentage (%)
Man	20	66.7
Woman	10	33.3
Total	30	100

Table 2. Volunteers characteristics based on age

Age	Amount	Percentage (%)
20-22 years	20	66.7
23-24 years	10	33.3
Total	30	100

Based on gender, most of the volunteers in this study were male at 66.7%, while female volunteers were 33.3%. Volunteers in this study were of comparable age. Based on age, most of them were 20-22 years old (66.7%) and 33.3% were 23-24 years old. The results of the conformity test for the respondent's assessment with the Cohens Kappa test are shown in Table 3.

Table 3. The results of the conformity test of the respondent's assessment with the Cohens Kappa test

	Kappa Coeff	p-value
Information Anatomy in Time Repetition variation	0.918	0.001

The results of the conformity test showed the coefficient of Kapaa is 0.918, which means that there was a similarity in perception between radiologists in evaluating the clarity of anatomical information of MRI knee joint.

Table 4. The difference anatomy information in knee joint MRI in the time repetition variation with the Friedman test

No.	Time Repetition (ms)	Mean Rank	p-value
1.	3500	1.69	p < 0.001
2.	4000	2.50	
3.	4500	3.92	
4.	5000	4.42	
5.	5500	4.69	
6.	6000	5.19	
7.	6500	5.60	

From the test results of Friedman, the variation value of Repetition Time (TR) on MRI anatomical information of the knee joint was p value <0.001 (p <0.05), which means there was a difference in each variation for the entire organ.

The results of testing each variation with the Friedman test on each organ are as follows:

1. In the ACL organ, the highest mean rank value is TR 6500 ms with a value of 5.58, then the second is the value of TR 6000 ms and 5500 ms with the mean value of the same rank is 5.08, which is at the fourth position value TR 5000 ms with a value of 4.58, which is on the fifth position TR 4500 ms value with a value of 4.08, which is the sixth position on the value of TR 4000 ms with a value of 2.17, and the last position is the value of TR 3500 ms with a mean rank 1.42. The significance of the variation of the TR at the anatomy of the ACL with p-value < 0.001, which means that there is a difference (p < 0.05) between each variation with ACL organ.
2. In the PCL organ, the highest mean rank value is TR 6500 ms with a value of 6.00, then the second is

the value of TR 6000 ms with a value of 5.42, the third position is the value of TR 5500 ms with a value of 4.42, the fourth position is the value of TR 5000 ms with a value of 3.92, which is on the fifth position TR 4500 ms value with a value of 3.42, which is the sixth position on the value of TR 4000 ms with a value of 2.75, and the last position is the value of TR 3500 ms with a mean rank of 2.08. The significance of variations in anatomy PCL TR value is 0.003, which means that there is a difference ($p < 0.05$) between each variation with PCL organ.

3. In the articular cartilage organ, the highest mean rank value is TR 6500 ms and 6000 ms with a value of 5.25, the third position is the value of TR 5500 ms and 5000 ms with a value of 4.75, which is fifth on the value of TR 4500 ms with a value of 4.25, which is the sixth position on the value of TR 4000 ms with a value of 2.25, and the last position is the value of TR 3500 ms with a mean

rank of 1.50. The significance of the variation of the TR at the anatomy of articular cartilage that is 0.001, which means that there is a difference ($p < 0.05$) between each variation with articular cartilage organ.

4. At the meniscus organ, the highest mean rank value is TR 6500 ms with a mean rank 5.58, TR 6000 ms second place with a value of 5.00, then the third position is the value of TR 5500 ms with a value of 4.50, the position the fourth is the value of TR 5000 ms with a value of 4.42, which is on the fifth position TR 4500 ms value with a value of 3.92, which is the sixth position on the value of TR 4000 ms with a value of 2.83, and the last position is the value of TR 3500 ms the mean rank of 1.75. The significance of variations in anatomy meniscus TR value is 0.006, which means that there is a difference ($p < 0.05$) between each variation with organ meniscus.

Table 5. Deferences anatomy of knee joints in variation time repetition with Friedman test

Organ	Time Repetition (ms)	Mean Rank	p-value
ACL	3500	1.42	< 0.001
	4000	2.17	
	4500	4.08	
	5000	4.58	
	5500	5.08	
	6000	5.08	
	6500	5.58	
PCL	3500	2.08	0.003
	4000	2.75	
	4500	3.42	
	5000	3.92	
	5500	4.42	
	6000	5.42	
	6500	6.00	
Articular Cartilage	3500	1.50	0.001
	4000	2.25	
	4500	4.25	
	5000	4.75	
	5500	4.75	
	6000	5.25	
	6500	5.25	
Meniscus	3500	1.75	0.006
	4000	2.83	
	4500	3.92	
	5000	4.42	
	5500	4.50	
	6000	5.00	
	6500	5.58	

Table 6. Wilcoxon test results between variation time repetition in information MRI knee joint anatomy

Time Repetition (ms)	p-value
5000 – 4500	0.395
5500 – 4500	0.131
6000 – 4500	0.078
6500 – 4500	0.066
5500 – 5000	0.414
6000 – TR 5000	0.034
6500 – TR 5000	0.024
6000 – TR 5500	0.102
6500 – TR 5500	0.038
6500 – TR 6000	0.083

Wilcoxon test results between the variation Time Repetition on MRI of the knee joint anatomical information is as follows:

1. For the information on the anatomy of the TR 5000 and TR 4500 ms, the value is $p = 0.395$ ($p > 0.05$), which means that there were no significant differences in anatomical MRI of the knee joint information between TR 4500 ms and TR 5000 ms.
2. For the information on the anatomy of the TR 5500 and TR 4500 ms, the value is $p = 0.131$ ($p > 0.05$), which means that there were no significant differences in anatomical MRI of the knee joint information between TR 4500 ms and TR 5500 ms.
3. For the information on the anatomy of the TR 6000 and TR 4500 ms, the value is $p = 0.078$ ($p > 0.05$), which means that there were no significant differences in anatomical MRI of the knee joint information between TR 4500 ms and TR 6000 ms.
4. For the information on the anatomy of the TR 6500 and TR 4500 ms, the p-value is 0.066 ($p > 0.05$), which means that there were no significant differences in anatomical MRI of the knee joint information between TR 4500 ms and TR 6500 ms.
5. For the information on the anatomy of the TR 5500 and TR 5000 ms, the p-value is 0.414 ($p > 0.05$), which means that there were no significant differences in anatomical MRI of the knee joint information between TR 5000 ms and TR 5500 ms.
6. For the information on the anatomy of the TR 6000 and TR 5000 ms, the p-value is 0.034 ($p < 0.05$), which means that there were significant differences of anatomical MRI of the knee joint information between TR 5000 ms and TR 6000 ms.
7. For the information on the anatomy of the TR 6500 and TR 5000 ms, the p-value is 0.024 ($p < 0.05$), which means that there were significant differences of anatomical MRI of the knee joint information between TR 5000 ms and TR 6500 ms.
8. For the information on the anatomy of the TR 6000 and TR 5500 ms, the p-value is 0.102 ($p > 0.05$), which means that there were no significant differences in anatomical MRI of the knee joint information between

TR 5500 ms and TR 6000 ms.

9. For the information on the anatomy of the TR 6500 and TR 5500 ms, the p-value is 0.038 ($p < 0.05$), which means that there were significant differences of anatomical MRI of the knee joint information between TR 5500 ms and TR 6500 ms.

10. For the information on the anatomy of the TR 6000 ms and TR 6500 ms on anatomical information with p value = 0.83 ($p > 0.05$), which means that there were no significant differences in anatomical MRI of the knee joint information between TR 6000 ms and TR 6500 ms.

Based on the description above, it can be concluded that the value of TR optimal anatomical information STIR sequence MRI of the knee joint is the TR 4500 because there was no significant difference in the variation of the TR another and with short scanning. The time was 2 minutes 15 seconds.

DISCUSSION

Judging from the results of these data, the results of this research show that there are significant differences in each variation of the TR on STIR sequences. To find the difference in the anatomical information, Friedman test was conducted. To determine the value of TR optimal anatomical information STIR sequence MRI of the knee joint sagittal slices, Wilcoxon test was conducted. Based on the test results Friedman to find out the difference to variations in the value of TR, the value of TR 3500 ms, TR 4000 ms, TR 4500 ms, TR 5000 ms, TR 5500 ms, TR 6000 ms, and TR 6500 ms value were ($p < 0.001$ or $p < 0.05$), which means there were significant differences or H_0 rejected.

Based on the Friedman test, each variation of the TR was $p < 0.05$, which means there was a difference in each variation of the TR on the whole organ. Then, the statistical test Friedman on each anatomy or organ ACL, PCL, articular cartilage, and meniscus showed the value $p < 0.05$. That means there is a difference with each anatomy based on variations in the value of TR.

Furthermore, based on the mean rank on the overall anatomy for each variation of the TR, the highest rank mean value was obtained from the value of TR 6500 ms while the lowest was the TR 3500 ms. The mean value of the highest rank in the ACL organ was the value of TR 6500 ms with a mean rank of 5.58. Then, the highest rank in the PCL was the TR 6500 ms with a mean rank 6.00. In articular cartilage, the highest mean rank was the TR 6500 ms, with a mean rank of 5.25. Furthermore, for meniscus, the highest mean rank value is the TR 6500 ms with a mean rank of 5.58.

Based on these results, the result of variations in the value of TR was the highest in the seventh variation of the value of the TR 6500 ms. Meanwhile, the lowest was in the first variation or TR 3500 ms. It can be concluded that the variation of TR were mostly good for the image of the anatomy of the knee joint which is TR 6500 ms with a time of 3 minutes 15 seconds scanning.

That is because the value of TR on sequences Inversion Recovery (IR) should be long enough to provide opportunities so that Net Magnetization Vector (NVM) can be in full recovery before the next inversion pulse is applied. If TR is too short then each network will be recovery with different levels which will ultimately affect the generated weighting (Westbrook et al., 2011). This is consistent with the theory that the main parameters on STIR sequences were TR, TE, and IT. In the picture STIR, the fat signal was suppressed so that the fat picture appeared black. Thus, the knee joint MRI with STIR sequences was vary with the use of different TR values (Westbrook et al., 2011).

According to (Westbrook et al., 2011) TR controlled the amount of longitudinal magnetization which allowed the recovery before the next excitation pulse was applied. TR length allowed full recovery of the longitudinal magnetization in slower recovery. A short TR does not allow full recovery of the longitudinal magnetization, resulting in faster recovery. TR long can improve SNR and TR short can reduce SNR. One of the factors that affect TR is the time of scanning. The increased TR also improves the patient scan time and the opportunity to move, so the effect on image quality. If the patient moves, it will lead to partial blurring due to motion artifact (artifacts due to movement).

The scan time is the time to complete the data acquisition. The scan time is important in maintaining the image quality. Long scan time gives patients more opportunities to move during acquisition. (Westbrook et al., 2011). Patient tolerance factor was considered. Wilcoxon test results were between TR variation. To compare in terms of SNR and scanning time and to obtain anatomical information with good quality, the optimal TR was used (not the highest) and the scanning time that did not take long. From the combination of these two things, the use of TR optimal knee joint MRI STIR sequences is at TR 4500 ms.

Expected by setting parameters on the value TR 4500 ms, this will provide good SNR and the scan time is not too long, which was 2 minutes 15 seconds. Thus, the originator of the disturbances on the image such as patient movement (motion artifact) can be minimized.

CONCLUSION

The results showed that there were differences in anatomical MRI information on the variation of the knee joint Repetition Time (TR) sequences Short Tau Inversion Recovery (STIR) Sagittal slices with p-value <0.001. There was a difference between anatomical information between TR 5000 ms and TR 6000 ms with p-value =

0.034, TR 5000 ms, and TR 6500 ms with p-value = 0.024, TR 5500 ms and 6500 ms with p-value = 0.038. There was no difference for anatomical information between TR 4500 ms and TR 5000 ms with p-value = 0.395, TR 4500 ms and TR 5500 ms with p-value = 0.131, TR 4500 ms and TR 6000 ms with p value = 0.078, TR 4500 ms and TR 6500 ms to the p-value = 0.066, TR 5000 ms and TR 5500 ms with p-value = 0.414, TR 5500 ms and TR 6000 ms with p-value = 0.102, TR 6000 ms and TR 6500 ms with p-value = 0.083.

The optimal value to produce anatomical information of the knee joint sagittal MRI sequences Short Tau Inversion Recovery (STIR) was TR 4500 ms.

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