Comparative in anatomical information and artifacts between T2W TSE Cartesian sequences and T2W TSE BLADE sequences on axial cervical MRI examinations

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Abstract. Observation of the T2W TSE Cartesian sequence of Axial Cervical MRI Examinations still lacks a blurring on the image. One solution to overcome the blurring problem is using the BLADE trajectory. According to Finkenzeller (2014) states that TSE BLADE is significantly superior with optimum sharpness, depiction of cerebral spinal fluid, and detection of all lesions. In addition, TSE BLADE can suppress motion artifacts. The purpose of this study was to determine differences in anatomic information and artifacts between the T2W TSE Cartesian and BLADE on axial MRI cervical examination and which sequences were more optimal in terms of anatomic information and artifacts. This type of research is a quantitative study with an experimental approach involving 10 volunteers and 2 respondents specializing in radiology. Each voluntary MRI cervical examination was performed using axes T2W TSE Cartesian and BLADE sequences. Image results were examined by respondents to obtain anatomi cal information and artifact. The data were processed and analyzed using Cohen's Kappa test and Wilcoxon test. The results showed that there were differences in anatomic information and artifacts between the T2W TSE Cartesian and BLADE on axial MRI cervical examinations with p-values of 0.038 or p <0.05 for differences in anatomic information, and p-values of 0.024 or p <0.05 for differences in artifacts. Sequence test results indicate that the TSE BLADE is more optimal than the TSE Cartesian, using the TSE BLADE sequence can suppress blurring artifacts so as to improve anatomical information. Conclusion: There is a difference in anatomical and artifact information between T2W TSE Cartesian and T2W TSE BLADE on Axial Cervical MRI examination. T2W TSE BLADE is superior compared to T2W TSE Cartesian

1. Introduction
Magnetic resonance imaging (MRI) is the method of choice for spinal imaging that can identify almost all clinically relevant pathologies, including degenerative and inflammatory, as well as traumatic or neoplastic lesions [1]. One of the spinal MRI examinations is the cervical MRI examination. Cervical MRI examination is a challenge for an MRI because of the inhomogeneous structure of cervical anatomy and the patient's involuntary movements. In cervical imaging, ingestion, rough patient movements, and deep breathing are the main sources of artifacts [2], so care should be taken of patient comfort and the use of fast sequence pulses to reduce the occurrence of artifacts caused by movement.

Sequence pulses are computer software that executes a series of commands to implement pulse radio frequency (RF), gradients, data sampling windows and others within a predetermined time [2]. The purpose of the sequence pulse is to change the magnetic moment of the hydrogen nucleus so that inherent
tissues are measured in time echo (TE), and images with different contrasts can be obtained [3]. There are quite a number of different sequence pulses at this time that are designed to obtain MRI images, but when looking at the bottom or origin of the sequence pulses can be divided into spin echo (SE), gradient echo (GRE) and inversion recovery (IR) [4]. From the basis of these sequences, then developed and categorized based on the time required to produce an image can be referred to as routine, fast, and ultrafast. For example, spin echo sequence pulses are developed into Fast Spin Echo (FSE) or Turbo Spin Echo (TSE), and ultrafast spin echo [2].

Spin echo sequence pulse uses 90º pulse excitation so that the Net magnetization vector (NMV) experiences a flip into the transverse plane. The NMV precession in the transverse plane induces a voltage in the receiver coil. Precessional paths of magnetic moments in the nucleus of hydrogen atoms are translated into the transverse plane. When the 90º RF is stopped, a free induction decay (FID) signal will be generated. After application of 90º RF, followed by one or more 180º rephasing pulses to produce spin echo. If only one echo is generated, an image with T1 Weighted can be created using short Time Echo (TE) and short Time Repetition (TR). For Proton Density (PD) and T2 Weighted, two RF pulses are reposing, producing two spin echoes. The first echo has a short TE and a long TR to produce images with proton density Weighted and the second has a long TE and long TR to produce images with T2 Weighted [3].

Turbo Spin Echo (TSE) sequence is the pulse sequence of spin echoes, but has a faster scanning time. In the spin echo sequence pulse, a 90º pulse excitation is followed by a 180º rephasing pulse. Only one phase encoding level is applied per TR on each slice and only one line of k-space is filled. As a factor affecting the scan time function of TR, Number of Excitation (NEX) and the number of phase encoding, one or more must be reduced. Reducing TR and NEX will affect image weighted and signal to noise ratio (SNR). Reducing the amount of phase encoding will reduce the spatial resolution, which is certainly avoided. In TSE sequences, scan time is reduced by providing more than one phase encoding level so that it can fill more than one k-space in each TR. This method is carried out by using a repeating 180º rephasing pulse to produce an Echo Train Length (ETL) [3]. K-space is a storage device. K-space stores digital data generated from special frequencies created from special encodings. Examples of k-space filling that are often used are Cartesian and BLADE. Cartesian is a simple k-space filling done linearly from top to bottom or bottom to top [3], while BLADE is an increased k-space load from the center of k-space, where rectangular data blocks are obtained and then rotated. Information that is excessively concentrated in the k-space center, is used to increase the SNR or to identify the time during the scan where the patient might be moving, so that the data block can be processed with a phase-shifting algorithm to eliminate the effect of movement on the data during the reconstruction process and motion artifacts can be suppressed [4]. Based of the author's observations of the TSE Cartesian sequence pulses on MRI cervical examination using axes k-space Cartesian, there is a weakness that the image looks blurred in the spinal cord region caused by movement of cerebral spinal fluid (CSF), and susceptible to motion artifacts. The use of axial T2W of the spine and spinal cord is susceptible to various types of artifacts, especially in the cervical and theoretical regions. One solution to overcome blurring artifacts on cervical MRI examination is to use TSE BLADE. The advantage of TSE BLADE on axial T2W is significantly superior with regard to sharpness, CSF depiction and detection of all lesions. In addition, TSE BLADE can suppress artifacts from patient movements [5].

The preliminary study that the authors conducted on the TSE BLADE sequence showed that using BLADE resulted in a faster examination time than using Cartesian and a sharper result. In addition, using BLADE can remove blurring artifacts caused by movement of the cerebro spinal fluid. The purpose of this study was to obtain information on the anatomy and the presence of artifacts in the cartesian and BLADE on T2 W TSE which was applied to the cervical MRI examination.

2. Methods
This research is a quantitative study with an experimental approach that aims to find out whether there are differences in anatomic information and artifacts between the T2W TSE sequence Cartesian and
BLADE on Axial Cervical MRI Examinations and find out which sequences are optimal in showing anatomic and artifact information on Axial Cervical MRI Examinations. Independent variables in this study are T2W TSE Cartesian and T2W TSE BLADE sequences. Dependent variable in this study is the anatomic information and artifacts on MRI examination of axial cervical. Controlled variables in this study are TR, FOV, slice thickness, Flip Angle, ETL, and neck coil.

This study involved 10 volunteers who were willing and fulfilled the voluntary inclusion criteria. Subjects of this study were two radiology specialists who had more than 3 years of work experience in the field of MRI expertise.

Procedure of this research was started by making T2W TSE BLADE sequences adapted from T2W TSE Cartesian by changing the trajectory parameters from Cartesian to BLADE, with the consequent changes in time echo (TE), averages, and elliptical filter parameters.

The next stage is scanned by starting with scanning localize, scanning myelo coronal and sagittal pieces, scanning T2W sagittal T2W sequences, scanning T2W TSE Cartesian sequences and T2W TSE BLADE. The results of the image are documented on DVD. Then assess the anatomy and artifact information to the two doctors who have agreed. The anatomical information assessment uses the anatomical information assessment form with an assessment score of 3 for clearly visible objects, 2 for clearly visible objects and 1 for unclear visible objects. Assessment of artifacts uses an artifact assessment form with an assessment score of 3 for artifacts that are unclear, 2 for artifacts seen quite clearly and 1 for artifacts clearly visible.

The results of the anatomic information and artifacts assessment between the T2W TSE Cartesian sequence and T2W TSE BLADE on axial MRI cervical examinations were analyzed using application software by conducting an agreement test of the two radiology specialists with a kappa test to see the level of agreement of the two respondents. Perform different tests with the Wilcoxon test to know anatomic information and artifacts between the T2W TSE sequences Cartesian sequence and BLADE on axial MRI cervical examinations. Perform sequential tests to see the optimization of the sequence in showing anatomical information and in suppressing artifacts by using Wilcoxon test measuring instruments seen from the results of the mean rank values in each sequence.

3. Results

The agreement test results from the two respondents stated that the test results were stated to be good because the kappa test values were in the range of 0.6-0.80, so that in subsequent testing the authors used research data from the first respondent because they had a longer working period compared to second respondents.
Table 2. Wilcoxon Test Results Anatomical Information Differences between T2W TSE Cartesian sequences and T2W TSE BLADE on Axial Cervical MRI Examinations.

| Sekuen                | p-value | result   |
|-----------------------|---------|----------|
| T2W TSE Cartesian     | 0.038   | difference |
| T2W TSE BLADE         |         |          |

Based on the Wilcoxon test results in table 2 shows the value of p value 0.038 or p <0.05 means that there are differences in anatomical information between the T2W TSE Cartesian sequence and T2W TSE BLADE on Axial Cervical MRI Examinations.

The results of differences in anatomic information between the T2W TSE Cartesian sequence and T2W TSE BLADE on the axial cervical MRI examination in each anatomical area assessed are as follows:

Table 3. Wilcoxon test results anatomical information differences between T2W TSE Cartesian sequences and BLADE

| Area Anatomi           | Sekuen TSE | p-value | Result   |
|------------------------|------------|---------|----------|
| Spinal Cord            | Cartesian  | 0.025   | difference |
|                        | BLADE      |         |          |
| Cerebro spinal fluid   | Cartesian  | 0.014   | difference difference |
|                        | BLADE      |         |          |
| Vertebral body         | Cartesian  | 0.317   | no difference |
|                        | BLADE      |         |          |
| Discus interverte bralis | Cartesian | 0.317   | no difference |
|                        | BLADE      |         |          |

Based on table 3 shows the results of different tests in each of the anatomical areas assessed. The anatomical area of spinal cord and cerebro spinal fluid has a p-value <0.05 meaning there is a difference in anatomic information between the T2W TSE Cartesian sequence and T2W TSE BLADE on the axial cervical MRI examination. While the anatomical area of the vertebral body and the intervertebral disc has a p-value > 0.05, it means that there is no difference in anatomic information between the T2W TSE Cartesian sequence and T2W TSE BLADE on the axial MRI.
Information:

a = T2W TSE Cartesian sequence  
b = T2W TSE BLADE sequence  
1 = Spinal cord  
2 = cerebral spinal fluid  
3 = Vertebral body  
4 = intervertebral disc

As seen in Figure 1 above visually looks different image results. According to the authors in the spinal cord and cerebral spinal fluid areas shown in figure (b) are brighter and firmer than the image (a) while in the vertebral body area and intervertebral discs appear to be different but not significant.

Test the difference in artifacts information between the T2W TSE Cartesian and BLADE on axial cervical MRI examinations using a Wilcoxon test. Results of the Wilcoxon artifact test on T2W TSE Cartesian and T2W TSE BLADE sequences on axial MRI cervical examination are shown in Table 4. Artifacts on cervical MRI examination can be caused by movements of cerebral spinal fluid or movements of the patient during the swallowing process so that it looks blurred around the object.

Table 4. Wilcoxon Artifact Test Results

| Artefak          | Sequences       | p-value | Hasil   |
|------------------|-----------------|---------|---------|
|                  | TSE Cartesian   | 0.024   | difference |
|                  | TSE BLADE      |         |          |

Figure 1. Results of MRI Cervical Axial
Based on table 4 states that the p-value in the artifact has a p-value of 0.024 (p < 0.05). This is TSE Cartesian and T2W TSE BLADE in terms of artifacts.

![Figure 2. Blurring Artifacts on Axial Cervical MRI Examinations.](image)

Information:
\( a = \) T2W TSE Cartesian sequence  
\( b = \) T2W TSE BLADE sequence

From Figure 2 shows picture (a) the visualization of blurring artifacts shown by arrows in the spinal cord and cerebral spinal fluid areas makes the organs unclear, has no clear and blurred boundaries, while in the picture (b) visualization of blurring artifacts does not appear on the image of the T2W TSE BLADE sequence.

To find out which sequence is more optimal can be seen from the Wilcoxon test results on the mean rank of anatomic information and artifacts. A high rank means that it is more optimal. Following are the mean rank results of the Wilcoxon test on anatomic information between the T2W TSE Cartesian and T2W TSE BLADE sequences on axial cervical MRI examination shown in Table 5.

| Area Anatomi            | Sequences       | Mean rank |
|-------------------------|-----------------|-----------|
| Spinal Cord             | TSE Cartesian   | 0.00      |
|                         | TSE BLADE       | 3.00      |
| *Cerebro spinal fluid*  | TSE Cartesian   | 0.00      |
|                         | TSE BLADE       | 3.50      |
| *Vertebral body*        | TSE Cartesian   | 2.50      |
|                         | TSE BLADE       | 2.50      |
| *Discus intervertebralis* | TSE Cartesian  | 1.00      |
|                         | TSE BLADE       | 0.00      |
| Keseluruhan             | TSE Cartesian   | 0.00      |
| *Area Anatomi*          | TSE BLADE       | 3.00      |

Based on the results of the Wilcoxon mean rank test in Table 5, shows that anatomic information using the T2W TSE BLADE sequence as a whole has a higher mean rank value with a mean rank value of 3.00 compared to the use of the T2W TSE Cartesian sequence which has a mean rank value of 0.00.
This means that overall T2W TSE BLADE is more optimal in showing anatomical information compared to T2W TSE Cartesian.

Assessment of each anatomic shows that in the spinal cord and crebro spinal fluid of the T2W TSE BLADE sequence has a superior mean rank value compared to the Cartesian. Body of vertebral of the T2W TSE Cartesian sequence has the same mean rank as the BLADE. Intervertebral discs in the T2W TSE Cartesian sequence had a superior mean rank compared to BLADE. Overall T2W TSE BLADE is more optimal compared to Cartesian T2W.

To see which order is better in suppressing artifacts axial cervical MRI examinations can be seen in the Wilcoxon test results by looking at the mean values. Highest average rating values indicate that the order is more optimal in suppressing artifacts or not susceptible to artifacts. Here are the results from the Wilcoxon average rank test.

| Artefak     | Mean rank |
|-------------|-----------|
| TSE Cartesian | 0.00      |
| TSE BLADE    | 3.50      |

Based on the Wilcoxon mean rank test results on artifact information between Cartesian and BLADE in table 6, shows that the mean rank value of T2W TSE BLADE is higher than Cartesian, it’s means BLADE is more optimal in suppressing artifacts. The artifact referred to in this research is the blurring artifact caused by the movement of cerebral spinal fluid.

4. Discussion

Based on the Wilcoxon non-parametric statistical test results in the anatomical information difference test stated that there are differences in anatomic information between the T2W TSE Cartesian sequence and T2W TSE BLADE on axial cervical MRI examinations indicated by p-value 0.038 or p <0.05, because the hypothesis Ha is rejected and Ho is accepted.

According table 5, spinal cord and cerebral spinal fluid showed that there were differences in anatomic information between T2W TSE Cartesian and BLADE. While in the vertebral body area and intervertebral discs showed no differences in anatomical information.

There are anatomical information differences between the Cartesian and BLADE in the anatomical area of the spinal cord and cerebral spinal fluid due to the influence of the use of BLADE trajectory which aims to reduce artifacts that run well in suppressing blurring artifacts caused by movement of spinal cord anatomy and cerebral spinal fluid. Spinal fluid cerebro. According to Elliott (2011) artifacts that appear can interfere with anatomical imagery and pathological conditions or may cause inaccuracies in making a diagnosis. The emergence of artifacts in the Cartesian reduces the value of anatomical information, resulting in anatomical information differences between Cartesian and BLADE in the anatomical area of spinal cord and cerebral spinal fluid.

Whereas in the anatomical area of the vertebral body and the intervertebral disc, there is no difference in anatomic information between the Cartesian and the BLADE because it is in the anatomic area away from the cerebral spinal fluid movement so that the BLADE function in that area is not running optimally and resulting in a doctor's view visually assessed not much different.

In addition, there are differences in anatomical information between the Cartesian and BLADE due to the effect of different sequential parameters used respectively. The use of Cartesian’s parameter is a used in hospitals, while parameter of BLADE is the adopted, only in the trajectory system changed from Cartesian to BLADE with the consequence of changes in other parameters namely time echo (TE), average (NEX) and Elliptical Filter from on becomes off.

A trajectory system is a k-space filling system in reconstructing an image. Changes in trajectory from BLADE to Cartesian will have an impact on the decline in artifacts and improve image quality. BLADE or Periodically Rotated Overlapping Parallel Lines with Enhanced Reconstruction (PROPELLER) is
increased k-space filling from the center of k-space, where rectangular data blocks are obtained and then rotated. Information that is excessively concentrated in the k-space center is used to increase the Signal to Noise Ratio (SNR) or to identify the time during the scan where the patient might be moving, so that the data block can be processed with a phase-shifting algorithm to eliminate the effect of movement of the data during the reconstruction process and Motion artifacts can be suppressed [4].

The effect of Averages / NEX on SNR is that SNR will rise linearly compared to changes in NEX. The greater the NEX, the greater the SNR will be [6]. A reduction in NEX 1 will reduce the SNR by 41%. In this study SNR on Cartesian was slightly superior to BLADE. Even though BLADE uses lower NEX, the BLADE is able to increase SNR because excessive information concentrated in the k-space center is used to increase SNR [4]. In addition, the selection of NEX itself will affect the scanning time. So that the scan time of TSE BLADE is faster than that of TSE Cartesian.

Effect of TE on image quality in T2 Weighted. T2 Weighted has a long TR and TE values, a network that is a fast decay time looking dark, and a network that has a longer decay time will look bright. In this case, fat is faster compared to water, so in this study TSE BLADE which has a TE value that is longer than the TSE Cartesian will affect the results of the image where the spinal cord fluid and cerebral spinal fluid are brighter than the TSE Cartesian.

Based on Wilcoxon's non-parametric statistical test results in the difference in an artifact information test state that there is a difference in artifact information between the T2W TSE Cartesian and BLADE on axial section cervical MRI examination indicated by p-value 0.024 or p <0.05.

There is a difference due to the use of different k-spaces, i.e. Cartesian k-space with k-space BLADE. Cartesian is a simple k-space filling done linearly from top to bottom or bottom to top [3], While BLADE is an increased k-space load from the center of k-space, where rectangular data blocks are obtained and then rotated. Information that is excessively concentrated in the k-space center, is used to increase the SNR or to identify the time during the scan where the patient might be moving, so that the data block can be processed with a phase-shifting algorithm to eliminate the effect of movement on the data during the reconstruction process and motion artifacts can be suppressed [4].

Based on the results of the mean rank non-parametric statistical test Wilcoxon to determine the most optimal sequence in showing anatomical information shows that the T2W TSE BLADE as a whole is assessed from anatomical information more optimized than the T2W TSE Cartesian with mean rank values for T2W TSE BLADE 3.00 and T2W TSE Cartesian 0.00.

The results of the mean rank based on the anatomical area assessed indicate that Cartesian is more optimal in maintaining the anatomical information of the vertebral body and the intervertebral disc, but is less than optimal for the spinal cord and cerebral spinal fluid compared to BLADE due to the Spinal cord and cerebral spinal fluid looks blurring artifacts so that it reduces the value of anatomic information. Whereas BLADE is more optimal for anatomical information of the spinal cord and cerebral spinal fluid, it is related to the function of BLADE to reduce motion artifacts including blur walking well can improve anatomical information information. According to Elliott (2011) artifacts that appear can cause the anatomical imagery and pathological conditions or can cause inaccuracies in making a diagnosis.

The effect of a greater TE value has an impact on increasing the signal in the spinal cord and cerebral spinal fluid so that it will appear brighter than the low TE in weight T2 and fat will be darker therefore in the vertebral body area and the intervertebral disc mean mean rank BLADE is lower than Cartesian.

Overall BLADE is superior in showing anatomical information compared to Cartesian on cervical MRI examination. To see abnormalities in the spinal cord area or cerebral spinal fluid that is caused due to the impulse of the HNP pathology where the hernia is experiencing disc hernia so that pressing the spinal cord area and cerebral spinal fluid is better to use BLADE, If to see an abnormality in the vertebral body area caused by metastasis from a pathology it is better to use Cartesian. Based on the mean rank results of Wilcoxon non-parametric statistical tests to determine most optimal sequences in suppressing artifacts shows that BLADE is considered superior in suppressing artifacts compared to Cartesian.

From the results of figure 2, it can be seen that by using k-space Cartesian there is a image blurring in the spinal cord area and cerebral spinal fluid, whereas by using k-space BLADE there is no visible
blurring artifact in the area. This proves that the BLADE function works well because it can suppress blurring artifacts caused by the movement of cerebral spinal fluid. The difference in the use of k-space is one of the factors that affect the value of the mean rank of artifact assessment, because by using BLADE moving objects that can produce motion or blurring images can be suppressed.

5. Conclusion
There is a difference in anatomical and artifact information between T2W TSE Cartesian and T2W TSE BLADE on Axial Cervical MRI examination. T2W TSE BLADE is superior compared to the T2W TSE Cartesian.

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