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Image optimization on magnetic resonance imaging (MRI) of brain with orthodontic bracket

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Abstract
Use of modalities Magnetic resonance imaging (MRI) has a vital role in the diagnosis of pathology that requires a picture with good tissue contrast. Another thing in the MRI modality that continues to be developed is the ability to reduce artifacts on examination. Artifacts due to Magnetic Susceptibility can occur at any MRI examination with the use of metal implants on the anatomy examined, one of which is the MRI Brain examination with the Orthodontic Bracket. The purpose of this study was to analyze the effectiveness of sequences to reduce metal artifacts due to the installation of Orthodontic Bracket.
The type of research is quantitative analytical research with a quasi-experimental research design. The research design used was a posttest design to determine the optimization of the application of the sequence of Slice Encoding Metal Artifact Correction (SEMAC) and View Angle Tilting (VAT) on MRI Brain with Orthodontic Bracket.
The results showed that SEMAC sequences combined with T2 TSE were able to reduce metal artifacts well, with mean rank in the Kruskal-Walls test of 16.63. VAT sequences combined with T2 TSE were able to reduce metal artifacts quite well, with mean rank in the Kruskal-Walls test of 15.19. The more optimal sequence for reducing metal artifacts is the SEMAC T2 TSE, where the sequence is able to reveal thin structures that are not visible in the T2 TSE and T2 TSE VAT sequences.

Keywords: MRI Brain, Orthodontic Bracket

Introduction
Use of magnetic resonance imaging (MRI) modalities has a vital role in the diagnosis of pathology that requires a picture with good tissue contrast. MRI provides higher resolution and greater sensitivity to tissue structure and water content in the imaging field, which makes it possible to detect small changes in the anatomy and vascular associated with cognitive impairment and dementia [1]. MRI Brain examination at high resolution will be able to detect abnormalities in the brain that were not detected beforehand [2, 3]. MRI modalities that continues to be developed is the ability to reduce artifacts on examination[4] to display advanced types of artifacts that can appear in MRI imaging, namely Phase Mismapping (motion), Aliasing (Wrap), Chemical Shift, Chemical Misregistration, Truncation, up to artifacts due to Magnetic Susceptibility [5, 6]. Magnetic susceptibility is caused by differences of degree magnetic characteristics in magnetic tissues [5, 6, 7]. However, magnetic susceptibility can occur on any MRI examination with the use of metal implants on the anatomy examined, one of which is the MRI Brain examination with Orthodontic Bracket [7, 8, 9].
Metal artifacts arising is due to the vulnerability of local inhomogeneity of the tissue structure around the location of the presence of metal implants [10]. Emptying intra-voxel decreases the received signal and produces a hypointense area on the MRI image [10, 11].
In addition to optimizing parameters in the standard sequence, several specific sequence strategies have been developed effectively to reduce metal artifacts, one of which is the application of Slice Encoding Metal Artifact Correction (SEMAC) and View Angle Tilting (VAT) [12, 13, 14]. Another technique is combining SEMAC with VAT which allows better correction of field artifacts from metal implants [15] wirth the objective of improving metal implants correction [16, 17, 18].
The purpose of this study was to analyze the effectiveness of Slice Encoding Metal Artifact Correction (SEMAC) application and View Angle Tilting (VAT) application to reduce metal artifacts on MRI Brain examination with Orthodontic Bracket.

Method
The type of research is quantitative analytical research with a quasi-experimental research design. The research design used posttest design to determine the optimization sequence of Slice Encoding Metal Artifact Correction (SEMAC) application and View Angle Tilting (VAT) application on MRI Brain with Orthodontic Bracket. The population in this study were volunteers using Orthodontic Bracket and MRI Brain was performed at the "X" Hospital in Jakarta.
The inclusion criteria of this study were: Healthy Volunteer with Orthodontic Bracket (Stainless steel brackets, Titanium brackets, Ceramicbrackets); BMI (18.5-22.9), Age range 15-35 years. The sampling technique in this study is Purposive sampling. Volunteers with MRI Brain examination using a variety of T2 TSE sequences, SEMAC T2 TSE, and VAT TSE T2. The research that has been carried out obtained the results of 24 MRI Brain images with T2 TSE sequences, T2 TSE SEMAC, and T2 TSE VAT. Each volunteer received 3 treatment variations of the sequence.
Data analysis was performed by the Kruskal-Wallis H Test to see whether or not there were differences in the effect between treatments on anatomical information including: clarity of organs in the Temporo mandibular joints, Oral Cavity, Posterior Cerebral Fossa, and Maxillary Sinus.

Result

Table 1: Respondents' Conformity Test Results

Uji Kesesuaian	p value
Responden 1 dan Responden 2	0.907

The results of the conformity test show that there is a very good agreement between respondents 1 and respondent 2 with a value of p value of 0.907. For further statistical information on anatomical information, researchers only used anatomical information data from the first respondent.
To determine the effect of applying T2 TSE sequences, T2 TSE SEMAC, and T2 TSE VAT on MRI Brain examination with Orthodontic Bracket can be seen from the results of the Kruskal-Wallis H non parametric statistical test.

Table 2: Results of Influence Test from MRI Brain Anatomy

Informasi Anatomi	Var	Mean Rank	N	p value
Anatomi MRI Brain	TSE	5,69	8	0,003
	VAT	15,19	8	
	SEMAC	16,63	8	

*SPSS: Kruskal-Wallis H

Table 2 showed that there is an influence on the application of SEMAC and VAT to MRI Brain anatomical image information with a p value of 0.003 (p <0.05). From the Mean Rank table, it is known that SEMAC is higher than the other variations of 16.63 while in the VAT mean rank application it is 15.19 and the lowest TSE mean rank is 5.69. Furthermore, the effect of the application of SEMAC and VAT on each organ was carried out to determine the differences in anatomic information of Oral cavity, temporo mandibular joint, posterior cerebral fossa, and maxillary sinus.

Table 3: Results of the Effect of Metal Artifact Application on Oral Cavity organs

Anatomy Information	Var	Mean Rank	N	p value
Oral Cavity	TSE	5,50	8	0,000
	VAT	12,63	8	
	SEMAC	19,38	8	

*SPSS : Kruskal-Wallis H

Table 3 showed that there is an influence on the application of SEMAC and VAT to information on MRI Brain anatomy images on Oral Cavity organs with a p value of 0,000 (p <0.05). From the Mean Rank table, it is known that SEMAC is higher than the other variations of 19.38 while in the implementation of the VAT mean rank it is 12.63 and the TSE mean rank is the lowest at 5.50.

Table 4: Results of the Effect of Metal Artifact on Temporo mandibular Joint organs

Anatomy Information	Var	Mean Rank	N	p value
Temporo mandibular Joint	TSE	5,50	8	0,000
	VAT	13,00	8	
	SEMAC	19,00	8	

*SPSS : Kruskal-Wallis H

Table 4 showed that there is an influence on the application of SEMAC and VAT to MRI Brain anatomic image information on Temporo mandibular Joint organs with a p value of 0,000 (p <0.05). From the Mean Rank table, it is known that SEMAC is higher than the other variations of 19.00 while in the application of VAT mean rank is 13.00 and TSE mean rank is the lowest, namely 5.50.

Table 5: Results of The Effect Metal Artifact Application on organs Posterior Cerebral Fossa

Anatomy Information	Var	Mean Rank	N	p value
Posterior Cerebral Fossa	TSE	9,00	8	0,047
	VAT	11,56	8	
	SEMAC	16,94	8	

*SPSS : Kruskal-Wallis H

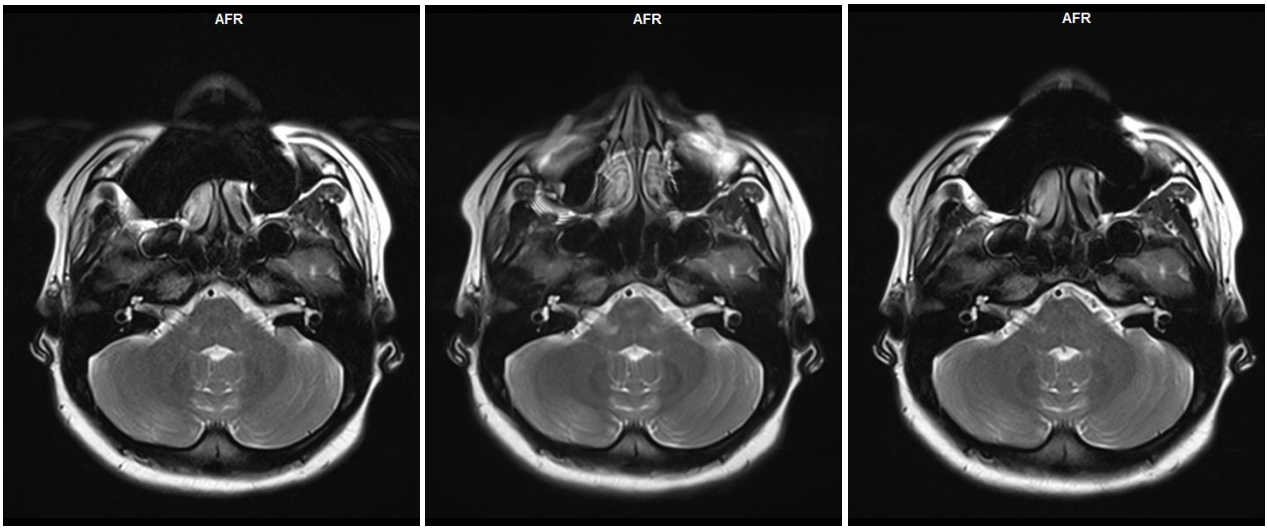
Table 5 showed that there is an influence on the application of SEMAC and VAT to information on brain MRI anatomy images in the Posterior Cerebral Fossa organ with a p value of 0.047 (p <0.05). From the Mean Rank table, it is known that SEMAC is higher than the other variations of 16.94 while in the implementation of the VAT mean rank is 11.56 and the TSE mean rank is the lowest at 9.00.

Table 6: Results of the Effect Metal Artifact Application on Maxillary Sinus organs

Anatomy Information	Var	Mean Rank	N	p value
Maxillary Sinus	TSE	6,88	8	0,011
	VAT	15,88	8	
	SEMAC	14,75	8	

*SPSS : Kruskal-Wallis H

Table 6 showed that there is an influence on the application of SEMAC and VAT to information on MRI Brain anatomy on Maxillary Sinus organs with a p value of 0.011 (p <0.05). From the Mean Rank table, it is known that VAT is higher than the other variations of 15.88 while the application of SEMAC mean rank is 14.75 and TSE mean rank is the lowest at 6.88.



(a) (b) (c)

Fig 1: Image Results of Effect Metal Reduction MRI Brain on overall anatomy (a) T2 TSE SEMAC, (b) T2 TSE VAT, (c) T2 TSE

Table 7: Results of the Effect Metal Artifact Application on overall anatomy

Anatomy Information	Var	Mean Rank	N	p value
overall anatomy	TSE	8,50	8	0,047
	VAT	16,00	8	
	SEMAC	13,00	8	

*SPSS : Kruskal-Wallis H

Table 7 showed that there is an influence on the application of SEMAC and VAT to information on Brain MRI anatomy images on overall anatomy with a p value of 0.047 (p <0.05). From the Mean Rank table, it is known that VAT is higher than the other variations of 16.00 while in the application of SEMAC mean rank is 13.00 and TSE mean rank is the lowest that is 8.50.

Discussion

Image quality is an important parameter that needs to be known by a radiographer to produce an optimal picture of MRI images by knowing the factors that influence the quality of MRI images [1, 3, 18]. Image quality on MRI is influenced by several factors, including SNR, CNR, spatial resolution and scan time. In addition, the presence of artifacts also greatly affects the quality of the image, especially anatomical information, which will be assessed and is the basis for determining the diagnosis [2, 5, 7].

This examination uses several variations of sequences which are useful for reducing metal artifacts including T2 TSE SEMAC, T2 TSE VAT and axial T2 TSE with assessed anatomical criteria including Oral cavity, temporomandibular joint, posterior cerebral fossa, and maxillary sinus [19]. Conformity test results in table 2 show that the assessment of respondents 1 and 2 has a strong relationship, then the first respondent data is taken to do the next statistical test [20, 21].

The non-parametric statistical test to see the effect of applying the SEMAC and VAT sequences in table 2 states that there is a significant influence between the application of the three sequences both SEMAC, VAT and TSE T2 to the Brain anatomy information produced, with a significance value of 0.003 (p <0.05) . This shows that there is an effect of applying the SEMAC and VAT sequences.

Regarding the use of orthodotic brackets that can cause metal artifacts, according to Shellock et al. in various studies relating to safety to conduct MRI in connection with 16 tested dental materials and devices containing ferromagnetic materials, and found that only three samples (SS, amalgam and silver dots) were causing problems for patients, during MRI scanning, because the material this is activated magnetically [24, 25].

In another study, Okano et al. suggested that Orthodontic Bracket made from ceramics applied to anterior teeth and metal bonds in molar teeth did not have a direct effect on diagnostic quality [26, 27]. MRI or on imaging of the temporo mandibular joint. SS (Stainless steel) and other metals used in dentures create a large number of artifacts which tends to obscure the details of the MRI image in the face area [28].

The selection of parameters in the examination is also an important thing to consider. Because the selection of parameters is very influential on the results of the acquisition of imaging data. Each parameter section also has its own function in displaying image quality [29].

The parameters that become the control variables in the study are TR (Time Recovery), TE (Time Echo), Slice Thickness, FOV, NEX, Matrix, Age, and BMI values. Because the variable is a control variable, it will not affect or change the results of the study [3, 27, 30].

Then according to Morikuni et al, when conducting research to examine the appearance of metal artifacts caused by mounting brackets, scanning MRI of the oral cavity was carried out with the type of Stainlessteel bracket [31]. SS (Stainlessteel) bracket used in their study contained 98% ferromagnetic material and particles, and therefore has a large enough capacity to interfere with magnetic field gradients [5, 31]. Similarly, in this study, we found that brackets with SS wire induced more metal artifacts.

Research by applying various types of brackets to see the influence of each bracect on metal artifacts that have appeared on MRI images has never been done before.

SEMAC is a sequence based on 2D TSE [32]. Adding encoding dimensions is done to correct field distortion. Each slice is added to the 3D encoding slice. This provides information about how depictions of distorted slices, such as shifting signals perpendicular to the image plane can be corrected by postprocessing during image reconstruction.[31)]

The main disadvantage of SEMAC is the increase in

imaging time required [32].

The results showed that the SEMAC sequence combined with T2 TSE was able to reduce metal artifacts well, this was supported by the high mean rank in the Kruskal-Wallis H. effect test. These results are consistent with the research conducted by Chen, Christina et al. to reduce metal artifacts, provide high-resolution images and good soft tissue contrast. Whereas according to Jungmann, Pia et al. That SEMAC is significant in reducing metal artifacts [29]. Clinical results suggest that this new technique will be useful for detecting postoperative periprosthetic pathology [7, 23]. SEMAC sequences are able to reveal small structures on tissues. certain compared to VAT, but the disadvantage of this sequence is that the time needed for data acquisition is longer when compared to other sequences [3, 16, 21].

In conventional SE acquisitions, during selection of slices, all rotating turns tilt their frequency to a band (i.e. slice selection bandwidth) [9, 17, 24]. When gradients are removed, spin no longer has the same magnetic field due to inhomogeneities, which means that no longer has the same Larmor frequency [12, 19]. For them to have the same Larmor frequency, during frequency coding, the same gradient is used for slice selection and applied at the same time as the gradient reading [7, 19].

The results showed that VAT sequences combined with T2 TSE were able to reduce metal artifacts quite well, this was based on mean rank values on the Kruskal-Wallis influence test. However, this application has an effect on blurred MRI images that arise as a result of applying VAT sequences.

This is in accordance with the statement from Bachschmidt T, that the effect that occurs is field distortion along the direction of reading [31]. VAT can cause image blurring caused by two separate effects. One reason is a shift in geometric slices. This effect can be reduced by using thin slices and high resolution. The second source of blurring is a low-pass filter that is superimposed by signal reading due to the addition of the VAT gradient. This can be reduced by the duration of the short reading [32].

In this study it can be concluded that the application of the SEMAC sequence on the Brain MRI examination to reduce the presence of metal artifacts caused by the installation of Orthodontic Bracket is considered to have better anatomical information compared to other sequences such as VAT and T2 TSE [33, 34, 35].

Conclusion

1. The SEMAC sequence combined with T2 TSE is able to reduce metal artifacts well, this is supported by the high mean rank in the Kruskal-Wallis H effect test of 16.63.
2. VAT sequences combined with T2 TSE are able to reduce metal artifacts quite well, this is based on the mean rank value of the Kruskal-Wallis H effect test of 15.19. However, the mean rank produced is still below the SEMAC T2 value. This application also affects the blurred MRI images that arise as a result of the application of T2 TSE VAT sequences.
3. The more optimal sequence for reducing metal artifacts is the SEMAC T2 TSE, where the sequence is able to reveal thin structures that are not visible in the T2 TSE and T2 TSE VAT sequences.

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