Original Research Article

Effect of Variation Number of Excitation (NEX) Parameter on The Quality Image of Magnetic Resonance Imaging Genu on T2 Weighted Image Sequence at Bali Mandara Regional General Hospital

# ABSTRACT

**Aim:** Study on the effect of NEX parameter variations on image quality in T2WI sequences on genu MRI images aims to determine the effect of Number of Excitation (NEX) variations on image quality which is influenced by scanning time and Signal to Noise Ratio (SNR), and determine the best NEX variation to produce scanning time and SNR T2WI MRI genu.

**Study Design:** This study used a quantitative analytic design in the form of experiments and direct field observations. This study was conducted in the MRI unit of Bali Mandara Hospital from January to December 2024.

**Methodology:** This study involved 30 patients who underwent genu MRI examination with 3 variations of NEX values ranging from (1, 2, and 3). Evaluating the scanning time and SNR value of the tissue by measuring the ROI directly on the MRI device. Data were analyzed using IBM SPSS statistical software and Excel software to evaluate the effect of NEX variation on image quality. The MRI machine used was Philips Ingenia CX 1.5 Tesla with standard protocol parameters for imaging genu

**Results:** Scanning time and SNR values were analyzed on ligament, bone, and fat tissues. The time required for scanning time was 115 seconds, 230 seconds, and 345 seconds, respectively. Sequentially, the average SNR values obtained based on the calculations performed were 6.906, 10.203, and 13.307 in ligament tissue, 81.209, 115.289, and 136.14 in bone tissue, and 106.662, 151.3 and 178.212 in fat tissue. Increasing the NEX value significantly increased the scanning time and SNR value. NEX 3 provides the highest scanning time and SNR value compared to other NEX variations. This indicates that multiple NEXs produce better image quality.

**Conclusion:** Good MRI image quality is determined by high scanning time and SNR values. This study recommends the use of NEX 3 in genu MRI imaging protocols to improve the accuracy of clinical examinations.

*Keywords: MRI, NEX, genu, scanning time, SNR*

# INTRODUCTION

Magnetic resonance imaging (MRI), which provides detailed images of soft tissue structures, is increasingly used in knee diagnosis. MRI can detect structural changes in the knee without clinical symptoms in asymptomatic individuals, providing valuable information about the morphological changes in the knee associated with aging. Unlike X-rays, which primarily show changes in bone, MRI can detect early changes in cartilage and other soft tissues, potentially allowing earlier diagnosis and treatment intervention (Salamah et al., 2024).



**Figure 1.** MRI machine

Magnetic resonance imaging (MRI) has the advantages of good tissue resolution, no ionizing radiation and non-invasiveness, and can provide high-resolution images, especially high-resolution T2-weighted imaging (T2WI), which is crucial for showing the details of tumor, lymph nodes, EMVI, and MRF (Zheng et al., 2024). One of the important aspects in MRI examination to determine the quality of MRI images, namely: Signal to Noise Ratio (SNR), Contrast to Noise Ratio (CNR), spatial resolution and scanning time. The parameters that affect the signal value and image contrast are the number of excitation (NEX), where the selection of NEX itself will affect the scanning time (Saefulloh, 2018).

Previous studies by Rochmayanti (2013) and Diana Ega Rani (2016) showed that increasing the number of excitation (NEX) significantly affected the signal-to-noise ratio (SNR) and scanning time. The higher the NEX, the higher the SNR and scanning time. Both studies concluded that a NEX value of 3 produced optimal image quality, especially in T1 spin echo head examination.

In light of the aforementioned, this study will focus on the impact of the NEX parameter on the image quality of genu MRI scans. Through identification and optimization of the aforementioned parameters, it is anticipated that the resulting MRI will have better quality, resulting in more accurate diagnosis and more effective treatment for patients with genu problems. The purpose of this study is to assess the impact of Number of Excitation (NEX) variations on MRI quality using scanning time and Signal to Noise Ratio (SNR), as well as to provide input on the advancement of medical technology.

Based on this, this study not only extends previous findings but also pays more attention to NEX parameters. The conditions of NEX use must be optimized so that the image has good quality.

# MATERIALS AND METHODS

## Materials

### Study area

The study was conducted at the Radiology Installation of Bali Mandara Regional General Hospital (RSUD), located at Jl. Bypass Ngurah Rai No.548, Sanur Kauh, South Denpasar, Denpasar City, Bali.

* + 1. **Study tools and materials**

The tools and materials used in this study include an MRI machine with Phillips Ingenia CX brand specifications, superconductor magnet type, with a power of 1.5 T, and a computer device used for patient data processing, parameter settings, and image analysis.

### Study design

This study used an experimental research design and direct field observation with a quantitative approach to evaluate the effects of NEX variations on image quality in genu MRI examinations.

### Study population

Patients undergoing MRI genu examination at Bali Mandara Regional Hospital.

### Sample size determination

The independent variables in this study are the variations of NEX parameters (NEX 1, NEX 2, and NEX 3). The dependent variables are the values of scanning time and SNR. Other parameters that are made constant, namely the Control Parameters that are made constant, such as slice thickness of 3 mm, interslice gap 0.5 mm, bandwidth of 217.8 Hz, number of slices 30 slices, TR parameter 2500 ms, TE parameter 80 ms, FOV of 170 x 170 mm, flip angle of 900, slice orient is axial.

1. **Methods**

### Sampling techniques

Data collection was conducted using the following steps:

1. Preparation Stage: Patients were given an explanation of the MRI procedure and asked to remove metal objects and magnets, if necessary, patients will be asked to change clothes with special clothes that have been provided before entering the MRI room.
2. Scanning Stage: Filling in patient data on the computer system, followed by setting parameters according to the protocol and genu scanning using the NEX variation studied.
3. Data Retrieval: 90 images from 30 patients were analyzed, which involved segmenting the ROI (region of interest) of ligament, bone, fat, and background as noise.

### Study instruments

### The research procedure consisted of the following stages:

1. Preparatory Stage: Patients are given an explanation of the MRI procedure and asked to remove metal objects and magnets if necessary. Patients will be asked to change into special clothes that have been provided before entering the MRI room. The radiologist prepares a knee coil to capture RF signals and headphones to reduce noise. The patient is positioned supine in the MRI scanner gantry.
2. Image Scanning Stage: Patient data is entered into the computer system. Parameters such as slice thickness, interslice gap, number of slice bandwidths, TR, TE, FOV, flip angle, and slice orient are adjusted according to the protocol. Scanning is performed with variations in NEX parameters (NEX 1, NEX 2, and NEX 3).
3. Data Capture Phase: Data is taken from 30 patients resulting in 90 images being analyzed. ROI segmentation is performed on ligaments, bones, fat, and background to calculate scanning time and SNR values.

### Data collection method

SNR measurements:

SNR is calculated by dividing the average signal of ligament, bone or fat by the standard deviation of noise. Statistical Test: Data were analyzed using SPSS with ANOVA test at a significance level of 0.05 and Excel software to evaluate the effect of NEX variation on SNR (Montgomery, 2021).

### Data management

* H0: NEX variation does not affect MRI image quality.
* H1: NEX variation affects MRI image quality.

The results of the F ANOVA test are compared with the critical value of Ftable to determine whether the variation of NEX has a significant effect on the SNR values. If Fcount > Ftable then H0 is rejected, which indicates a significant effect (Ghozali, 2016).

# RESULTS AND DISCUSSION

This study involved 30 patients (16 males, 14 females) aged 15-64 years. MRI genu examination produced images that were analyzed using region of interest (ROI) segmentation (Astuti et al., 2017). ROI measurements were performed on ligaments, bones, fat, and background for three NEX variations. From the ROI data, SNR values ​​were then determined.

## Effect of NEX Variation on scanning time

Scanning time in MRI is affected by several parameters, including TR, number of phase encodings, and NEX. Increasing NEX results in longer acquisition times, but also increases the risk of motion artifacts (Rochmayanti et al., 2013). Increasing scanning time between NEX 1 and 2 results in a two-fold increase in time. In the NEX 1 variation, it takes 115 seconds, the NEX 2 variation takes 230 seconds, and the NEX 3 variation takes 345 seconds.

## Effect of NEX Variation on SNR

Based Based on the measurements, it can be seen that the SNR value of each tissue increases with each increase in NEX. From the results of the data measurements above, an average calculation of the SNR is carried out on each NEX variation as shown in Table 1.

Table 1. Average SNR value

|  |  |
| --- | --- |
| NEX variation | Average SNR result |
| Ligament | Bone | Fat |
| 1 | 6.906 | 81.209 | 106.662 |
| 2 | 10.203 | 115.289 | 151.3 |
| 3 | 13.307 | 136.14 | 178.212 |

Based on Table 1, the relationship between NEX (number of excitation) variations and SNR (signal to noise ratio) values ​​can be seen in Figure 2

**Figure 2.** Graph of the effect of NEX variations on SNR values

Differences in NEX (Number of Exitations) values ​​affect the intensity of the received signal, because tissue with a high hydrogen (H) atom content will produce a stronger signal (hyperintense) than tissue with few hydrogen atoms (Westbrook et al., 2011). Increasing signal intensity increases the SNR (Signal-to-Noise Ratio), which differs in ligaments, bones, and fat due to variations in the number of hydrogen atoms in each tissue. Bone and ligaments have low signal intensity on almost all MRI due to their low proton content. Mineral-rich bone and collagenous tissues (tendons, ligaments) have less water and more protein, resulting in low signal on T2-weighted imaging (T2WI) (Mitchell et al., 1987). Fat have high proton density, with many hydrogen protons resulting in high signal intensity on T2WI (Weishaupt et al., 2003).

The results of the analysis show that the SNR value increases with the increase in NEX. (Zafar, 2019) NEX will increase SNR but will not affect contrast unless the tissues are being lost in noise (low CNR). The graph in Figure 2 illustrates the average SNR value of patient images, with the highest SNR obtained at NEX 3. Before the anova test, normality and homogeneity tests were conducted, which showed that the data met the statistical assumptions (sig > 0.05) (Fitri et al., 2023).

Table 2. F anova test results on SNR values



The F Anova test was conducted to test the effect of NEX (independent variable) on SNR (dependent variable). The results of the analysis showed that in ligament, bone, and fat tissues, the significance value was <0.05, so H0 was rejected and H1 was accepted, which means that NEX variations had a significant effect on SNR. Examination of F count and F table with SPSS and Excel showed F count > F table, and the F statistic value was greater than the critical F at the significance level α = 0.05 (Junaidi, 2010). This indicates that increasing NEX has a significant impact on increasing SNR, in accordance with the proposed hypothesis.

# CONCLUSION

This study shows that the variation of NEX (number of excitation) has a significant effect on the scanning time and signal to noise ratio (SNR) values ​​in ligament, bone and fat tissues. The time required for scanning time was 115 seconds, 230 seconds, and 345 seconds, respectively. Sequentially, the average SNR values obtained based on the calculations performed were 6.906, 10.203, and 13.307 in ligament tissue, 81.209, 115.289, and 136.14 in bone tissue, and 106.662, 151.3 and 178.212 in fat tissue. The F Anova test was conducted to examine the effect of NEX (independent variable) on SNR (dependent variable). The analysis results showed that in ligament, bone, and fat tissues, the significance value was < 0.05, leading to the rejection of H0 and acceptance of H1. This indicates that NEX variations significantly affect SNR. Increasing the NEX value significantly increased the scanning time and SNR value. The results of the analysis show that the higher the NEX value given, the higher the scanning time and SNR values. The highest scanning time and SNR values ​​are found in NEX 3, which indicates that this NEX is good for producing high-quality images.

# RECOMMENDATIONS

For future research development, it is recommended to conduct research on other organs with a wider variety of parameters in order to obtain more optimal results.

**DISCLAIMER (ARTIFICIAL INTELLIGENCE)**

Author(s) hereby declares that NO generative AI technologies such as Large Language Models and text-to-image generators have been used during writing or editing of this manuscript.

# CONSENT

All authors declare that a ‘written informed consent was obtained from all the patient;

# REFERENCES

Astuti, S. D., Astutik, N. V. I., & Muzamil, A. (2017). *Optimization of Bandwidth and Time Echo Parameters to Reduce Susceptibility Artifacts and Chemical Shift in MRI*. Journal of Postgraduate Biosciences, *19*(3), 237. https://doi.org/10.20473/jbp.v19i3.2017.237-245

D.C. Montgomery, E.A. Peck, and G.G. Vining., (2021). *Introduction to Linear Regression Analysis, sixth edition*. John Wiley & Sons, Inc. New Jersey, USA.

Fitri, A., Rahim, R., Nurhayati, Aziz, Pagiling, S. L., Natsir, I., Munfarikhatin, A., Simanjuntak, D. N., Huatgaol, K., & Anugrah, N. E. (2023). *Basics of Statistics for Research*. Yayasan Kita Tulis. https://repository.unugiri.ac.id:8443/id/eprint/4882/1/Anisa %2C Book Basics of Statistics for Research.pdf

Ghozali, I. (2016). *Application of Multivariete Analysis with IBM SPSS 23 Program 8th Edition.* Semarang: Diponegoro University Publishing Agency.

Mitchell, D. G., Burk, D. L., Vinitski, S., & Rifkin, M. D. (1987). *The biophysical basis of tissue contrast in extracranial MR imaging*. In American Journal of Roentgenology (Vol. 149, Issue 4, pp. 831–837). https://doi.org/10.2214/ajr.149.4.831

Rani, Diana Ega. (2016). “Optimization of Number of Excitation (NEX) on Signal To-Noise Ratio (SNR) and Scanning Time Speed on MRI Examination”. *Final Project*. Airlangga University.

Rochmayanti, D., Widodo, T. S., & Soesanti, I. (2013). Analysis of Number of Signals Averaged (NSA) Parameter Changes on SNR Improvement and Imaging Time on MRI. *Jnteti*, *2*(4), 37–45.

Saefulloh Henky. Masrochah Siti. Fatimah. (2018). Differences in SNR Image Quality in the Use of SENSE in MRCP Examination of Coronal T2 Cut TSE Sequences. *JImeD*, *Vol. 4*(No. 2), 85–89.

Salamah, A. A. S., Ramos-Bossini, A. J. L., Khan, K. S., & Santiago, F. R. (2024). Diagnostic accuracy of magnetic resonance imaging (MRI) for symptomatic knee osteoarthritis: a scoping review. *Quantitative Imaging in Medicine and Surgery*, *14*(11), 8001–8011. https://doi.org/10.21037/qims-24-1544

Junaidi. (2010). *Point Percentage Distribution F Probability = 0.05*. http://junaidichaniago.wordpress.com.

Weishaupt, Dominik, D. Kochli Victor, and Marincek Borut., (2003). *How Does MRI Work? An Introduction the Physic and Funtion of Magneting Resonance Imaging*. Heildelberg: Business Media. https://doi.org/10.1007/978-3-662-07805-1.

Westbrook, C., Roth, K., & Talbot, J. (2011). *MRI in Practice Fourth Edition*.United Kingdom: Wiley-Blackwel: UK.

Zafar, W. (2019). Resolution, SNR, Signal Averaging and Scan Time in MRI for Metastatic Lesion in Spine: A Case Report in a 74 Years Old Patient. *Clinical Radiology & Imaging Journal*, *3*(1), 1–4. https://doi.org/10.23880/crij-16000139

Zheng, G., Fu, J., Wang, Z., Li, W., Li, A., & Yu, D. (2024). *AI-assisted compressed sensing MRI improves imaging quality in rectal cancer : a comparative study with conventional acceleration techniques*. 0–2. https://doi.org/10.21037/qims-24-1317