



# Journal of Health and Medical Sciences

**Apriantoro, Nursama Heru, Sriyatun, Samsun, Winarno, Guntur, Aryani, Fitri, Pramono, Avicenna, Dimas Muhammad, and Poernama, Nadya Octafiani. (2019), SNR Value Evaluation of Knee MRI 1.5 T Using Volume and Surface Coil in Fatmawati General Hospital Jakarta. In: *Journal of Health and Medical Sciences*, Vol.2, No.1, 14-20.**

ISSN 2622-7258

DOI: 10.31014/aior.1994.02.01.14

The online version of this article can be found at:  
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Published by:  
The Asian Institute of Research

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## SNR Value Evaluation of Knee MRI 1.5 T Using Volume and Surface Coil in Fatmawati General Hospital Jakarta

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### Abstract

Introduction: Signal to noise ratio (SNR) is one of the determining factors of MRI images quality. SNR is defined as the ratio of the intensity of an object signal seen with noise. There are several factors that can affect SNR, one of them is the radiofrequency coil. Knee MRI examination based on the literature using a Knee coil with the shape of the volume. While in some hospitals the use of coil when the MRI knee examination can also use the surface coil. This is because the hospital does not have the coil volume or the condition of the patient's knee that it is not possible to use volume coil. Objective : To evaluate SNR on MRI Knee examination using volume coil and surface coil with 1.5T Magnetom Esenza MRI Scanners at Fatmawati Hospital. Method: The type of this research is quantitative analytics with experimental method, which was conducted in Radiology installation of Magnetic Resonance Imaging (MRI) at Fatmawati General Hospital Jakarta starting from March to April 2018, with 16 samples. The technique of data collecting is done by observation and experiment. Research instrument consists of the worksheet, operator console, and counting sheet. Processing and data analysis is done by using paired sample T-test statistic. Results: The result of this study indicates that there is a difference of image quality in SNR aspect on the image of MRI knee inspection using volume coil and surface coil marked with p-value <0.05. Conclusion: MRI Knee examination using volume coil possess higher SNR than using the surface coil. But, the surface coil can be the second choice for MRI Knee examination if the hospital doesn't have volume coil or surface coil, it can't be used for the patient.

**Keywords:** MRI Knee, SNR, Volume Coil, and Surface Coil

### 1. Introduction

The principle of MRI was discovered in 1970 by Nobel Laureates, Paul Lauterbur and Peter Mansfield(1). Broadly speaking, MRI occurs because of a patient which is placed in a field that has high magnetic strength and will be temporarily magnetized. Resonance will be generated through the application of certain pulses and then absorbed by the patient. After that, excess energy is released and calculated. The signal is captured and processed by the computer and converted into a grayscale MRI (2,3).

The ability to represent a multiplanar plane, removing bone artifacts and increasing the contrast resolution of soft tissue is an advantage of MRI in the case of the musculoskeletal system compared to Computed Tomography (CT). The musculoskeletal system has become a very controlled area by MRI (4–6). So that MRI is very useful for diagnosing tearing of the cruciate and collateral ligaments and osteonecrosis in the femoris condylus (7,8).

The quality of MRI images is controlled by many factors, in this case, such as selecting the right parameters in the chosen protocol. It is very important for the operator to know these factors and how they are related so that optimal image quality can be produced. There are 4 important factors in determining image quality, namely signal to noise ratio (SNR), contrast to noise ratio (CNR), spatial resolution and scan time (9).

Signal to noise ratio (SNR) is defined as the ratio of the signal intensity of the object seen with noise (9–11). In MRI imagery, SNR can be assessed subjectively and objectively. Objective assessment was carried out using mathematical calculations of signal intensity and noise from the images assessed, in this case the anatomy often assessed in knee MRI examinations such as the anterior cruciate ligament (ACL), posterior cruciate ligament (PCL), articular cartilage of the femur, femur, patella, and tibia (12,13).

Signal intensity on knee anatomy and surrounding organs is known by carrying out ROI (region of interest) (11), ROI is a measurement technique by activating the ruler menu on the MRI computer console to determine the average signal intensity of the organs examined. When performing ROI, the monitor will also display the noise (standard deviation) value of the image, this signal intensity and noise value will be used to calculate the SNR. The higher the SNR value, the better the image quality (9).

There are several factors that can affect SNR, such as magnetic field strength, proton density of organs examined, voxel volume, time repetition (TR), time echo (TE), number of average, number of acquisition (NSA), radiofrequency coil, etc. (9,11,14). Radiofrequency (RF) coil is a hardware instrument that functions to receive signals (9).

As long as researchers carry out practical field training in hospitals, the use of coil when examining knee, MRI is not only using volume coil such as knee coil but also using surface coils such as body coil and flex coil. One of them is at Fatmawati Central Hospital.

A Knee MRI examination using a surface coil on a 1.5 T plane was carried out by D. Lawrence Burk, Emanuel Kanal, James A. Brunberg, et al. in the journal "1.5 T Surface-Coil MRI of the Knee". The conclusion of the experiment is that Knee MRI examination using surface coil can improve SNR and show meniscus, synovial fluid, ligament, etc. well (7). However, in the experiment, the SNR value was not calculated from the results of the description and did not display a comparison with the use of coil volume so that the difference is unknown.

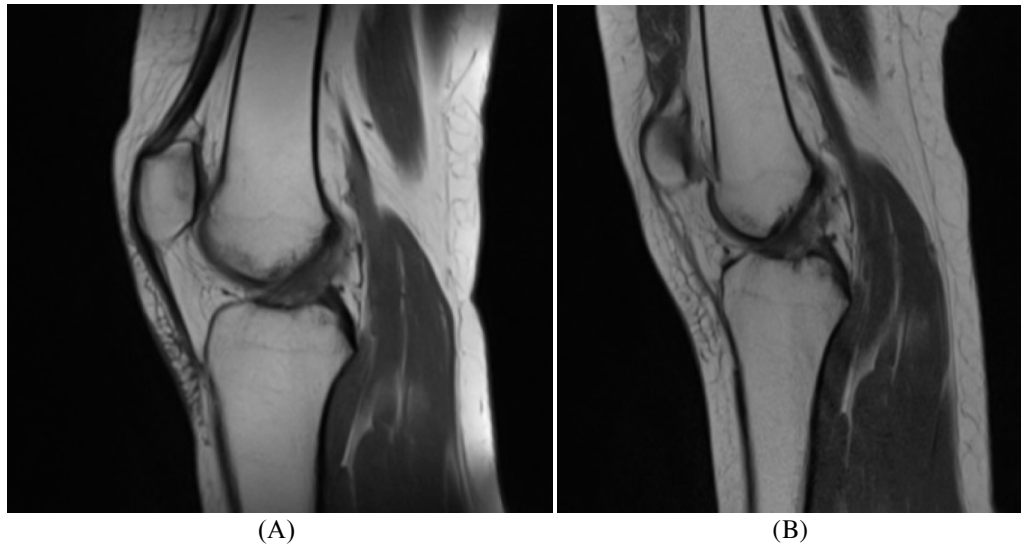
This causes researcher's interest in taking the title "Evaluation of SNR value on Knee MRI examination using coil volume and surface coil with MRI 1.5 Tesla machine in Fatmawati General Hospital" in order to assess whether there are SNR differences between the two coils and evaluate which coil is capable of displaying knee MRI image with better SNR category, in order to produce an optimal image.

## 2. Methods

The type of research used is quantitative analytic. The method of observation and experimentation was done in the Radiology Installation of Fatmawati General Hospital in February to April 2018. The population was all patients who came to undergo a knee MRI examination in Radiology Installation in Fatmawati General Hospital with a total sample of 16 patients. The research instruments are worksheets, operator MRI consoles, and measurement sheets. The method of data collection is performed by experimental techniques, and the researcher performs an MRI examination of the fragments of the PD sagittal sequence using the volume coil and surface coil that SNR will be assessed objectively. Test the hypothesis using the Dependent Paired Sample T-test. The MRI scanner that used is 1.5 Tesla, volume coil (Knee coil), surface coil (flex coil), emergency bell, headphone, and operator console.

### 3. Results

The results either the Knee MRI images are sagittal slice with Proton Density TSE Sequence using volume coil and surface coil as shown in Figure 1.



**Figure 1.** Sagittal Image of Knee MRI using : (A) Volume Coil (B) Surface Coil

Table 1. Recapitulation of anatomical SNR values of the sagittal slice with Proton Density TSE Sequence with the volume coil

Sample	SNR values of the knee anatomy using volume coil						Total	Mean
	ACL	PCL	ACoF	Femur	Patella	Tibia		
1	17.84	23.41	34.34	126.10	115.78	97.35	414.83	69.14
2	26.78	8.79	42.47	146.24	123.73	115.62	463.62	77.27
3	39.23	7.81	41.72	95.86	94.10	72.21	350.92	58.49
4	39.27	26.68	60.22	145.00	137.74	133.86	542.78	90.46
5	38.28	22.19	55.32	163.80	155.98	144.15	579.74	96.62
6	20.36	14.41	36.64	87.78	88.10	71.35	318.64	53.11
7	14.75	18.67	35.61	76.40	81.34	69.16	295.94	49.32
8	57.29	21.19	92.30	240.15	248.17	106.26	765.37	127.56
9	70.06	33.09	55.93	117.15	112.45	32.21	420.88	70.15
10	47.22	16.61	56.91	172.08	150.36	157.68	600.86	100.14
11	25.55	6.63	40.84	137.91	120.21	137.46	468.60	78.10
12	45.37	7.93	77.70	210.04	195.96	133.96	670.96	111.83
13	21.80	20.09	42.96	126.51	131.88	85.92	429.17	71.53
14	24.11	22.40	32.66	108.03	86.66	85.90	359.76	59.96
15	27.86	21.93	55.98	141.47	137.09	105.36	489.70	81.62
16	20.19	12.57	39.00	119.65	119.54	99.50	410.46	68.41
Average	33.50	17.78	50.04	138.39	131.19	103.00	473.89	<b>78.98</b>

Table 1 is a recapitulation of the anatomical SNR values of sagittal slice with Proton Density TSE Sequence using the ROI technique. The objective calculation result (ROI technique) of anatomical SNR values of sagittal slice with Proton Density TSE Sequence using volume coil is 78.98.

Table 2. Recapitulation of anatomical SNR values of sagittal slice with Proton Density TSE Sequence with surface coil

Sample	SNR values of the knee anatomy using Surface Coil						Total	Mean
	ACL	PCL	ACoF	Femur	Patella	Tibia		
1	12.63	13.71	25.06	111.04	103.37	89.55	355.36	59.23
2	16.54	8.05	24.26	114.44	100.48	90.03	353.81	58.97
3	19.66	12.76	27.23	68.05	73.40	57.80	258.91	43.15
4	63.19	24.56	57.75	155.04	168.18	126.39	595.11	99.18
5	32.08	16.39	42.33	132.43	118.24	109.93	451.41	75.23
6	20.19	17.35	46.57	110.04	114.01	97.44	405.60	67.60
7	23.06	18.88	44.56	95.23	108.04	70.39	360.17	60.03
8	34.69	13.83	56.39	172.16	142.59	121.66	541.31	90.22
9	22.89	15.31	42.76	84.49	86.74	72.51	324.69	54.12
10	18.23	13.07	30.71	109.05	98.59	92.19	361.83	60.31
11	15.72	9.81	32.52	98.85	91.93	85.00	333.82	55.64
12	27.22	11.53	32.61	145.91	109.29	86.06	412.61	68.77
13	18.92	20.74	53.05	126.64	121.22	107.60	448.17	74.70
14	29.45	26.10	40.15	139.95	138.43	110.95	485.04	80.84
15	21.61	15.43	38.38	110.42	108.76	93.53	388.13	64.69
16	7.65	14.12	45.62	110.18	108.17	89.27	375.02	62.50
Average	23.98	15.73	40.00	117.74	111.97	93.77	403.19	<b>67.20</b>

Table 2 is a recapitulation of the anatomical SNR values of sagittal pieces using the ROI technique. The objective calculation results (ROI technique) of anatomical SNR values of sagittal slice with Proton Density TSE Sequence using surface coil is 67.20.

Table 3. Normality test SNR values of the knee anatomy using volume coil and surface coil

Coil	Shapiro-Wilk		
	Statistic	Df	Sig.
Volume Coil	0.948	16	0.452
Surface Coil	0.946	16	0.430

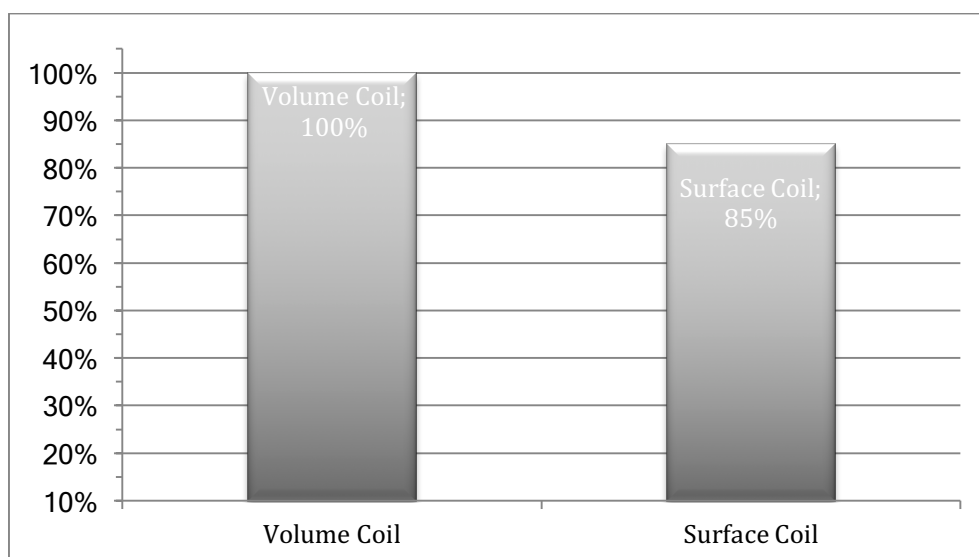
Table 3 explains that the significant test results of mean of anatomical SNR values of sagittal slice with Proton Density TSE Sequence with volume coil possess p-value (sig) = 0.452 ( $p > 0.05$ ) and use surface coil p-value =

0.43 ( $p > 0.05$ ) then normal data distribution. Because the data is normally distributed, the data is tested using the Paired-Samples T-Test.

Table 4. Paired Sample T-Test SNR values of the knee anatomy using volume coil and surface coil

Pair	Volume Coil Surface Coil	Mean	Std Dev.	Std Error	95% Confidence Interval of the Difference		t	df	Sig. (2-tail ed)
					Lower	Upper			
		11.78	19.44	4.86	1.42	22.14	2.42	15	.03

In table 4, the Sig. (2-tailed) Shows the value of hypothesis decision, after analysis using statistical calculation software, with paired samples T-test results obtained p-value = 0.03 ( $p < 0.05$ ), so  $H_0$  is rejected. That is, there is a difference in the quantity of images in the aspect of SNR values of the knee anatomy between those that use volume coil and surface coil.



**Figure 2** Percentage of SNR values of the knee anatomy using volume coil and surface coil (SNR values of the knee anatomy using volume coil as reference, 78.98 = 100%).

On Figure 2 by making SNR values of the knee anatomy using volume coil as the optimal SNR value on knee MRI examination (78.98 = 100%), the percentage SNR values of the knee anatomy was obtained using surface coil (67.20 = 85%). So that the percentage difference between SNR values of the knee anatomy using volume coil and surface coil is 15%. Based on the results of research on 16 samples regarding the evaluation of SNR values of the knee MRI examinations using coil volume and surface coil with MRI scanner 1.5 Tesla in Fatmawati General Hospital, the following discussion was found:

#### 4. Discussion

##### a. Signal to Noise Ratio

The calculation results of SNR values of MRI examination on knee anatomy such as anterior cruciate ligament (ACL), posterior cruciate ligament (PCL), articular cartilage of femur, patella, femur, and tibia using volume coil and surface coil in 16 samples can be seen from paired analysis T test samples obtained a significance value / p-value = 0.028, thus the p-value  $< p = 0.05$ . So it can be concluded that  $H_0$  is rejected, that is, there are differences in image quality in the SNR aspect on the results of the MRI knee examination image using different coils (volume coil and surface coil).

This is in accordance with the theory, one of which is in the book "MRI in Practice: by Catherine Wetsbrook mentioning one that affects SNR is the radiofrequency coil. RF coil function is to generate and provide RF and detect signals. Coil transmitters are useful for emitting radio waves at a localized nucleus so that an excitation phase occurs. While the receiving coil is useful for receiving output signals from the system after the excitation phase occurs (15). The selection of the right coil type will have an effect on producing a maximum SNR value. SNR is one of the determinants of the quality of MRI images, SNR is the factor that most determines the quality of MRI images (9,11,14). In research with objective calculation of SNR values as can be seen in table 4.5, knee SNR values using coil volume are in the range 49.31-127.56 with an average value of 78.98, while the SNR value of the MRI knee uses surface coil in table 4.6 in the range 43.15-99.18 with an average value of 67.2, from the results of these calculations it is known that the average value of knee SNR uses a higher coil volume than the average value of the knee anatomy SNR using surface coil. With knee SNR anatomical value using coil volume as a reference, 78.98 (100%), then obtained knee SNR value using surface coil 67.2 (85%), then the difference between SNR values of the knee anatomy uses volume coil with surface coil is only around 15%.

#### **b. Advantages and disadvantages of volume and surface coil**

The strength of the knee coil is its design in the form of a volume and in accordance with the knee form so that it can provide a homogeneous image in the anterior and posterior regions, as described by Blink, (16). Because the shape is in the form of volume and according to the shape of the knee making it easier for the MRI operator to adjust the position of the knee. In terms of image quality by looking at SNR, SNR volume coil is higher than SNR on surface coil. The disadvantage of the knee coil is that the coil diameter is not too large and inflexible so that in certain cases MRI examination or at knee large size cannot be done.

The advantage of flex coil is its flexible design so that it can be arranged in such a way that it can be as close as possible to the object and form the object to be examined, as described by Blink (16). Because the size is large enough and flexible so that it can be used on large enough objects. The shortage of flex coil when the MRI knee examination is done requires a longer time and produces image quality, namely with lower SNR compared to SNR volume coil and the possibility of wraparound artifacts, ie organ image artifacts that are not checked into the examined organs, so attention is needed which is specifically in positioning the knee of patients to be examined so as to provide optimal image quality results.

### **5. Conclusion**

The results of calculation of SNR values of the knee anatomy through objective assessment, namely the ROI technique on the MRI operator console shows that there are differences in image quality, namely knee SNR on the use of volume coil (knee coil) and surface coil (flex coil). This is in accordance with the theory, one of which is in the book "MRI in Practice" by Catherine Wetsbrook, which mentions one that affects SNR, namely the radiofrequency coil. Knee MRI image results using sagittal slice with volume coil possess an average signal to noise ratio of 78.98, this value is higher than the MRI image knee using sagittal slice with surfaces coil with an average value of 67.2. With a difference of 11.78 or about 15% of SNR values of the knee anatomy using volume coil. Judging from the signal to noise ratio value of MRI examination knee is better to use volume coil. With differences in knees SNR using a surface coil that is not much different, namely 11.78 or about 15% of the knee anatomy uses coil volume.

The excess of the volume coil (knee coil) is its design in the form of volume and in accordance with the knee form so that it can provide a homogeneous image in the anterior and posterior regions and facilitate the MRI operator to adjust the position of the knee. The disadvantage of the knee coil is that the coil diameter is not too large and inflexible so that in certain cases MRI examination or at knee large size cannot be done. Meanwhile, the advantage of surface coil (flex coil) is that the design is flexible so that it can be arranged in such a way that it can form objects and can be used on large enough objects. Lack of flex coil during MRI knee examination takes longer and requires special attention in positioning the patient's knee to be examined in order to provide optimal image quality results.

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