Development of RF coil for integration system of endoscope with MRI for esophageal examination

Y. Matsuoka[1], T. Ozaki[2], Y. Mori[3], K. Murakami[3], M. Matsumoto[4], E. Kumamoto[3], K. Imagawa[2], M. Gotanda[2], K. Kuroda[1,4]

[1]Institute of Biomedical Research and Innovation, Kobe, Hyogo, Japan, [2]Olympus Medical Systems Corporation, Hachioji, Tokyo, Japan, [3]Kobe University, Kobe, Hyogo, Japan, [4]Tokai University, Hiratsuka, Kanagawa, Japan

Introduction:

Endoscope has been used to diagnose the luminal organ, which give the patient the minimum risk but need the high manipulation technique to the doctor. But it might be difficult to find out the depth of the tumor range by the endoscope. On the other hand, magnetic resonance imaging (MRI) and ultrasonography can provide the anatomical image inside body, especially MRI makes high contrast image at the soft tissue and the ultrasonography has high response time. For the precise diagnosis it is necessary of the higher contrast image, therefore the purpose of this study is to establish the integration of the endoscopy on MRI, which has the specific RF coil and the tracking device for the endoscope in MRI, and the navigation system comprised of the MR images as a wide range around the target, the high resolution MR image of the target region, and the optical image. For this purpose, the performance of the developed RF coil for the endoscope was evaluated, and also the influence of the endoscope equipments on MRI was examined.

Materials and Methods:

In this system, 3T-MRI (Singa 3.0T VH/i, LX ver.8.3m4, GE Healthcare, Milwaukee, WI, USA) and MR-compatible endoscope (XGIF-MR30C, Olympus Medical Systems Co., Tokyo, Japan) were used and the esophagus was selected as the target organ. The prototype RF coil for the MR endoscope was mounted on the acrylic pipe of 12 mm outside diameter as one turn saddle form shown in Fig.1, which had a length of 20 mm and a central angle of 150 degree for the circumference of the coil, and was made of the etched copper line of 0.035 mm thickness with a width of 0.2 mm. And the area except the coil region on the acrylic pipe was prepared for the optical region of the endoscope. The availability of this coil was examined with the phantom comprised of 20 % of gelatin, 5 mmol/L of $CuSO_4$ and fruit. MR image was obtained by Spoiled Gradient echo (SPGR) with TR, 100 ms; TE, 5.7 ms; flip angle, 10 degree; readout band width, 31.25 kHz; FOV, 8×8 cm; slice thickness, 5 mm; matrix. 256×128; signal acquisition, 1. And the GE headcoil was used for the excitation. In addition, the influence of the endoscope equipments on MRI was tested, in which the electrical equipments such as the light source, the Camera Control Unit (CCU), the control system and so on, were covered with the electrostatic shielding case in the MRI room. The display devices as the LCD monitor the projector also were set up in the room without shielding. Then the MR image of GE phantom by GE headcoil with SPGR sequence was assessed.

Results:

The RF coil had Q factor of about 40 in loaded, and the image of the phantom by this coil is shown in Fig.2. SNR was calculated in the corrected image that was obtained by normalizing with the maximum signal intensity, for which the MR image of the homogeneous phantom (20 % of gelatin and 5 mmol/L of $CuSO_4$) by the same condition was applied. The property of SNR was indicated in Fig.3. The transverse axis is rotation angle **θ** between the line pass through the center of the circle including the coil (**O**) to the ROI and the reference line through both the middle point of the coil element and the center **O**. The angle was indicated as the positive to the counterclockwise rotation. The range of this coil to identify the fruit region was extended to about 16 mm from the center **O**. While the influence of the endoscope equipments on MRI was confirmed as about 40 % decrease of SNR when all electrical equipment power were turned on, and as about 30 % decrease when the equipments power in the shield case were on but the display devices off. However, there was no serious artifact on both images.

Discussion:

The MR image produced by the developed RF coil has a limited effective region but could be available for the diagnosis of the tumor invasion in the esophagus. In previous study about the MR endoscope [(1)~(3)], the RF coil was integrated on the end of the endoscope, not beyond the tip. Consequently it could cause the difficulty in selecting or recognizing the scan plane for the MRI in the optical image. However, the developed coil placed ahead of the endoscope tip could provide the optical region with the MR effective region on the periphery of the RF coil simultaneously. But the quality of the MR image around the optical region is poor certainly. By the rotation of the RF coil with the endoscope to the target lesion, this problem could be solved. This simple manipulation would enable the doctor to identify the relation between the MR image and the optical image easily. Concerning the influence of the endoscope equipments on MRI, the reduction of SNR as the result might not be so serious problem. It might be possible to decrease this influence by covering the display devices with the electrostatic shield.

Conclusion:

The ability of the specific RF coil for the MR endoscope system was revealed and the effectiveness as the integration of the endoscope system on MRI was also confirmed basically. For the next step, the navigation for the procedure of the endoscopy in MRI and the tracking system should be established.

Acknowledgements:

This study was supported by the Grant-in-aid for Scientific Research for Young Scientists B, Ministry of Education, Culture, Sports, Science and Technology.

Reference:

(1) Y. Matsuoka, K. Kuroda et al., Proc. ISMRM 12th Scientific Meeting, Kyoto, p.969, 2004
(2) D. J. Gilderdale, A. D. Williams et al., JMRI, 18, pp.131-135, 2003
(3) K. Inui, S. Nakazawa et al., Pancreas, Vol.16, No.3, pp.413-417, 1998

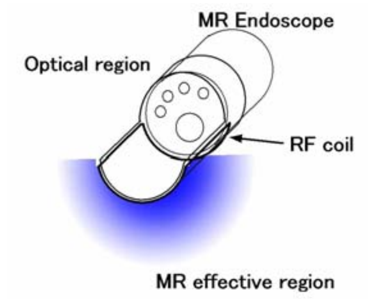

Fig.1 RF coil structure

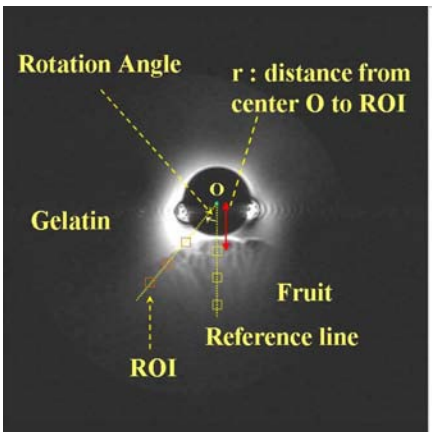

Fig.2 MR image of phantom with fruit

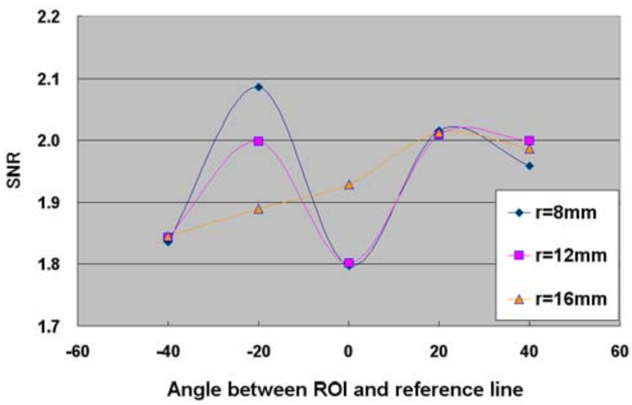

Fig.3 SNR