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Comparison of cervical vertebrae MRI image information between axial T2 Fse and T2 propeller sequences

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ABSTRACT

Examinations performed on MRI of cervical vertebrae take a long time and cause patients to feel uncomfortable during the examination. FSE is a technique that can be used to produce fast examination times. Patient discomfort can also cause movement during the examination, which can cause artifacts in the resulting images. These movements can be minimized with the PROPELLER technique. This study is quantitative using an experimental method with a sample size of 15 volunteers who were each scanned with T2 FSE and T2 PROPELLER sequences. This study was conducted using a questionnaire in which each image produced was evaluated by 2 radiology specialist observers using the visual grading analysis (VGA) method to assess each anatomy of the corpus vertebrae, intervertebrae disc, spinal cord, CSF, intraforamen structure, nerve root and artifacts. The statistical results showed that the image quality of T2 FSE and T2 PROPELLER sequences had ap value of 0.000 ($p<0.05$). The sequence has a difference, namely T2 PROPELLER produces more detailed image quality on anatomy and pathology, and can reduce the occurrence of artifacts due to movement in the cervical area, and T2 FSE produces less informative image quality due to artifacts. In addition, there are differences in MRI scanning time of cervical vertebrae T2 FSE sequences which are faster than T2 PROPELLER and T2 PROPELLER is good at reducing artifacts.

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INTRODUCTION

The technique based on hydrogen atomic nuclei in Magnetic Resonance Imaging (MRI) imaging can depict cross-sections of the human body and soft tissues in detail.(Red Good YB, Darmini, 2020). Magnetic Resonance Imaging (MRI) shows the anatomical parts of the human body using a magnetic field. High sensitivity to differences in soft tissue and patient safety resulting from non-ionizing radiation are among the main reasons for using MRI as a substitute for various computed tomography (CT) methods and radiographic projections, etc (Nidaa Azmii Susdiningtyas, Farrah Hendara Ningrum, Nanang Sulaksono, & Sudiyono, 2019).

MRI examinations show that most, 90%, are used to examine the head and spine organs, while the remaining 10% are used to examine other organs (Jatmiko, Wandani, & Istigfarisky, 2021)(Suteja, Wulandari, & Triningsih, 2022). One of the most common and widely performed types of imaging in hospitals is an MRI of the spine. This is because an MRI of the spine can identify various types of pathology clinically, including traumatic, degenerative, or neoplastic lesions. Cervical examination is part of an MRI examination of the spine or cervical vertebrae (Malik, 2023)(Murniati, Rochmayanti, & Purnomo, 2021).

*Cervical*is the smallest bone that can be distinguished from the thoracic and lumbar vertebrae by the presence of a foramen on each transverse process.(Masrochah, Fatimah, & Yunitaningrum, 2020). The seven vertebrae that form the cervical vertebrae function to support the head and provide great freedom of movement so that it can move to the right, left, up, and down. In addition, it can provide protection to the vertebral area and arteries, the upper part of the spinal cord, and the flexibility of the cervical and brachial plexuses (Menchetti, 2022)(Nadeak, 2019).

In MRI examinations of various types of cases in the cervical vertebrae, and can also be observed well in the results of MRI examinations of the cervical vertebrae, but the examination time required will be relatively longer, so that there will definitely be movement in the anatomical area of the patient's cervical spine (Soesilo Wibowo Ardi, Kurniawati Ary, & Hernastiti, 2016). Based on this, cervical vertebrae examination can be applied with axial T2 FSE (Fast Spin Echo) sequence in cervical vertebrae MRI examination (Catherine Westbrook, 2018). This is because the FSE series helps patients and radiology specialists to perform examinations more quickly, reducing the time during scanning and minimizing movement. The use of the FSE sequence can also produce images with strong signals in cerebrospinal fluid (CSF), detecting various pathologies such as edema, tumors, nerve root details, infections, fractures, and ligament injuries(Muzamil, Nurdin, Rohmah, Rulaningtyas, & Astuti, 2023).

A movement during the examination can cause motion artifacts or movement artifacts. The PROPELLER (Periodically Rotated Overlapping Parallel Lines with Enhanced Reconstruction) technique is one technique that can be done to reduce the occurrence of these artifacts. PROPELLER is a method designed to reduce motion artifacts and other movement problems such as this is called PROPELLER as overlapping parallel lines with advanced reconstruction that rotates periodically (Li et al., 2022). PROPELLER can be used for MRI examination in less cooperative patients, and can also be applied to cooperative patients. Fine movements may occur due to swallowing, and inhalation. In addition, there are often artifacts caused by common CSF flow that can often occur (Song et al., 2024).

In PROPELLER all lines have overlapping centers in k-space because the rotating lines fill k-space. When different lines are acquired, the superimposed k-space center region can be used to estimate the k-space phase difference caused by the metal. This can reduce artifacts in the phase encoding direction. Susceptibility effects cause local distortions in the static magnetic field and mainly affect the decay of the T2 signal. Therefore, before each readout, the PROPELLER circuit refocuses T2 using a spin echo pulse and removes the distorted T2 signal from the NMR signal to reduce distortion in the image (Muzamil et al., 2023). The use of the PROPELLER technique can display anatomical criteria more clearly so that it can improve image quality and increase the resulting diagnostic analysis to be more accurate (Kartikasari, Kartili, Rochmayanti, & Aprilia, 2020).

In MRI examination of the cervical vertebrae according to research (Wen, Zhang, Zhu, & Liu, 2023). The use of T2 FSE sequences has been proven to be good for detecting pathological conditions. However, the cervical vertebrae are very susceptible to movement, either sudden or unintentional, and can occur in patients who are uncooperative or cooperative. This is because the propeller technique is not sensitive to movement in cervical anatomy (Shigenaga, Takenaka, Hashimoto, & Ishida, 2021). The PROPELLER technique at Jogja International Hospital (JIH) Purwokerto is rarely applied to non-cooperative or cooperative patients. The PROPELLER technique at Jogja International Hospital (JIH) Purwokerto is rarely applied to non-cooperative or cooperative patients. Based on this background, the author aims to study more deeply to compare and analyze the most optimal axial images between the T2 FSE and T2 PROPELLER axial sequences.

RESEARCH METHOD

This type of research is a quantitative study with a simple experimental approach that aims to determine the differences in optimal image information on MRI cervical vertebrae axial cuts on the T2 FSE sequence with T2 PROPELLER. This data collection was carried out at the Radiology Installation of Jogja International Hospital (JIH) Purwokerto in February 2025, using a GE 1.5 T MRI device. This study analyzed the T2 FSE and T2 PROPELLER sequences on axial cuts. The number of samples in the study used was 15 samples, each of which would be scanned with the T2 FSE and T2 PROPELLER sequences (Lukito, Darmini, & Murniati, 2017). The following are the parameters used in examinations with the T2 FSE and T2 PROPELLER sequences.

Table 1. Cervical vertebrae MRI examination parameters

1. Parameter	2. T2 FSE sequence	3. T2 PROPELLER Sequence
4. TR	5. 3500	6. 3500
7. TE	8. 100	9. 100
10. FOV	11. 180	12. 180
13. Slice Thickness	14. 3.5mm	15. 3.5mm
16. NEX	17. 2	18. 2

This quantitative research was conducted with a questionnaire, then each image produced will be evaluated by 2 observers, this is in accordance with research (Chokshi et al., 2025), the 2 observers are radiology specialists with the visual grading analysis (VGA) method including corpus vertebrae, discus intervertebrae, spinal cord, CSF, intraforamen structure, nerve root, and artifacts. The following is a Likert scale table.

Table 2. Visibility evaluation standards T2 fse and T2 propeller axial sequences

	Anatomy	Artifact	
Scale	Information	Scale	Information
1	Lacking, information is not clear enough, not bright enough, not clear enough, and blurry.	1	Lacking, large number of artifacts, severe distortion, slight blurring, and poor visualization
2	Sufficient, the image information is clear enough or visible but must be observed carefully	2	Fair, moderate amount of artifacts, moderate distortion, barely visible blurring, and moderate visualization
3	Clear, good, firm, bright, crisp and non-blurry image information	3	Good, few artifacts, little distortion, no blurring, and good visualization.

RESULTS AND DISCUSSIONS

From the results of research conducted at the radiology installation of Jogja International Hospital (JIH) Purwokerto in February 2025, 15 research samples were used with volunteers. The following are the results of MRI images of the cervical vertebrae using the T2 FSE and T2 PROPELLER sequences.

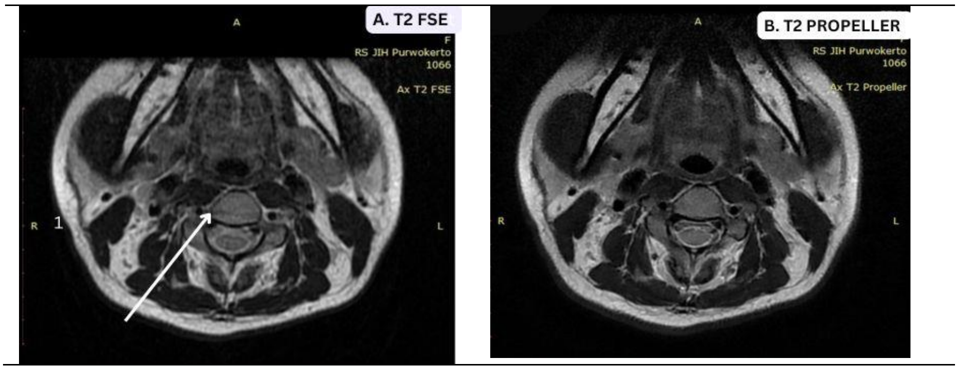

Figure 1. (A) T2 FSE (arrow indicates presence of artifact); (B) T2 Propeller (absence of artifact)

Image assessment on T2 FSE and T2 PROPELLER sequences before the Wilcoxon test is performed, a kappa test will first be performed which aims to analyze the results of the observer's assessment agreement, namely with a radiology specialist. The following is a table showing the results of the Kappa statistical test.

Table 3. Kappa test results

Sequence	Kappa Value	Information
Axial T2 FSE	0.864	Almost perfect deal
Axial T2 PROPELLER	0.884	Almost perfect deal

Based on the questionnaire results in Table 3, it shows that the two radiology specialists who have been analyzed using the Cohen's Kappa statistical test showed an average result (average kappa = 0.874), on the T2 FSE sequence with a value of 0.864 and on the T2 PROPELLER sequence with a value of 0.884. The average results were taken from one observer who has extensive experience and expertise in the field of MRI imaging for more than 5 years, so that it can guarantee the level of validity of the research results.

To analyze the results of the questionnaire data from the observer, the Wilcoxon Signed Test was used in the form of ordinal data which is useful for seeing differences in optimal anatomical image information on MRI of the cervical vertebrae, in addition to seeing the results of the mean rank value on each T2 FSE and T2 PROPELLER sequence.

Table 4. Overall wilcoxon test result

No.	Sequence	p-value	Information
1	Axial T2 FSE - Axial T2 PROPELLER	0.001	There is a significant difference

The overall Wilcoxon test results in Table 4 show Asymp. Sig. (2-tailed) <0.001, this indicates that the p-value <0.05, this means that there is a significant difference in anatomical image information on each T2 FSE and T2 PROPELLER sequence in MRI examination of the cervical vertebrae.

Table 5. Wilcoxon test results on MRI image information anatomy of cervical vertebrae between axial sequence T2 FSE and T2 propeller

No.	Image Information	p-value	Information
1.	Corpus VertebraeT2 FSE Corpus VertebraeT2 PROPELLER	0.005	There is a significant difference
2.	Discus VertebraeT2 FSE Discus Vertebrae	0.005	There is a significant difference
3.	Spinal CordT2 FSE		

No.	Image Information	p-value	Information
		0.005	There is a significant difference
	Spinal CordT2 PROPELLER		
4.	CSF T2 FSE		
		0.003	There is a significant difference
	CSF T2 PROPELLER		
5.	Intraforamen StructureT2 FSE		
		0.001	There is a significant difference
	T2 PROPELLER Intraforamen Structure		
6.	Nerve Root T2 FSE		
		0.001	There is a significant difference
	Nerve Root T2 PROPELLER		
7.	T2 FSE Artifact		
		0.003	There is a significant difference
	T2 PROPELLR Artifact		

Based on the results in table 5, the results of the Wilcoxon difference test on the assessment of anatomical images and artifacts show a p-value below 0.05. The p-value on both T2 FSE and T2 PROPELLER sequences shows a significant difference.

Table 6. Wilcoxon mean rank statistical test results on MRI image information of cervical vertebrae between axial T2 FSE and T2 propeller sequences

No.	Criteria	Sequence	Mean Rank
1.	Corpus vertebrae	T2 FSE	7.50
		T2 PROPELLER	8.08
2.	Discus intervertebrae	T2 FSE	7.50
		T2 PROPELLER	8.08
3.	Spinal cord	T2 FSE	7.50
		T2 PROPELLER	8.08
4.	CSF	T2 FSE	6.00
		T2 PROPELLER	7.08
5.	Intraforamen Structure	T2 FSE	0.00
		T2 PROPELLER	6.50
6.	Nerve root	T2 FSE	0.00
		T2 PROPELLER	7.00
7.	Artifact	T2 FSE	6.00
		T2 PROPELLER	7.08

Based on the analysis of the mean rank value, the Wilcoxon statistical test displays the mean rank value on the T2 PROPELLER sequence > T2 FSE. The results of the Wilcoxon test on the anatomy of the vertebral corpus, intervertebral disc, spinal cord and artifacts with the T2 PROPELLER sequence have a large mean rank value. In the CSF information using the T2 PROPELLER sequence, the mean rank value shows results that are still large. The anatomical value of the intraforamen structure and nerve root has a fairly large mean rank value. The six anatomies shown in the table show that the mean rank produced on T2 PROPELLER has a greater advantage compared to T2 FSE

Discussion

This study was conducted using 15 samples of cervical vertebrae MRI, each scanned on axial slices with T2 FSE and T2 PROPELLER sequences to determine the overall average value. This study was conducted at Jogja International Hospital (JIH) Purwokerto. The results of the image evaluation were processed by computer with the SPSS 30 program.

Based on research on MRI examination of axial slices of the cervical vertebrae, the first step taken was the Cohen's Kappa test, the results of which showed agreement between two observers or an observer by a radiology specialist. From the kappa test, the highest value was found in the T2 PROPELLER sequence of axial slices. According to (Tasyawati & Utami, 2024) the value of agreement in two observers is if the Cohen's Kappa test result is less than 0.00 (invalid), 0.01-0.20 (very low), 0.21-0.40 (low), 0.41-0.60 (moderate), 0.61-0.80 (high), 0.81-01.00 (very high). Therefore, the test results have an objective consistency value based on the average value of the kappa test research with the two sequences.

Based on the Wilcoxon statistical test as a whole, it can show a p-value = 0.001, which means the p-value is less than 0.05. Therefore, Ho is rejected and Ha is accepted, this shows that the overall anatomical test results are better on T2 PROPELLER. In addition, the mean rank value for the overall use of the T2 PROPELLER sequence is also superior in displaying the quality of image information more optimally and there is a significant difference when compared to the use of the T2 FSE sequence.

Based on the overall Kappa and Wilcoxon tests conducted in this study, the order of the T2 FSE and T2 PROPELLER sequences differed significantly in cervical vertebrae MRI. The use of the T2 PROPELLER technique can improve the quality of cervical vertebrae MRI images optimally, so that the resulting image results will increase the good diagnostic value by a radiologist. The image quality using the T2 PROPELLER technique has a significant increase in imaging quality compared to the T2 FSE sequence.

This is in accordance with previous research conducted byAriec, (2024). AndSriyatun et al., (2023) which states that the T2 PROPELLER sequence can produce more in-depth anatomical information by showing superior anatomical structures with clearer and more defined boundaries.Meanwhile, in the artifact area on the T2 FSE sequence, it produces clearer artifacts, which can reduce the quality of each image information produced. This is because the neck bone is very susceptible to movement when MRI imaging is performed. This statement is in accordance with (Rochmayanti, Murniati, Fatimah, & Sulistyadi, 2022). The use of T2 axial slices of the spine and spinal cord is very sensitive to the occurrence of various types of artifacts, especially in the anatomical areas of the cervical and thoracic vertebrae where movement often occurs.

According to Shimamoto et al., (2018) in the cervical area there can be movement due to breathing and swallowing saliva either intentionally or unintentionally. In addition, it can occur due to CSF flow, blood circulation flow, and relaxation of the esophageal muscles. This movement can also occur in patients who are uncooperative or even in cooperative patients. Based on this, this study applies the T2 PROPELLER technique to reduce or reduce the occurrence of various types of artifacts that can occur during MRI examination of the cervical vertebrae.This is in accordance with research (Li et al., 2022). The use of the T2 PROPELLER technique can effectively reduce artifacts and can minimize distortion in the MRI image results of the cervical spine. According to Rochmayanti et al., (2022). PROPELLER or BLADE occurs when the filling of k-space is enhanced from the center of k-space, where rectangular data blocks are acquired and then rotated. The redundant information concentrated in the center of k-space is used to improve the signal to noise ratio (SNR) or to identify times during the scan when the patient moves, these data blocks can be processed with a phase-shifting algorithm to eliminate the effects of movement on the data during the reconstruction process and motion artifacts can be suppressed, so that artifacts can be minimized.

Based on the statement, the results of this study also show that the use of the PROPELLER technique, in addition to reducing artifacts, can also produce better image information and show that pathology can be seen more clearly, this is because the resulting image in the pathology area appears more enhanced and the fat area appears hyperintense and the boundary between anatomy and pathology appears more defined. This statement is in accordance with the statement according to (Wen et al., 2023) that the T2 PROPELLER technique is better at differentiating pathology in the cervical vertebra area than the T2 FSE technique. However, the PROPELLER technique has a longer acquisition time compared to the T2 FSE sequence which has a faster acquisition time. This is because the T2 FSE sequence applies longer

TR and TE values. Based on this, the overall analysis results show that there is a significant difference in transparent images between the T2 FSE image results and the T2 PROPELLER image results in MRI of the cervical vertebrae with axial slices.

Based on this, there are limitations of research in hospitals, namely that this study only discusses the T2 FSE and T2 PROPELLER sequences. In addition, this study only discusses anatomical information on the two images produced from the two sequences. This study was conducted with a 1.5 Tesla MRI, while the 3 Tesla MRI is more sensitive to larger artifacts and only obtains axial section images, does not obtain sagittal and coronal images, based on this, radiologists cannot analyze the image on other sections to see from various sides on the T2 PROPELLER sequence. Therefore, axial, sagittal, and coronal sections are needed, for further research purposes it is necessary to combine axial, sagittal and coronal images.

CONCLUSION

There is a difference in the image quality of MRI cervical vertebrae in axial cuts between the T2 FSE and T2 PROPELLER sequences. This is because the two sequences produce different images, the T2 PROPELLER sequence produces more detailed image quality in anatomy and pathology, and can reduce the occurrence of artifacts caused by movement in the cervical which is sensitive to movement, while the T2 FSE produces less informative image quality due to artifacts.

There is a difference in scan time on axial cervical MRI between the T2 FSE and T2 PROPELLER sequences, this is because the acquisition time between the two sequences is different, the T2 PROPELLER sequence produces a longer acquisition time and the T2 FSE produces a faster acquisition time. This is because the T2 FSE uses long TE and TR values.

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References

Ariec, I. W. (2024). ANALISIS PERBEDAAN INFORMASI CITRA ANATOMI SEKUEN SAGITTAL T2 FSE DAN SAGITTAL T2 FSE PROPELLER PADA PEMERIKSAAN MRI CERVICAL DENGAN KASUS CERVICAL ROOT SYNDROME, *8*, 6736–6743.

Catherine Westbrook. (2018). *Handbook of MRI Technique. Department of Allied Health and Medicine Faculty of Health, Social Care and Education Anglia Ruskin University Cambridge, UK. 2014. Analytical Biochemistry* (Vol. 11).

Jatmiko, A. W., Wandani, C. A., & Istigfarisky, L. W. (2021). Efek Pemakaian Kontras Untuk Optimalisasi Citra Pada Pemeriksaan Diagnostik Magnetic Resonance Imaging (MRI). *Jurnal Biosains Pascasarjana*, *23*(1), 28.

Kartikasari, Y., Kartili, M. I., Rochmayanti, D., & Aprilia, N. (2020). Perbedaan Informasi Citra Anatomi Sekuen Diffusion Weighted Imaging (Dwi) Antara Penggunaan Propeller Dengan Tanpa Propeller Pada Pemeriksaan Mri Brain Dengan Kasus Stroke. *Jurnal Imejing Diagnostik (JImeD)*, *6*(1), 36–43. https://doi.org/10.31983/jimed.v6i1.5565

Li, W., Shi, J., Bian, W., Li, J., Chen, X., Feng, J., … Niu, J. (2022). Performance of PROPELLER FSE T2WI in reducing metal artifacts of material porcelain fused to metal crown: a clinical preliminary study. *Scientific Reports*, *12*(1), 1–7. https://doi.org/10.1038/s41598-022-12402-2

Lukito, S. A., Darmini, D., & Murniati, E. (2017). Analisis Informasi Citra Antara Sekuens T2 FRFSE dengan T2 Propeller pada pemeriksaan MRI Cervikal Potongan Axial dengan Pesawat MRI GE Signa 1,5 T. *Jurnal Imejing Diagnostik (JImeD)*, *3*(2), 266–270. https://doi.org/10.31983/jimed.v3i2.3197

Malik, D. M. (2023). PERBANDINGAN GAMBARAN MRI DARI PERUBAHAN PATOLOGIS ELEMEN COLLUMNA VERTEBRALIS PADA FRAKTUR VERTEBRA METASTASIS DAN FRAKTUR VERTEBRA INFEKSI. Universitas Hasanuddin.

Masrochah, S., Fatimah, F., & Yunitaningrum, N. (2020). Analisa Informasi Citra MRI Cervical Potongan Sagital Pada Variasi Nilai Time Repetition (TR) Dengan Sekuens Short Tau Inversion Recovery (STIR). *Jurnal Imejing Diagnostik (JImeD)*, *6*(2), 79–85. https://doi.org/10.31983/jimed.v6i2.5822

Menchetti, P. P. M. (2022). Cervical Spine: Minimally Invasive and Open Surgery: Second Edition. *Cervical Spine: Minimally Invasive and Open Surgery: Second Edition*, (January), 1–347. https://doi.org/10.1007/978-3-030-94829-0

Merah Bagus YB, Darmini, S. M. (2020). Analisis Perbedaan Kualitas Citra Dan Informasi Anatomi Pada Pemeriksaan Mri Lumbal Sekuen T2Wi Fast Spin Echo (Fse) Potongan Sagital Dengan Variasi Nilai Time Repetition. *JRI (Jurnal Radiografer Indonesia)*, *3*(1), 5–12. https://doi.org/10.55451/jri.v3i1.53

Murniati, E., Rochmayanti, D., & Purnomo, T. (2021). Comparative in anatomical information and artifacts between T2W TSE Cartesian sequences and T2W TSE BLADE sequences on axial cervical MRI examinations. *Journal of Physics: Conference Series*, *1943*(1). https://doi.org/10.1088/1742-6596/1943/1/012051

Muzamil, A., Nurdin, D. Z. I., Rohmah, J., Rulaningtyas, R., & Astuti, S. D. (2023). Cervical MRI Image Quality Optimization based on Repetition Time (TR) and Echo Train Length (ETL) Settings. *Hellenic Journal of Radiology*, *8*(2), 19–27. https://doi.org/10.36162/hjr.v8i2.528

Nadeak, B. (2019). PENEGAKAN DIAGNOSIS DAN PENANGGULANGAN CERVICAL YS HERNIATED NUCLEUS PULPOSUS. *Jurnal Pro-Life*, *6*(2), 191–201.

Nidaa Azmii Susdiningtyas, Farrah Hendara Ningrum, Nanang Sulaksono, & Sudiyono. (2019). Perbedaan Informasi Anatomi Citra Mri Cervical Pada Kasus Hernia Nucleus Pulpopus (Hnp) Dengan Sekuen T2W Fast Spin Echo (Fse) Antara Penggunaan Flow Compensation Dan Tanpa Flow Compensation. *JRI (Jurnal Radiografer Indonesia)*, *2*(2), 94–99. https://doi.org/10.55451/jri.v2i2.41

Rochmayanti, D., Murniati, E., Fatimah, F., & Sulistyadi, A. H. (2022). Image Quality of T2W Tse Cartesian Versus T2W Tse Blade, a Quantitative Analysis on Axial Cervical Mri. *Jurnal Imejing Diagnostik (JImeD)*, *8*(2), 100–104. https://doi.org/10.31983/jimed.v8i2.8955

Shigenaga, Y., Takenaka, D., Hashimoto, T., & Ishida, T. (2021). Robustness of a combined modified dixon and propeller sequence with two interleaved echoes in clinical head and neck mri. *Magnetic Resonance in Medical Sciences*, *20*(1), 76–82. https://doi.org/10.2463/mrms.mp.2019-0161

Shimamoto, H., Tsujimoto, T., Kakimoto, N., Majima, M., Iwamoto, Y., Senda, Y., & Murakami, S. (2018). Effectiveness of the periodically rotated overlapping parallel lines with enhanced reconstruction (PROPELLER) technique for reducing motion artifacts caused by mandibular movements on fat-suppressed T2-weighted magnetic resonance (MR) images. *Magnetic Resonance Imaging*, *54*(July), 1–7. https://doi.org/10.1016/j.mri.2018.07.015

Soesilo Wibowo Ardi, Kurniawati Ary, & Hernastiti, U. S. (2016). Analysis of Mri Image Information of Cervical Spine Axial Slices Using Flow Compensation Between T2 Weighted Turbo Spin Echo (Tse) and Gradient Echo (Gre) Sequences. *JImeD*, *2*(2), 142–147.

Song, Y. S., Lee, I. S., Hwang, M., Jang, K., Wang, X., & Fung, M. (2024). Clinical efficacy of motion-insensitive imaging technique with deep learning reconstruction to improve image quality in cervical spine MR imaging, (February), 812–819.

Sriyatun, S., Supriyaningsih, E., & Oktavianti, Y. (2023). Pengaruh Penggunaan T2 Blade terhadap Kualitas Citra MRI Cervical Potongan Sagital pada Pasien Non-Cooperative. *Jurnal Imejing Diagnostik (JImeD)*, *9*(2), 62–67. https://doi.org/10.31983/jimed.v9i2.10051

Suteja, G. W., Wulandari, P. I., & Triningsih, T. (2022). Optimalisasi pemeriksaan MRI lumbal pada kasus low back pain dengan protocol wholespine sequen T2 TSE sagital di Rumah Sakit Kasih Ibu Denpasar. *Nautical : Jurnal Ilmiah Multidisiplin Indonesia*, *1*(9), 906–921.

Tasyawati, R. M., & Utami, H. S. (2024). ANALISIS PERBANDINGAN INFORMASI CITRA MRI VERTEBRA ANTARA STIR MAVRIC-SL DAN T2 FSE FATSAT SAGITAL PADA, *5*, 2366–2373.

Wen, B., Zhang, Z., Zhu, J., & Liu, L. (2023). Synthetic MRI plus FSE- PROPELLER DWI for differentiating malignant from benign head and neck tumors : a preliminary study, (September), 1–10. https://doi.org/10.3389/fonc.2023.1225420