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Feasibility Study of Applying the Acrylic Assistant Equipment (ACR) to Reduce Patient's Discomfort in Lower Abdomen MRI Scan

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ABSTRACT

In lower abdominal MRI scan, patients have been tested by physically contacting with the body array coil. In this study, we have designed the acrylic assistant equipment (ACR) which allows the contactless scan of the patient to the coil and evaluated the feasibility by comparing the acquired images with ACR to those obtained without ACR. We tested 10 cases (F: 5, m: 5) by using the Ingenia 3.0T^{TM} MR system and dStreamTM torso coil (Philips Healthcare, Netherlands). We implemented T1 AX TSE and eTHRIVE (GRE) techniques. The scanned images were quantitatively and qualitatively assessed. In qualitatively, the TSE shows 4.44 and 4.56 mean values with and without the ACR and 4.34 and 4.28 at the GRE, respectively. In quantitatively, the TSE shows 12.15 CNR, 17.95 SNR and 12.71 CNR, 18.96 SNR with and without the ACR. And GRE shows 17.72 CNR, 22.59 SNR and 18.26 CNR, 24.47 SNR with and without the ACR, respectively. We have designed and implemented the acrylic assistant equipment to lower abdominal patients. Our data indicate that it is possible to obtain similar image qualities to current lower abdominal MRI scan without the physical contact to the patient.

Keywords: acrylic assistant equipment (ACR), lower abdominal MRI, discomfort.

Ⅰ. INTRODUCTION

Magnetic Resonance Imaging (MRI) has been described as the most important medical innovation in the last 25 years and most rapidly advancing diagnostic imaging tools today.[1] The MRI is that, unlike conventional x-ray or CT imaging, it does not involve exposure to the radiation so they can be safely used in people who might be particularly vulnerable to the effects of radiation, such as pregnant women and babies.[2] Through the development of highly specialized and efficient contrast agents, MRI has evolved into a versatile technique with multiple functions and has become one of the most powerful noninvasive imaging tools. High resolution and excellent soft tissue contrast are its main advantages over other in-vivo imaging techniques.[3] However, the combination of being put in an enclosed space and the loud noises that are made by the magnets can make some people feel claustrophobic while they are having an MRI scan.[4,5]

Good quality examination largely depends on how an individual tolerates lying in the MR scanner, environment and performed procedures. Factors influencing to the patient tolerance for all MR scanners independent of magnetic field strength are extended time of scanning, ambient temperature, acoustic noise, uncomfortable position during laying and a personal level of the discomfort.[6] Thus, even in some cases, the stress to the patient can be further since the additional coil needs to be used depending on the area to be

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scanned.[7] In abdominal or pelvic MRI scans, the patient is examined in physical contact with the body array coil by placing on the body. However, some of the patients are complaining about the pain or breathing difficulty since the weight of the body array coil, and sometimes this discomfort can cause the patient motion artifact.

In this study, we designed acrylic assistant equipment (ACR), which enables the contactless scan to minimize the patient discomfort during scanning by supporting the coil. The obtained images with ACR were compared to those obtained without ACR, and evaluated quantitatively and qualitatively together.

Ⅱ. MATERIAL AND METHODS

1. Test setup

We fully explained our study to the patients and obtained the written consent. We conducted test on 10 lower abdominal patients (5 male, 5 female) with Ingenia 3.0TTM MR system and dStreamTM torso coil (Philips Health care, Netherlands) using two representative pulse sequences. Scan parameters for T1 AX turbo spin echo (TSE) and gradient echo (eTHRIVE, GRE) are presented in Table1.

Table 1. Scan parameters used in this study

	Matrix	FOV (mm)	TR (sec)	TE (sec)	Slice Thickness (mm)	Gap (mm)	Scan time (sec)	BW (mm)	NEX (#)
TSE	512×358	250	548	10	5	1	197	176.9	1
GRE	252×190	250	3.5	1.7	9	0	15	718.9	1

Fig. 1 shows the ACR which we made for the experiment and its actual application. The upper part of the ACR is bent like the ellipsoidal shape so that the coil spontaneously covers the patient’s body when it placed on the surface of ACR. And the lower parts are slightly tilted towards outside for the stable supporting. The ACR is about 3mm thickness and made in three sizes to accommodate the differences of patient size. (Width: 40, 45, 50 cm, Height: 20, 25, 30 cm, Depth: 15 cm)

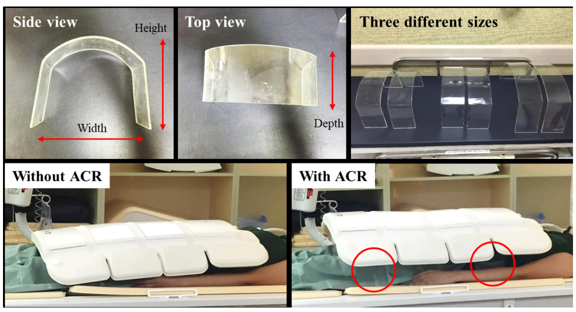


Fig. 1. Photographs of the generated ACR (upper) and its actual application (lower).

2. Data analysis

The scanned images were quantitatively evaluated in terms of the signal to noise ratio (SNR) and contrast to noise ratio (CNR). Several methods to measure the SNR and CNR have been studied and they can be mainly differentiated into methods based on a single image, on a pair of images, or on a series of many images[8]. As shown in Fig. 2, we measured SNR and CNR based on two regions of interests (ROI) at the same slice in each pulse sequence image with and without the ACR using the mean value of the ROI intensity. One is tissue of interest, and another is the image background, i.e., in air, outside of the imaged object with 28 mm diameter size. The tissue ROI was selected at the gluteus maximus muscle, with a standard deviation lower than 50. Since the muscle area is relatively uniform compared to other organs at the MRI image. The SNR and CNR were calculated by using the equations as follows:

$$SNR = 10\log\left(\frac{Mean_{ROI}}{SD_{Background}}\right) \quad (1)$$

$$CNR = \frac{|Mean_{Background} - Mean_{ROI}|}{\sqrt{SD_{Background}^2 + SD_{ROI}^2}} \quad (2)$$

In addition, we also performed the qualitative assessment using the image-scoring method which is commonly used for the evaluation of medical image quality[9,10]. Five experienced radiologists are randomly observed the scanned images and evaluated by categorizing into one of four quality groups: excellent (5), reasonable (4), intermediate (2-3), unacceptable (0-1) based on the image accuracy especially organ and skin line.

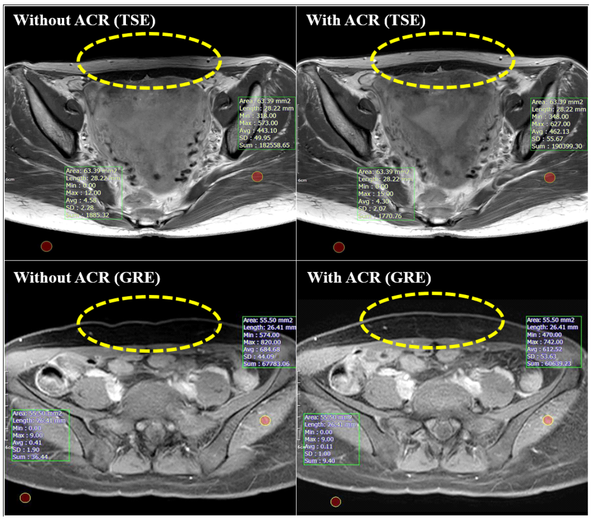


Fig. 2. Scanned images of TSE (top row) and GRE (bottom row) with and without the ACR. Dashed circles indicate the image distortion caused by physical contact when without the ACR.

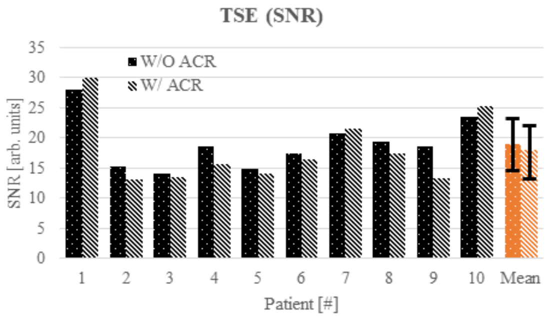
Ⅲ. RESULT AND DISCUSSION

Fig. 3 shows the results of quantitative analysis of each patient. At the TSE pulse sequence, (a) the average SNR without ACR was 18.96 ± 4.26, while 17.95 ± 5.74 with ACR. And (b) the average CNR without ACR was 12.71 ± 6.70, while 12.15 ± 5.15 with ACR. Likewise, at the GRE pulse sequence, (c) the average SNR without ACR was 24.47 ± 8.56, while 23.59 ± 8.59 with ACR. And (d) the average CNR without ACR was 18.26 ± 6.74, while 17.72 ± 6.14 with ACR. Basically, the quantitative differences of scanned images according to the existence of ACR were not considerably affected to the image quality regardless of the scan method. Average differences were 5.32 % in SNR, 4.44 % in CNR with the TSE, and 3.57 % in SNR and 2.96 % in CNR with the GRE.

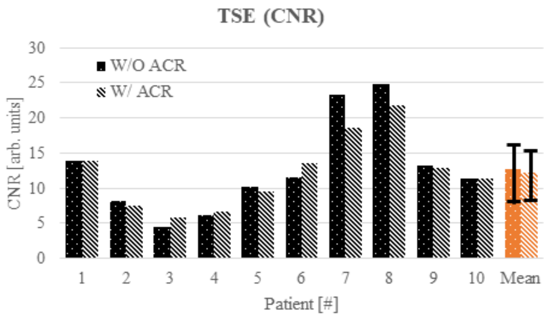
In qualitatively, as shown in Fig. 4, the TSE shows 4.44 ± 0.21 and 4.56 ± 0.24 average score with and without the ACR, while the GRE shows 4.34 ± 0.28 and 4.28 ± 0.23 average score with and without the ACR, respectively. As in the quantitative test, the results of qualitative evaluation showed very small differences of 2.63% for TSE and 1.40% for GRE according to the presence of ACR.

Consequently, our results confirmed that the use of ACR has a small effect of less than 5.32% difference quantitatively or qualitatively with respect to MR image quality, and even in certain cases (using ACR or not) the values were not constantly high or low. However, as shown by the dashed circle in Fig. 2, image distortion due to the physical contact between the coil and the patient occurs when scanning without ACR. In other words, using ACR enables the image acquisition of similar quality and prevents physical contact with the coil, which enables prevention of image distortion as well as comfortable scanning. This can be a critical factor in fields that the precise localization is required, such as radiation therapy.

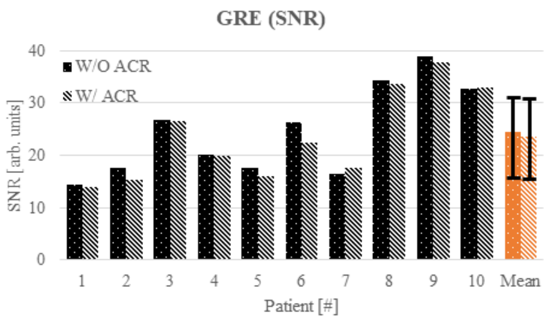
The SNR and CNR according to the pulse sequences were not constantly large or small depending on the use of ACR, and varied depending on the individual patient. This tendency was also observed in the results of image-scoring qualitative evaluation. This means that the use of ACR does not have a noticeable effect on the MR image quality.



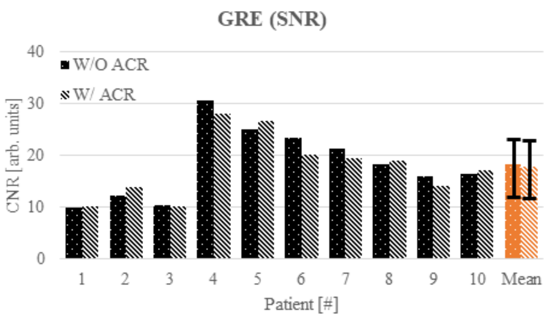
(a)



(b)

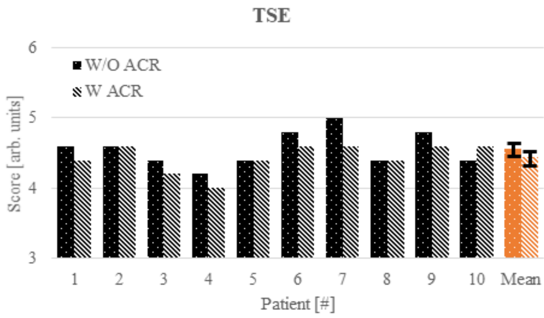


(c)

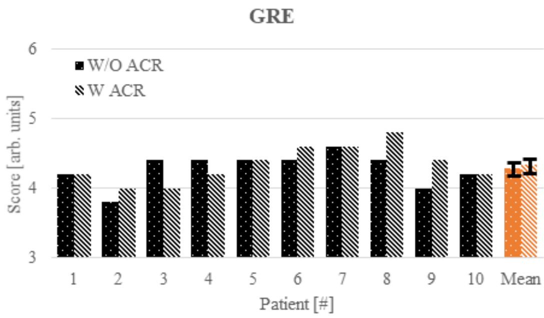


(d)

Fig. 3. SNR and CNR of each patient using the (a,b) TSE and (c,d) GRE pulse sequences.



(a)



(b)

Fig. 4. Scoring point of each patient using the (a) TSE and (b) GRE pulse sequences respectively, for the qualitative evaluation.

Ⅳ. CONCLUSION

We have designed and implemented the ACR for the lower abdominal patients to prevent the physical contact between the body surface coil and the patient who experiencing discomfort due to the coil weight. We obtained MR images with and without ACR in 10 patients using two different pulse sequences (TSE, GRE), and assessed quantitatively and qualitatively. Our data indicate that using ACR can be applied to achieve similar image quality to current abdominal MRI scans without physical contact between the patient and the coil. Our study has limitations such as the small number of sample and only tested at the 3T MR system. Nevertheless, we expect the proposed approach in this study can be applied to patients with complaints due to coils during MR scans of the lower abdomen.

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하복부 MRI 검사 시 환자의 불편함을 줄이기 위한 아크릴 보조 장치 사용의 타당성 조사

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요 약

하복부 MRI 검사에서 환자는 body array coil과 물리적으로 접촉하여 검사를 받는다. 이 연구에서는 아크릴 보조장치(ACR)를 설계하여 코일과 환자의 비접촉식 스캔을 가능하게하고, ACR을 이용해서 획득 한 영상을 ACR 없이 얻은 영상와 비교하여 실현 가능성을 평가하였다. Ingenia 3.0TTM MR 시스템과 dStreamTM torso coil (Philips Healthcare, Netherlands)을 사용하여 10건(F : 5, m : 5)을 테스트하였다. 대표적인 두가지 pulse sequence(T1 AXE TSE, eTHRIVE (GRE))를 사용하여, 스캔 한 영상을 정량적, 정성적으로 비교 분석 하였다. 정성적으로 보면, TSE는 ACR의 유무에 관계없이 4.44와 4.56의 평균값을, GRE에서는 각각 4.34와 4.28을 보여준다. 정량적으로, TSE는 ACR 유무에 관계없이 12.15 CNR, 17.95 SNR 및 12.71 CNR, 18.96 SNR을 보였으며, GRE는 ACR이 있는 경우와 없는 경우 각각 17.72 CNR, 22.59 SNR 및 18.26 CNR, 24.47 SNR을 보여주었다. 즉, ACR의 사용이 환자를 편안하게 하지만, 화질에는 큰 영향이 없음을 확인하였다.

우리는 하복부 환자의 MRI 검사용 아크릴 보조 장치를 설계하고 적용해보았다. 우리의 결과는 환자와의 물리적 접촉없이 현재의 복부 MRI 스캔과 유사한 이미지 품질을 얻을 수 있음을 보여주었다.

중심단어: 아크릴 보조 장치(ACR), 하복부 MRI, 불편함.