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A Study on Aliasing Artifact Shielding Materials using Aluminum Material in Magnetic Resonance Imaging

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In order to remove the aliasing artifact that occurs during magnetic resonance imaging, a shield was fabricated using aluminum, which is inexpensive and easily available in the vicinity, among materials that are not affected by magnetic fields, and its usefulness was evaluated. In the experiment using Phantom, it was confirmed that perfect shielding was achieved and no aliasing artifacts appeared. In addition, it was confirmed that the aliasing artifact was removed in the quantitative signal strength evaluation, and it was confirmed that the aliasing artifact was removed and the scan time was not increased in the ghost signal percentage evaluation, confirming the usefulness as a shielding body.

Keywords : magnetic resonance imaging, aluminum shielding, aliasing artifact, T1-weighted image, T2-weighted image

1. Introduction

Magnetic resonance imaging (MRI) is a test method that generates a magnetic field and high frequency and sends it to the human body to calculate and image the signal generated by the reaction of hydrogen nuclei in the human body. It is harmless to the human body, non-invasive, and has excellent contrast between tissues [1, 2]. In addition, magnetic resonance imaging is a method to acquire images using high frequency; that is, when the energy levels of particles having nuclear magnetic moments are separated in a static magnetic field, it uses the resonance phenomenon that occurs between the oscillating magnetic field or electromagnetic wave of a frequency corresponding to the interval [3, 4]. In particular, since normal tissues and lesions have different T1 weighted image (T1) and T2 weighted image (T2) relaxation times, the importance of magnetic resonance imaging in diagnosing and describing lesions using the difference in signal intensity between the lesion and the surrounding tissue has been reported through various papers [5-7].

Most magnetic resonance imaging is a test that images a local area in detail. However, in the magnetic resonance imaging process, there is a limit to giving radio frequency (RF) pulse only to field of view (FOV) to be seen, and various artifacts are generated due to the RF pulses applied to the whole body [8]. In particular, in the case of the object, even if it is included in the range receiving the RF pulse but is outside the FOV, the signal at the corresponding part is generated in both the phase encoding direction and the frequency encoding direction, so an aliasing artifact that produces the same signal on the opposite side occurs. And the problem of how to remove this artifact is an important factor in determining the quality of magnetic resonance imaging [9, 10].

There are various methods to remove aliasing artifacts, including the application of an over-sampling technique, a change of phase-encoding direction, an increase of FOV, and the application of a pre-saturation slab [11, 12]. However, these methods have the disadvantage of increasing the patient's examination time, and to solve this problem, various physical shielding materials that can artificially block the RF pulse are manufactured and used. However, this also has a disadvantage that most hospitals cannot select this physical method due to the high price of commercially available shielding materials. Therefore, in this study, among the materials that can block the RF pulse without affecting the magnetic field uniformity, the self-manufactured RF pulse shield using aluminum

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materials that can be easily obtained from the surroundings is the disadvantage of the existing method, the increase in inspection time and the image We want to evaluate whether it is possible to reduce the occurrence of aliasing artifacts without deterioration of quality through experiments.

2. Research Method

2.1. Test equipment

This study used 3.0T MRI equipment (Philips Ingenia Elition X) and a 32-channel anterior coil. American college of radiology (ACR)-PH1 MRI phantom and cylindrical fluid phantom were used to measure the degree of aliasing artifact generation in magnetic resonance imaging. As the magnetic resonance image shielding body, it was manufactured using aluminum, which is generally easily available among materials capable of shielding the RF pulse. 10 aluminum boards with a thickness of 15 μm were overlapped to make a size of 60 cm wide and 40 cm long, and the outside was wrapped with a cloth to prevent direct contact with the phantom, then the test was conducted (Fig. 1).

2.2. Test method

To evaluate the performance of the self-manufactured aluminum shield in reducing aliasing artifacts during magnetic resonance imaging, the ACR-PH1 MRI phantom and fluid phantom were placed parallel to the long axis of the 32-channel anterior coil, and the ACR phantom was centered to acquire images by setting the FOV as much as possible. The test was conducted under three conditions: the foregoing case, the case of applying the oversampling technique to the fluid phantom outside the FOV, and the case of applying the self-manufactured aluminum shield under the same conditions as the above conditions (Fig. 2). T1 weighted images, T2 weighted images, and diffusion weighted images (DWI) of the axial image of the phantom were acquired five times each and compared and analyzed (Table 1).

Table 1. The parameters of test method.

Division	TR(ms)	TE(ms)	FOV(mm)	NEX
T1 WI	500	20	300	2
T2 WI	2800	80	300	2
DWI	3093	66	300	2

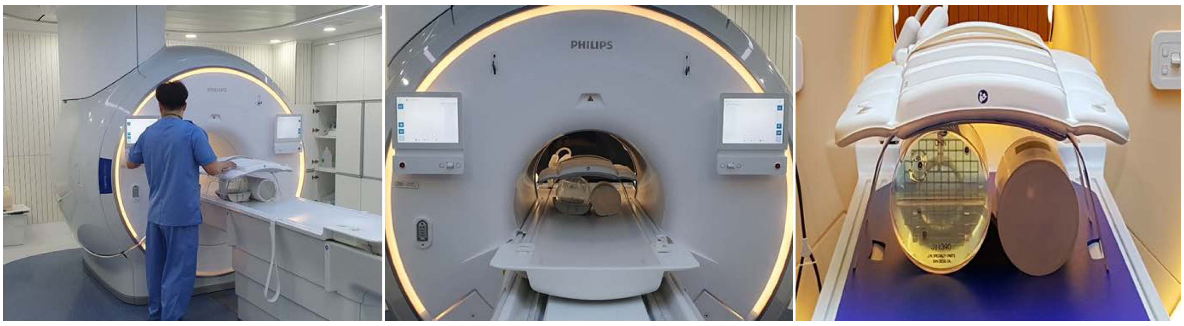
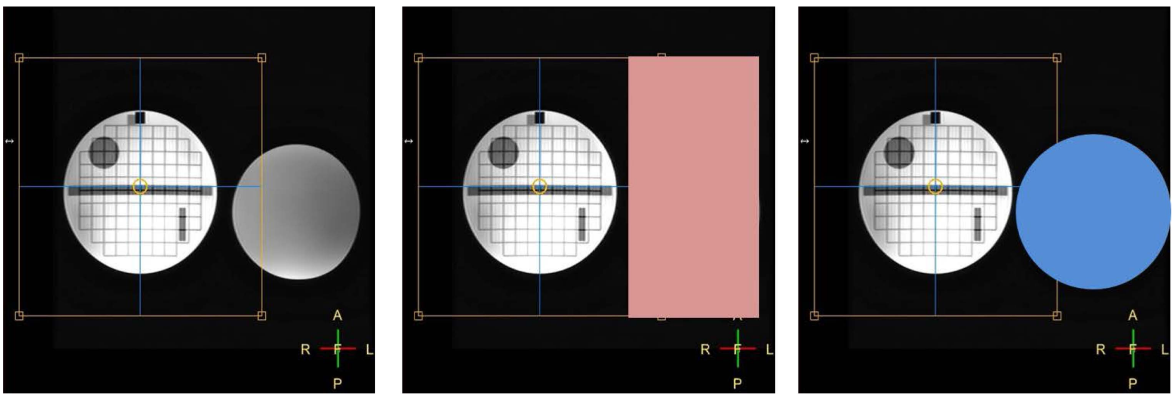


Fig. 1. (Color online) 3.0T MRI equipment and test phantom.



(a) Not shielding (b) Over-sampling (c) Aluminum shielding

Fig. 2. (Color online) Phantom image test method.

2.3. Analysis of imaging

Among 10 images obtained through phantom imaging, the middle image was selected, and the signal strength was measured by setting region of interest (ROI) in 4 areas including the background in the selected image. Based on the signal strength when the aluminum shield was not used, the degree of aliasing artifact reduction was evaluated by comparing the signal strength in the case over-sampling was applied and the case the aluminum shield was applied. And among the MRI degree control items, the aliasing artifact reduction degree was evaluated quantitatively between the cases where the aluminum shield was not used, an over-sampling was applied, and the aluminum shield was utilized using the percent signal ghosting measurement method. All images were analyzed using Image J ver. 1.8.0, an image measurement program.

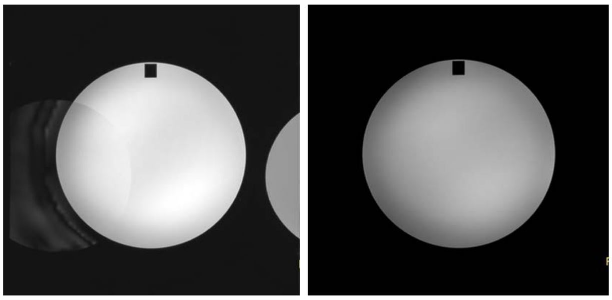
2.4. RF pulse blocking mechanism using aluminum

Aluminum has conductivity for electricity and reflectivity for electromagnetic waves, and these characteristics effectively block RF pulses [13-15]. Aluminum is a material with excellent electrical conductivity. When the RF pulse comes into contact with aluminum, it absorbs the RF energy by allowing the RF pulse to flow like electricity through the aluminum. The RF pulse used in MRI scan is electromagnetic wave energy in the range of 64 MHz to 128 MHz. This electromagnetic wave energy is absorbed by the aluminum conductor and flows, blocking it from flowing into the field of view. Also, aluminum has a high reflectance for electromagnetic waves. When an RF pulse hits an aluminum surface, it reflects similarly to how a mirror reflects light. This reflection blocks the RF pulses from flowing into the field of view.

3. Research Result

3.1. Imaging comparison before and after use of aluminum shielding material

Before using the aluminum shield, the image of the fluid phantom was included on the right side of the ACR phantom, but after using the aluminum shield, the image of the fluid phantom did not appear at all. These results show that the aluminum shield completely shields the fluid phantom included in the FOV. In addition, aliasing artifact appeared severely on the left side before using the aluminum shield, but it can be confirmed that the aliasing artifact does not appear after using the aluminum shield (Fig. 3). These results can also be found in DWI images where artifacts and image distortion appear most severely in magnetic resonance imaging. Before using the aluminum shield, the fluid phantom was included and artifacts appeared severely, but after using the aluminum shield, the fluid phantom image disappeared and the artifacts were significantly reduced (Fig. 4).



(a) Before shielding (b) After shielding

Fig. 3. Imaging comparison before and after of aluminum shielding.

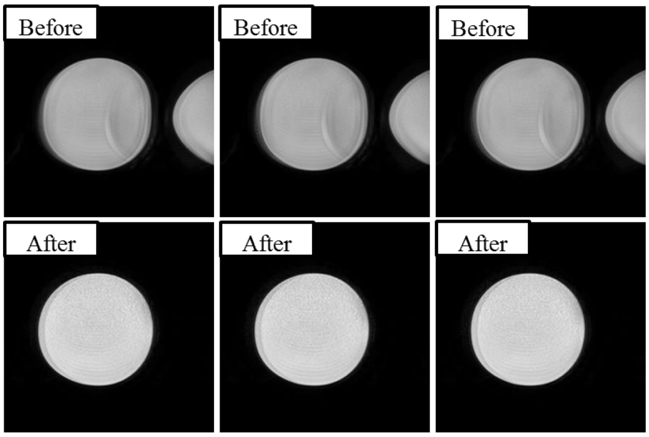


Fig. 4. DWI Imaging comparison before and after of aluminum shielding.

3.2. Evaluation of quantitative signal intensity

In order to quantitatively evaluate whether the occurrence of aliasing artifacts was reduced when the aluminum shield was used, ROIs were set in 4 background areas around the ACR phantom to measure signal strength (Fig. 5). In the image without aluminum shielding, the signal strengths of 3 points including T1 image (256.37±56.75), T2 image (382.24±32.37), and DWI image (282.39±58.12) on the left side of the ACR phantom were significantly higher than that of other 3 points, which confirmed that aliasing artifacts occurred. However, in the case of using the over-sampling technique and the aluminum shield, the signal strength equivalent to the noise level was measured in all four areas of the T1 image, T2 image, and DWI image, confirming that the aliasing artifact was removed

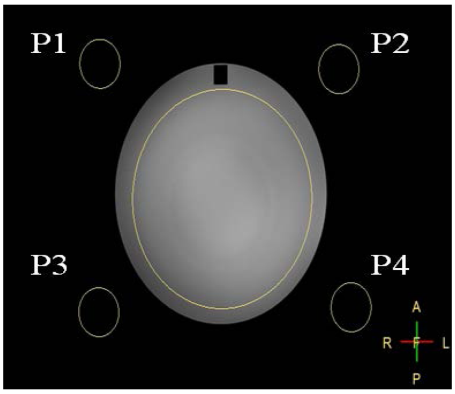


Fig. 5. (Color online) 4-point background signal measurement.

Table 3. Ghost rate measurement result.

Sequence Division	Ghost rate	Scan Time
T1 WI		
Not Shielding	4.36±0.14	152sec
Over-sampling	0.18±0.06	503sec
Al Shielding	0.28±0.12	152sec
T2 WI		
Not Shielding	6.38±0.34	112sec
Over-sampling	0.32±0.38	304sec
Al Shielding	0.42±0.12	112sec
DWI		
Not Shielding	5.87±0.34	58sec
Over-sampling	1.31±0.21	142sec
Al Shielding	1.59±0.28	58sec

(Table 2).

3.3. Evaluation of Ghost Signal Percentage

As a result of measuring the percentage of ghost signal, which is an MRI quality control item, to evaluate the degree of aliasing artifact reduction according to each technique, in the Not Shielding image, T1 image was 4.36±0.14%, T2 image was 6.38±0.34%, and DWI image was 5.87± 0.34, a value exceeding the standard 2.5% was calculated, confirming that aliasing artifacts were generated. However, in the over-sampling technique, T1 image decreased to 0.18±0.06%, T2 image decreased to 0.32±0.38%, and DWI image decreased to 1.31±0.21%. When using an aluminum shield, T1 image decreased to 0.28±0.12%, and T2 image decreased to 0.42%±0.12%, and DWI image decreased to 1.59±0.28%, confirming that both techniques reduce the occurrence of aliasing artifacts. In the over-sampling technique, the scan time was 503 sec on T1 image, 304 sec on T2 image, and 142 sec on DWI image, indicating that the scan time increased about 2 to 3 times compared to the Not Shielding test. However, no increase of scan time was observed in the case of using an aluminum shield (Table 3).

4. Discussion

Artifacts, which appear as image defects in magnetic resonance imaging, refer to all phenomena that cause unnecessary imaging results for diagnosis due to the patient, surrounding environment, and equipment defects in various stages of obtaining the final image necessary for diagnosis using magnetic resonance [16, 17]. In particular, when performing magnetic resonance imaging of the human body, only one part of the upper extremity or lower extremity is often examined, so aliasing artifacts frequently occur due to structures on the opposite side

Table 2. Evaluation of quantitative signal intensity.

Division	Point1	Point2	Point3	Point4
T1 WI				
Not Shielding	1.57±0.04	1.57±0.04	256.37±56.75	2.43±1.08
Over-sampling	1.83±0.07	1.01±0.01	1.31±0.37	1.51±0.35
Al Shielding	1.27±0.02	1.27±0.02	1.35±0.24	1.38±0.12
T2 WI				
Not Shielding	1.63±0.03	1.63±0.03	382.24±32.37	2.87±0.74
Over-sampling	1.57±0.05	1.50±0.15	1.67±0.03	1.67±0.03
Al Shielding	1.49±0.02	1.43±0.02	1.54±0.12	1.57±0.06
DWI				
Not Shielding	2.37±0.26	2.54±0.42	282.39±58.12	2.63±1.26
Over-sampling	2.28±0.66	2.42±0.54	2.43±0.28	2.58±0.44
Al Shielding	1.88±0.12	2.24±0.25	2.48±0.48	1.75±0.36

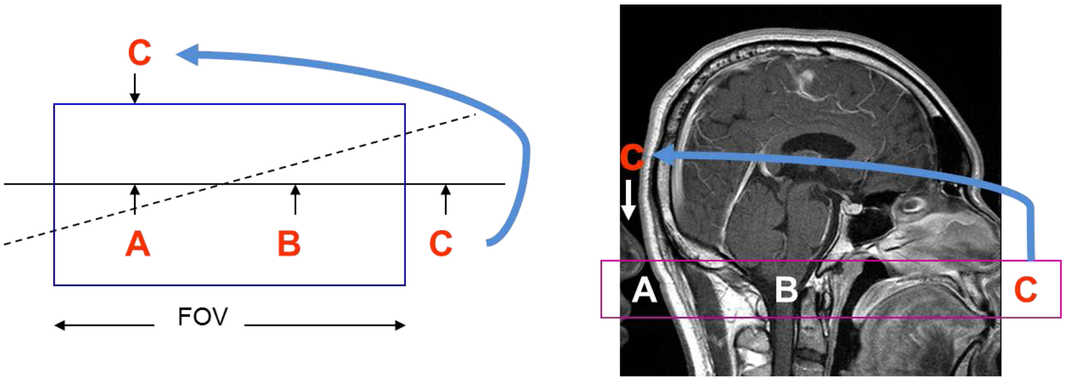


Fig. 6. (Color online) Principles of aliasing artifact occurrence.

[18, 19]. Structures located within the FOV are shifted in phase by 360×n° by the RF pulse [20]. However, since the structures located outside the FOV have a phase shift exceeding 1 phase, the phase is shifted to the opposite direction of the image in the phase encoding direction, resulting in aliasing artifacts appearing overlaid on the structures within the FOV (Fig. 6).

Methods used to remove these aliasing artifacts include application of oversampling technique, change of phase-encoding direction, increase of FOV, and application of pre-saturation slab. However, these methods increase the examination time of the patient [21-23]. And there is a method of removing artifacts using a shielding material that can artificially block RF. It is manufactured and used as a shielding body that has the characteristics of absorbing electromagnetic waves and converting them into thermal energy. Under the assumption that if the RF does not react with the human body, the signal of the image is not generated, the interaction between the RF and the human body is blocked in advance to remove the artifact. This has the advantage of reducing the examination time compared to the existing methods but has the disadvantage that it cannot be easily used because of high price [24-26]. Therefore, in this study, a new shield that can improve the disadvantages of existing RF absorbers and shields was fabricated and its usefulness was evaluated in removing aliasing artifacts.

Existing RF absorbents and shields suppress artifact generation by blocking RF pulses. Using this, a shield was fabricated using aluminum, which is not affected by magnetic fields among metal materials that can block RF, and is inexpensive, and can be easily obtained from the surroundings. As with the existing absorbents and shielding materials, it was found that the shield made of aluminum also could remove aliasing artifacts efficiently without increasing the scan time through the experiment. In the image comparison experiment before and after using the aluminum shield using the phantom, it was confirmed that the aluminum shield perfectly shielded the fluid phantom and no aliasing artifacts appeared. In the quantitative signal intensity comparison test, when the aluminum shield was not used, T1 image (256.37±56.75),

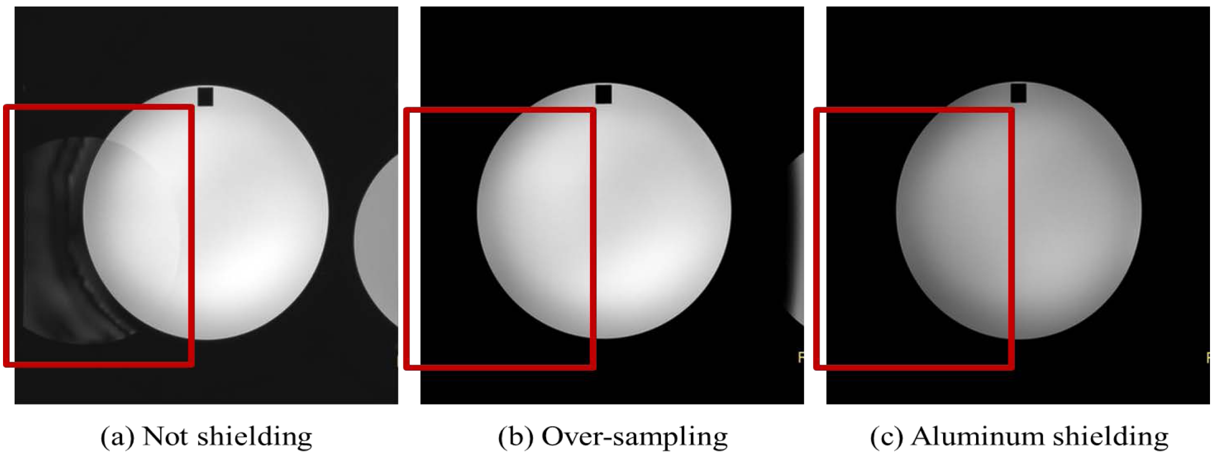


Fig. 7. (Color online) Aliasing artifact comparison of phantom imaging.

T2 image (382.24±32.37), and DWI image (282.39±58.12) all showed high signal strength at point 3 on the left side of the ACR phantom confirming that aliasing artifacts occurred. However, in the case of using an aluminum shield, it was confirmed that aliasing artifacts were removed because only noise level signal strength appeared in T1 image (1.35 ± 0.24), T2 image (1.54 ± 0.12), and DWI image (2.48 ± 0.48). In addition, in the ghost signal percentage evaluation, when the over-sampling technique was applied, the aliasing artifact was removed, but the scan time increased by 2 to 3 times, and when the aluminum shield was applied, the aliasing artifact was removed without increasing the scan time (Fig. 7). This means that, like existing shields using stainless and nickel alloy meshes, aluminum shields can reduce aliasing artifacts without increasing scan time which is a disadvantage of existing artifact reduction techniques. Therefore, it is thought that the low price and the advantage of being easily available in the surroundings will be more useful than the existing absorbers or shields when applied to actual examinations in many hospitals.

However, more research and experiments will be needed to commercialize the aluminum shield for test [27, 28]. Although not implemented in this study, previous studies have pointed out the problem that accurate measurement of temperature change is required because the existing absorbent or shield increases the temperature. This may cause burns to the tester. Therefore, additional studies on the temperature change over time in the area where the shielding material is applied will be needed.

In this study, a shield was fabricated using aluminum, which is not affected by magnetic fields and is inexpensive and easily available in the surroundings, among metal materials that can block high-frequency magnetic resonance imaging. In conclusion, the case of using an aluminum shield rather than the case of applying the over-sampling technique effectively removed aliasing artifacts without increasing the scan time, confirming the usefulness as a shield.

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