Eduvest – Journal of Universal Studies
Volume 5 Number 8, August, 2025
p- ISSN 2775-3735- e-ISSN 2775-3727

Analysis Pediatric Brain Anatomy and Motion Artifacts Between T2 TSE And T2 TSE Fast Blade Sagittal MRI 3T

Umi Rahmayanti LS[1], Hernastiti Sedya Utami[2]*, Arga Pratama Rahardian[3], Mochamad Syafi'ie[4], Pradana Nur Oviyanti[5]
[1,2,3,5]Universitas Muhammadiyah Purwokerto, Indonesia
[4]RSUP Dr. Sardjito Yogyakarta, Indonesia,
Email: 1umirahmayanti018@gmail.com,2hernastitisedyautami@ump.ac.id*, argarahardian@ump.ac.id3, msyafiie75@gmail.com4, pradananuroviyanti@gmail.com

ABSTRACT

Pediatric brain MRI is vulnerable to patient movement due to discomfort, resulting in anxiety and increased susceptibility to artifacts. Sedation is used to keep patients calm during the MRI examination, but it does not affect pulsation and flow artifacts. Therefore, fast acquisition techniques that are motion-insensitive are required. Routine protocols for T2 sagittal pediatric brain MRI use TSE sequences, but artifacts often appear in the images. BLADE fast imaging sequences are used as a pulse sequence technique, one of which is TSE with T2W. This research compared the image quality of T2 TSE and T2 TSE fast BLADE sequences in pediatric brain MRI. It is a quantitative study with an experimental approach. The sample consisted of all pediatric brain MRI examinations of patients ≤5 years old using both T2 TSE and T2 TSE fast BLADE sequences, totaling 32 patients. Assessment of MRI image quality was performed by three observers through visual grading analysis of sagittal brain anatomy visualization and motion artifacts. The data were analyzed using the Wilcoxon signed-rank test. The results showed that T2 TSE fast BLADE is significantly superior ($p < 0.05$) compared to T2 TSE in visualizing overall anatomy, minimizing artifacts, improving image sharpness, lesion detection, and diagnostic reliability of sagittal pediatric brain MRI. The conclusion is that the T2 TSE fast BLADE sequence can be recommended for pediatric brain MRI examinations because BLADE can eliminate motion artifacts and produce optimal image quality.

KEYWORDS Anatomy, Fast BLADE, Motion artifacts, Pediatric brain MRI, T2 TSE

INTRODUCTION

Brain is an organ of the body that is located in the skull bone and coated with meninges (Uswatun et al., 2023). The brain is a central component of the central nervous system (CNS) that functions to receive stimulating signals from internal and external bodies. In general, the brain can be divided into three main parts, namely the cerebrum, brainstem, and cerebellum (Van et al., 2022). MRI has great advantages in visualizing diseases in children, allowing evaluation of structure, function, and soft tissue morphology with high soft-tissue contrast (Dong et al., 2019).

MRI (Magnetic Resonance Imaging) is increasingly used to evaluate diseases in children, but MRI scanning is difficult to perform in children because it requires a long time, claustrophobia, and the noise of the equipment makes it difficult for children to lie down quietly and difficult to follow breathing instructions during the examination Sedation is required in children under 6 years old to minimize motion artifact for optimal image quality. Based on this, techniques are needed to reduce the use of sedation in pediatric diagnostic imaging (Ahmad et al., 2018).

MRI generally uses T1 and T2 weighting to produce images that can be assessed for diagnosis. T1 weighting is used to show anatomy whereas, T2 weighting is used to show clinical or pathology (Michael L. Grey & Jagan Mohan Ailinani, 2018). According to Westbrook (2014), the standard brain examination uses sequences namely Sagittal, Axial, Oblique (SE/FSE/GRE T1), Coronal SE/FSE PD/T2. While the routine brain MRI examination protocol at Dr. Sardjito Hospital Yogyakarta is to use the T1 TSE, T2 SWI (Susceptibility Weighted Imaging), T2 TSE, FLAIR (Fluid Attenuated Inversion Recovery), and DWI (Diffusion Weighted Imaging) sequences.

Examination using the MRI modality is sensitive to patient and physiological movements in MRI brain examinations such as unconscious movements, heart movements, breathing, vascular pulses, gastrointestinal peristalsis, heart movements, cerebrospinal fluid (CSF), and blood flow (Corcuera et al., 2015). All of these physiological movements produce motion artifacts that cause the image to blur (Zaitsev et al., 2015). In addition, the noise of the MRI equipment during the examination makes the patient uncomfortable so that they become anxious, which can increase artifact susceptibility. Giving sedation and general anesthesia can reduce patient movement but does not affect pulsation and flow artifacts (Rochmayanti et al., 2022). This can lead to misinterpretation because the anatomical details produced are not optimal.

Parameters that can speed up scanning time and reduce motion artifacts, can use the TSE (Turbo Spin Echo) sequence and its modified sequence, BLADE. TSE T2 sequences are widely used for T2W imaging because the scan time value obtained is short and can increase SNR (Westbrook, 2014). This is because the TSE acquisition technique uses a turbo factor so that K-Space is filled quickly (Susanto et al., 2018). However, T2 TSE has the disadvantage that the image looks blurry and susceptible to motion artifacts. This is due to the process of filling K-Space in ETL (Echo Train Length) with different TE (Westbrook, 2014). Space serves to store digital data stored in K-Space generated from spatial frequencies resulting from spatial coding (Stifany et al., 2023). In TSE, K-Space filling is a square or cartesian pattern that is done strip by strip. Whereas K-Space filling in BLADE is done radially with parallel data loaded around the K-Space (Cazzoli et al., 2022).

Based on the results of Cazzoli et al. (2022), regarding T2 TSE with BLADE, it was found that the BLADE technique can reduce sensitivity to movement and provide a clearer picture of brain morphology in non-cooperative patients. Finkenzeller et al. (2015) trying to compare T2 TSE with BLADE on cervical MRI obtained results significantly superior in evaluating the spinal cord and overall lesion detection in sagittal slice, BLADE is considered better in visualizing pathology. In addition to having advantages, BLADE also has disadvantages, such as longer acquisition time due to the large amount of data wasted in K-

Space filling time (Stifany et al., 2023), and relative undersampling in peripheral K-Space, causing blurring of anatomical boundary (Kozak et al., 2020).

Based on the research conducted, some researchers showed that the BLADE technique is very likely to be applied to other body parts towards optimizing the use of T2 TSE BLADE sequences to minimize image quality and artifact reduction. Therefore, the researcher is interested in further examining whether there is a difference in pediatric brain MRI anatomy and motion artifacts between T2 TSE and T2 TSE Fast BLADE sagittal images 3T.

This study aims to compare the quality of brain anatomical images and the reduction of motion artifacts between the conventional T2 TSE sequence and the T2 TSE Fast BLADE in the brain MRI of children aged ≤5 years. The specific objective is to evaluate the advantages of the BLADE technique in minimizing motion and pulsation artifacts, as well as to improve the sharpness of visualization of brain anatomical structures such as the basal ganglia, brainstem, and cerebellum. The benefits of this study include: (1) providing empirical evidence for clinicians in selecting the optimal MRI protocol for pediatric patients, especially those who are uncooperative; (2) reduce dependence on sedation with image acquisition techniques that are more tolerant of movement; and (3) contribute to the development of more accurate and efficient standards for pediatric MRI examinations in health facilities, especially in Indonesia. These findings are expected to be a reference in improving diagnostic quality and comfort for pediatric patients.

RESEARCH METHOD

This type of research was quantitative with an experimental approach from July to August 2024 at the Radiology Installation of Dr. Sardjito Yogyakarta Central General Hospital. The study population was pediatric brain MRI with a sample size of 32 patients. The inclusion criteria of age ≤ 5 without certain clinical conditions, anesthesia and without anesthesia and willing to take part in the research. While the exclusion criteria are the child's age ≥ 5 years and not willing to be a sample. This study implemented T2 TSE and T2 TSE Fast BLADE sequences in pediatric brain MRI. T2 TSE parameters are repetition time (TR) 4500 ms; echo time (TE) 100 ms; field of view (FOV) 220 mm; slice thickness 4 mm; Turbo Factor/ETL 11; 0.7 x 0.7 x 4.0 mm matrix; flip angle 150^0; Cartesian Trajectory. Meanwhile, the T2 TSE Fast BLADE sequence parameters are repetition time (TR) 4070 ms; echo time (TE) 110 ms; field of view (FOV) 220 mm; slice thickness 4 mm; Turbo Factor/ETL 50; matrix 0.9 x 0.9 x 4.0 mm; flip angle 140^0; BLADE Trajectory. MRI image information assessment from the visual grading analysis on T2W TSE and T2W TSE Fast BLADE MRI brain sagittal anatomy images such as basal ganglia; brain steam, parietal white matter (PWM), parietooccipital gray matter (PGM), cerebellum, lateral ventricle, pons, medulla oblongata and fourth ventricle. There was scored on a scale of 1 to 3 (1 = less clear, 2 = clear, and 3 = very clear). Motion artifact assessment was scored on a scale of 0 to 3 (0 = not visible, 1 = moderately visible, 2 = visible, and 3 = very clearly visible). Data were analyzed by the test the suitability of visual grading with Cohen's Kappa test and using the Wilcoxon Signed Rank Test to determine the difference in anatomical image information between the two techniques. The research has ethical review and has been found to comply with the ethical clearance criteria set out in the ethical reference number KE/FK/1410/EC/2024.

RESULT AND DISCUSSION

Description of outcome characteristics

This study was conducted on 32 paediatric patients aged 0-5 years with no specific clinical features using T2 TSE and T2 TSE Fast BLADE sagittal sequences. The sample in this study used MAC Sedation and Chloral Hydrate. In Table 1, it is known that the highest number of patients is male, namely 22 patients. Meanwhile, based on sedation, the highest number of MAC patients was 20 patients.

Table 1. Characteristics based on age, gender, and sedation

Age category (y.o)	Gender				Sedation			
	Male		Female		MAC		Chloral hydrate	
	(F)	%	(F)	%	(F)	%	(F)	%
0 – 2	14	63.6	4	40.0	9	45.0	9	75.0
2 – 3	5	22.7	1	10.0	5	25.0	1	8.3
3 – 5	3	13.6	5	50.0	6	30.0	2	16.7
Total	22	100.0	10	100.0	20	100.0	12	100.0

Source: Primary research data processed from pediatric MRI patient medical records at Dr. Sardjito Central General Hospital (2024)

Anatomical image information difference between T2 TSE AND T2 TSE Fast BLADE sequences in sagittal pediatric brain MRI examination

The results of the study were subjected to Cohen's Kappa statistical test on 32 samples from the three observers. The Cohen's Kappa test was tested on each variation. The results of the Cohen's Kappa statistical test are as Table 2.

Table 2. The result cohen's kappa observer for T2 TSE and T2 TSE fast BLADE

No	Sequence	Confidence level			Mean
		O1*O2	O1*O3	O2*O3	
1	T2 TSE	0.776	0.606	0.620	0.667
2	T2 TSE Fast-BLADE	0.642	0.640	0.686	0.656

Source: Statistical analysis using SPSS v.26 based on assessments by 3 independent observers

Based on Table 2, it can be seen that the agreement value between the three respondents is in the good agreement level Rizky et al (2022), which is in the range of 0.61 - 0.80 where the average value of T2 TSE sequence testing is 0.667 and T2 TSE Fast-BLADE is 0.656. Furthermore, the Wilcoxon Signed Rank Test was conducted, because it uses categorical measurements with an ordinal data scale and comes from "paired" samples with a total of 2 groups. Tests for differences in anatomical image information between the use of T2 TSE and T2 TSE Fast BLADE sequences are as Table 3.

Table 3. The results of anatomical Wilcoxon Test

No	Organ name	Significance (p-value)	Total
1	Basal Ganglia	$p < 0.001$	$p < 0.001^*$
2	Brain Steam	$p < 0.001$	
3	Parietal White Matter	0.470	

No	Organ name	Significance (p-value)	Total
4	Parietooccipital Gray Matter	0.479	
5	Cerebellum	0.016	
6	Ventricle Lateral	0.059	
7	Pons	$p < 0.001$	
8	Medulla Oblongata	$p < 0.001$	
9	Fourth Ventricle (4^{th})	0.035	

*p < 0.05 shows that there is a difference

Source: Wilcoxon Signed Rank Test output (α=0.05) comparing visual grading scores between sequence

Based on Table 3, the results of the Wilcoxon Signed Rank Test of anatomical information on the Basal Ganglia, Brain Stem Cerebellum, Pons, Medulla Oblongata, and 4^{th} Ventricle organs obtained $p < 0.50$ with a confidence level of 95%, meaning that there is a significant difference, while anatomical information on the Parietal White Matter, Parietooccipital Gray Matter and Lateral Ventricle organs obtained $p> 0.05$ with a 95% confidence level, meaning there is no difference between the T2 TSE and T2 TSE Fast BLADE sequences.

Table 4. The results wilcoxon motion artifact

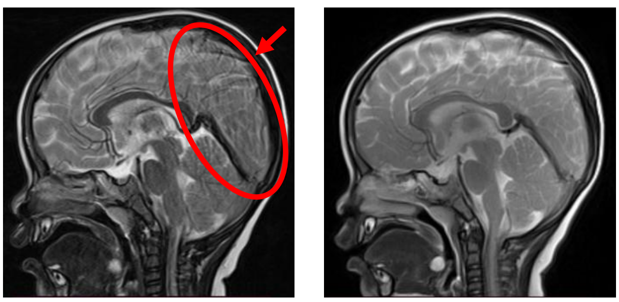
No	Artefact Assessment	Significance (p-value)	Description
1	Motion Artifact	$p < 0.001$	There's a difference

Source: Motion artifact significance analysis (p<0.001) using Wilcoxon test on ordinal scale data (0-3)

Based on Table 4, the Wilcoxon motion artifact test results obtained $p < 0.001$. This means that there is a significant difference in pediatric brain MRI images between the T2 TSE and T2 TSE Fast BLADE sagittal sequences. Can significantly minimize artifacts both physiologically and patient movement, distortion, optimal image quality and provide clarity of a pathology.

Result of anatomical image information between sequences T2 TSE and T2 TSE Fast BLADE sagittal pediatric brain MRI examination

The Wilcoxon test is a different test to determine whether there is a difference in each variable. In the Wilcoxon test, the overall organ and motion artifact in the T2 TSE sequence with and without Fast BLADE is $p < 0.05$, meaning that there is a difference between the T2 TSE and T2 TSE Fast BLADE sequences.



(A) (B)

Figure 1. Sample patient X (Male/1 y.o) T2 TSE (A), and T2 TSE Fast BLADE (B) images. The overall anatomical appearance of the BLADE sequence is more optimal than T2 TSE (A), due to the reduction of motion artifacts. Whereas the T2 TSE showed significant motion artifacts (red arrow).

Source: 3T MRI acquisitions at Dr. Sardjito Hospital

Table 5. The results Wilcoxon mean ranks and sum of ranks anatomy and motion artifact criteria

No	Organ name	Sequence	N	Mean rank	Total ranks
1	Basal Ganglia	T2 TSE	1	9.50	9.50
		T2 TSE Fast-BLADE	18	10.03	180.5
2	Brain Stem	T2 TSE	1	10.50	10.50
		T2 TSE Fast-BLADE	20	11.03	220.5
3	Parietal White Matter	T2 TSE	5	8.30	41.50
		T2 TSE Fast-BLADE	9	7.06	63.50
4	Parietooccipital Gray Matter	T2 TSE	6	8.00	48.00
		T2 TSE Fast-BLADE	9	8.00	72.00
5	Cerebellum	T2 TSE	3	7.00	21.00
		T2 TSE Fast-BLADE	12	8.25	99.00
6	Ventricle Lateral	T2 TSE	0	0.00	0.00
		T2 TSE Fast-BLADE	4	2.50	10.00
7	Pons	T2 TSE	2	9.50	19.00
		T2 TSE Fast-BLADE	21	12.24	257.0
8	Medulla Oblongata	T2 TSE	0	0.00	0.00
		T2 TSE Fast-BLADE	25	13.00	325.0
9	Ventricle 4	T2 TSE	2	6.00	12.00
		T2 TSE Fast-BLADE	9	6.00	54.00
10	Motion Artefak	T2 TSE	0	0.00	0.00
		T2 TSE Fast-BLADE	32	16.50	528.0

Source: Rank calculation synthesis

Based on the Wilcoxon test results, judging from the mean rank and sum of ranks values per anatomy and motion artifact criteria, the sum of ranks between the T2 TSE and T2 TSE Fast BLADE sequences generally has a higher sum of ranks value in the T2 TSE Fast BLADE sequence than the T2 TSE sequence. In the anatomy of Parietal White Matter (PWM) and Parietooccipital Gray Matter (PGM) have a significance value of $p>0.05$. The statistical results of positive Ranks PWM and PGM (table 5) are 9 positive data (N) which means that the 9 samples have good results on the T2 TSE Fast BLADE sequence. The result of Mean Ranks PWM is 7.60 and Sum of Ranks 63.50 while Mean Ranks PGM is 8.00 and Sum of Ranks 72.00. The similarity value of the two anatomical information (Ties) is 18 and 17 so that there is similarity of image information on the T2 TSE sequence and with and without fast BLADE.

Ventricle lateral (VL) has a significance value of $p>0.05$, the statistical test results of Positive Ranks VL statistics (table 5) there are 4 positive data (N) which means that the 4 samples have good results in the T2 TSE Fast BLADE sequence.

In this study, we evaluated the image results between T2 TSE and T2 TSE Fast BLADE sequences on sagittal sections of pediatric brain MRI, one of the inclusion criteria in this study was related to the use of sedation. Based on the results of sample characteristics (table 1), sedation was considered based on age and important diagnostics. MAC (Monitored Anesthesia Care) is a specialized anesthesia service for diagnostic procedures, sedation is given intravenously, this action aims to relieve patient anxiety, and effective pain control (Das & Ghosh, 2015). While Chloral hydrate is a sedation drug for diagnostic procedures in children that is given orally (Omar et al., 2014).

The overall anatomical image information in T2 TSE Fast BLADE is significantly superior to T2 TSE. This is because the BLADE sequence can eliminate pulsation artifacts and flow artifacts significantly in the brain, so that anatomy and pathology are seen more optimally (Zaitsev et al., 2015). The BLADE technique can produce relative oversampling in the central K-Space so as to maintain good image contrast and SNR (Kozak et al., 2020). Heit et al. (2017), results explain that the radial K-Space technique in BLADE not only reduces artifacts but also has the ability to improve image quality by reducing artifacts in the image. So that the T2 TSE Fast BLADE image can significantly produce optimal image sharpness due to the reduction of motion artifacts, apart from that it can improve image quality and visualize lesion characteristics firmly in the image.

Based on the results of the Wilcoxon test, the mean rank and sum of ranks are obtained for each anatomical organ and motion artifact (Table 5). The T2 TSE Fast BLADE sequence has a higher sum of ranks value than the T2 TSE sequence, this is due to the large amount of output data (N) in the T2 TSE Fast BLADE sequence and also the large sample size ($m = n = 30$) so that a good test is used is the Wilcoxon rank sum test (Resti et al., 2014). Based on this, it can be concluded that the T2 TSE Fast BLADE sequence is superior to the T2 TSE sequence on the difference in image information. The difference is influenced by the difference in K-Space filling in each sequence. According to Shakeela et al. (2022), the use of BLADE in the T2 TSE sequence can improve spatial resolution and is less sensitive to motion.

The results of artifact assessment showed a significant difference between T2 TSE and T2 TSE Fast BLADE shown in table 4. BLADE technique can spread motion artifacts in various directions so that it is effective in minimizing motion artifacts (Kozak et al., 2020). BLADE can provide good image quality and reduce motion artifacts with a sensitivity and specificity of 100% and 78% (Corcuera et al., 2015). The results of research by Deng et al. (2019), radial samples have good quality with motion artifact information of 31% can be reduced to 2% when using the BLADE technique.

Basal ganglia anatomy in the T2 TSE Fast BLADE sequence can clearly visualize the substantia nigra, red nucleus, and mammillary body areas because it uses a radial data capture pattern during K-Space filling so that it can reduce focal hypointense and susceptibility artifacts in the basal ganglia area (Saade et al., 2015). The basal ganglia structure is located deep in the neural parenchyma so that the magnetization process is difficult to detect to display the anatomy when subjected to a small magnetic field so that it will cause inhomogeneity with the tissue when the RF signal is being stored (Glatz et al., 2013).

The anatomy of brainstem and cerebellum has a significant value with a high mean rank value in the T2 TSE Fast BLADE sequence (table 5). The use of BLADE sequences can clearly visualize the edges of the lesion area and also see the size of the lesion. This is in line with Von Kalle's research that from the sample they used the T2 TSE sequence for pathology detection in the form of hyperintense lesions in the thalamus, brainstem, and cerebellum areas where these lesions are difficult to detect due to artifacts (Von Kalle et al., 2020). In anatomy Parietooccipital White Matter (PWM) and Parietal Gray Matter (PGM) have similarities in image information between T2 TSE and T2 TSE Fast BLADE sequences (Table 5). Anatomically, the brain consists of soft tissue, resulting in high tissue contrast and firm boundaries (Tika, 2020). In Eleftherios et al's study, BLADE sequences helped in visualizing white matter, gray matter, and edema clearly, this is because BLADE sequences can minimize pulsation artifacts and flow artifacts (Chen et al., 2021). Therefore, there is no significant difference but the T2 TSE BLADE sequence is superior in visualizations of the anatomy.

The lateral Ventricle (VL) anatomy has similar image information values in the T2 TSE and T2 TSE Fast BLADE sequences. BLADE can visualize high inhomogeneity in the lateral ventricle (Okuchi et al., 2022). Pons anatomy on T2 TSE Fast BLADE sequences can optimally visualize anatomical and diagnostic information, and provide good image quality by minimizing susceptibility artifacts and image distortion (Kim et al., 2018). Anatomy of the Medulla Oblongata in the T2 TSE Fast BLADE sequence can visualize diagnostic images on the spinal cord optimally, and produce good image quality in terms of image contrast and sharpness, this is because BLADE can suppress flow artifacts CSF (Okuchi et al., 2022). In addition, artifacts are often found in the 3th ventricle and 4th ventricle (Ogbole et al., 2016). In the study Mavroidis et al, (2017), explained that the use of BLADE technique can significantly suppress flow artifacts and can visualize if there is a lesion in the 4th ventricle area well.

Motion artifacts are artifacts caused by patient motion either intentionally or unintentionally during the image capture process. One of the significant problems in brain MRI examinations is head movement, basically movements made by patients without realizing it will trigger artifacts on MRI imaging, this often occurs in pediatric brain MRI examinations without sedation. In addition, diagnostic imaging on MRI of the posterior fossa, cerebellum and brainstem can be significantly impaired by artifacts from pulsating blood flow of CSF without patient head movement. Apart from that, motion artifacts can also be caused by physiological movements such as breathing, heartbeat flow artifacts that can cause artifacts so that there can be misinterpretation of a pathology (Murphy, 2016).

The advantage of the Cartesian technique for T2 TSE series is the short examination time because when coding K-Space data the Cartesian technique is faster than the BLADE technique. The advantage of the Fast BLADE T2 TSE series is that it can minimize the occurrence of motion artifacts and obtain the desired image in areas of inhomogeneity in moving objects by filling the K-Space with circular rotation mode and each BLADE consists of several direct parallel phases. An encoder that can collect images with a turbo spin echo sequence (Tika, 2020). The principle of the BLADE technique is oversampling at the center of K-Space starting from the midpoint in all directions where the filling of K-Space is done by rotating starting from the center of K-Space repeatedly at each TR so that there are 'blades' that superimpose each other and allow the center of K-Space to oversample. It is this advantage that can reduce motion artifacts because it can be used to correct movement. Apart from that, the BLADE technique has other advantages, namely having a long ETL, and also a large turbo factor on the T2 TSE Fast BLADE sequence. In the research of Mandang et al. (2022), BLADE can reduce motion artifact to 0% with K-Space sampling specificity of 100% and 84% respectively.

CONCLUSION

Fast BLADE sequences can reduce motion and pulsation artifacts in T2 TSE images without losing relevant image quality. Therefore, this technique is optimal in the visualizing image information in the anatomy of basal ganglia, brainstem, parietal white matter, parietooccipital gray matter, cerebellum, lateral ventricle, pons, medulla oblongata and fourth ventricle well in pediatric patients and can also improve the depiction of lesions in the brain and low contrast in children in the posterior fossa of pediatric patients. In addition, the T2 TSE Fast BLADE sequence can improve the overall image quality while removing motion artifacts, pulsation artifacts and flow artifacts. Further research is needed in specific pathologies aiming to obtain definitive conclusions in other MRI examinations.

REFERENCES

Ahmad, R., Hu, H. H., Krishnamurthy, R., & Krishnamurthy, R. (2018). Reducing sedation for pediatric body MRI using accelerated and abbreviated imaging protocols. *Pediatric Radiology*, *48*(1), 37–49. https://doi.org/10.1007/s00247-017-3987-6

Cazzoli, M., Pelizzari, L., & Lipari, S. (2022). *BLADE: Reducing Motion Artifacts in Uncooperative Patients with Acquired Brain Injury*.

Chen, H.-C., Yang, H.-C., Chen, C.-C., Harrevelt, S., Chao, Y.-C., Lin, J.-M., Yu, W.-H., Chang, H.-C., Chang, C.-K., & Hwang, F.-N. (2021). Improved Image Quality for Static BLADE Magnetic Resonance Imaging Using the Total-Variation Regularized Least Absolute Deviation Solver. *Tomography*, *7*(4), 555–572. https://doi.org/10.3390/tomography7040048

Corcuera-Solano, I., Doshi, A., Pawha, P. S., Gui, D., Gaddipati, A., & Tanenbaum, L. (2015). Quiet PROPELLER MRI techniques match the quality of conventional PROPELLER brain imaging techniques. *AJNR. American Journal of Neuroradiology*, *36*(6), 1124–1123.

Das, S., & Ghosh, S. (2015). Monitored anesthesia care: An overview. In *Journal of Anaesthesiology Clinical Pharmacology* (Vol. 31, Issue 1, pp. 27–29). Medknow Publications. https://doi.org/10.4103/0970-9185.150525

Dong, S. Z., Zhu, M., & Bulas, D. (2019). Techniques for minimizing sedation in pediatric MRI. In *Journal of Magnetic Resonance Imaging* (Vol. 50, Issue 4, pp. 1047–1054). John Wiley and Sons Inc. https://doi.org/10.1002/jmri.26703

Finkenzeller, T., Wendl, C. M., Lenhart, S., Stroszczynski, C., Schuierer, G., & Fellner, C. (2015). BLADE sequences in transverse T2-weighted MR imaging of the cervical spinecut-off for artefacts? *RoFo Fortschritte Auf Dem Gebiet Der Rontgenstrahlen Und Der Bildgebenden Verfahren*, *187*(2), 102–108. https://doi.org/10.1055/s-0034-1385179

Glatz, A., Valdés Hernández, M. C., Kiker, A. J., Bastin, M. E., Deary, I. J., & Wardlaw, J. M. (2013). Characterization of multifocal T2*-weighted MRI hypointensities in the basal ganglia of elderly, community-dwelling subjects. *NeuroImage*, *82*, 470–480. https://doi.org/10.1016/j.neuroimage.2013.06.013

Heit JJ, Iv M, & Wintenmark M. (2017). Imaging of intracranial hemorrhage. . . *Journal of Stroke*, *19*(1), 11–27.

Kim, T. H., Baek, M. Y., Park, J. E., Ryu, Y. J., Cheon, J. E., Kim, I. O., & Choi, Y. H. (2018). Comparison of DWI methods in the pediatric brain: PROPELLER turbo spin-echo imaging versus readout-segmented echo-planar imaging versus single-shot echo-planar imaging. *American Journal of Roentgenology*, *210*(6), 1352–1358. https://doi.org/10.2214/AJR.17.18796

Kozak, B. M., Jaimes, C., Kirsch, J., & Gee, M. S. (2020). MRI Techniques to Decrease Imaging Times in Children. *Radiographics*, *40*(2), 485–502. https://doi.org/10.1148/rg.2020190112

Mandang, M. W., Prasetyo, E., & Tangel, S. J. Ch. (2022). Role of 3D CT in Diagnosis of Skull Base Fractures. *E-CliniC*, *10*(1), 136. https://doi.org/10.35790/ecl.v10i1.37806

Mavroidis, P., Giankou, E., Tsikrika, A., Kapsalaki, E., Chatzigeorgiou, V., Batsikas, G., Zaimis, G., Kostopoulos, S., Glotsos, D., Ninos, K., Georgountzos, V., Kavouras, D., & Lavdas, E. (2017). Brain imaging: Comparison of T1W FLAIR BLADE with conventional T1W SE. *Magnetic Resonance Imaging*, *37*, 234–242. https://doi.org/10.1016/j.mri.2016.12.007

Michael L. Grey, & Jagan Mohan Ailinani. (2018). *CT & MRI Pathology: A Pocket Atlas* (Third Edition). McGraw-Hill Education.

Murphy, A. (2016). Motion artifact. In *Radiopaedia.org*. Radiopaedia.org. https://doi.org/10.53347/rID-48589

Ogbole, G., Soneye, M., Okorie, C., & Sammet, S. (2016). Intraventricular cerebrospinal fluid pulsation artifacts on low-field magnetic resonance imaging: Potential pitfall in diagnosis? *Nigerian Medical Journal*, *57*(1), 59. https://doi.org/10.4103/0300-1652.180565

Okuchi, S., Fushimi, Y., Yoshida, K., Nakajima, S., Sakata, A., Hinoda, T., Otani, S., Sagawa, H., Zhou, K., Yamao, Y., Okawa, M., & Nakamoto, Y. (2022). Comparison of TGSE-BLADE DWI, RESOLVE DWI, and SS-EPI DWI in healthy volunteers and patients after cerebral aneurysm clipping. *Scientific Reports*, *12*(1). https://doi.org/10.1038/s41598-022-22760-6

Omar M Hijazi, Anwar E Ahmed, Jaber A Anazi, Hashim E Al-Hashemi, & Majed I Al-Jeraisy. (2014). Chloral hydrate versus midazolam as sedative agents for diagnostic procedures in children. *Saudi Med J .*, *2*(35), 123–131.

Resti Mustika Sari, Yudiantri Asdi, & Ferra Yanuari. (2014). Perbandingan Kuasa Wilcoxon Rank Sum Test dan Permutation Test dalam Berbagai Distribusi Tidak Normal. *Jurnal Matematika UNAND*, *3*(4), 139–146.

Rizky Parlika, Putra Dwi Wira Gardha Yuniahans, Rayhan Saneval Arhinza, Vito Fausta Majid, & Muhammad Ghifari Alifiane. (2022). Uji Validitas Aplikasi Si-Book Menggunakan SPSS sengan Kombinasi Metode R-Tabel dan Cohen's Kappa. *Jurnal Keilmuan Dan Aplikasi Bidang Teknik Informatika*, *16*(2), 121–133.

Rochmayanti, D., Murniati, E., Haris Sulistiyadi, A., Teknik Radiodiagnostik dan Radioterapi, J., Kemenkes Semarang, P., & Corresponding Author, I. (2022). Jurnal Imejing Diagnostik Kualitas Citra Sekuen T2W TSE Cartesian Versus T2W TSE BLADE: Analisis Kuantitatif pada MRI Cervical Potongan Axial. *Jurnal Imejing Diagnostik*, *8*, 100–104. http://ejournal.poltekkes-smg.ac.id/ojs/index.php/jimed/index

Saade, C., Daniel, R., Nader, A., Al-Husseini, D., Brennan, P., & El-Merhi, F. (2015). Concentric rectangular blades rotated around the K-space origin reduces hypointensities in the basal ganglia during T2-weighted brain MRI: Case report. *Journal of Medical Imaging and Radiation Sciences*, *46*(3), 351–355. https://doi.org/10.1016/j.jmir.2015.06.015

Shakeela Rasheed, Muhammad Zakir, Javed Tauqir, Zunaira Rasheed, & Tauqir Ahmad. (2022). Role of radial k –space sampling technique in non-cooperative patients for the compensation of motion artifact in magnetic resonance imaging (MRI). *The Professional Medical Journal*, *29*(12), 1872–1879. https://doi.org/10.29309/tpmj/2022.29.12.6884

Stifany Elena Herlianti Duri, I Putu Eka Juliantara, & I Wayan Ariec Sugiantara. (2023). Analisis Perbedaan Contrast to Noise Ratio (CNR) terhadap Variasi K-Space Filling pada Pemeriksaan MRI Brain Sekuen T2WI Axial dengan Klinis Space Occupying Lession (SOL). *Jurnal Ilmiah Kedokteran Dan Kesehatan*, *3*(1), 174–184. https://doi.org/10.55606/klinik.v3i1.2279

Susanto, F., Santoso, A. G., & Abimanyu, B. (2018). Analysis Of Turbo Spin Echo (TSE) T2 Weighting Brain MRI Axial Slices With Sensitivity Encoding (SENSE) and Without SENSE Usage: Evaluation on Signal To Noise Ratio (SNR) and Scan Time. *JImeD*, *2*(2), 148–153.

Tika Sari Pratiwi. (2020). *Reduksi Artefak Citra MRI Otak pada Pasien Non Kooperatif Melalui Sekuen T2 TSE Cartesian dan T2 TSE Propeller/BLADE Potongan Axial* [Thesis]. Universitas Airlangga.

Uswatun Hasanah, Agus Supinganto, Desyani Ariza, La Ode Marsudi, Dhika Juliana Sukmana, Dewinta Nur Alvionita, Hardani, Ika Nurfajri Mentari, Pauzan, M.Imun, Samsul Hadi, M.Ling., & Ka'bah. (2023). *Buku Ajar Anatomi dan Fisiologi Manusia* (Asmia Nurulia Hana, Ed.). Penerbit Samudra Biru (Anggota IKAPI).

Van Putte, Cinnamon L, Jennifer L. Regan, & Andrew F. Russo. (2022). *Seeley's essentials of anatomy & physiology. McGraw-Hill* (Eleven). McGraw-Hill.

Von Kalle, T., Blank, ; B, Fabig-Moritz, ; C, Müller-Abt, ; P, Zieger, ; M, Wohlfarth, ; K, & Winkler, ; P. (2020). *Diagnostic Relevant Reduction of Motion Artifacts in the Posterior Fossa by syngo BLADE Imaging*. www.siemens.com/magnetom-world

Westbrook, C. (2014). *Handbook of MRI Technique* (Fourth Edition). Willey Blackwell.

Zaitsev, M., Maclaren, J., & Herbst, M. (2015). Motion artifacts in MRI: A complex problem with many partial solutions. *Ournal of Magnetic Resonance Imaging: JMRI*, *42*(4), 887–901.