Navigation of quick MR scanning setup with intraluminal RF coil for integrated MR-endoscope system

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Purpose

While an endoscope provides the image of the surface of the gastrointestinal tract, it does not provide information about internal tissues. The visualization under the tissue surface is important for precise diagnosis and pre-operative planning. When compared to ultrasound, MRI provides a high soft-tissue contrast image with an arbitrary slice orientation; therefore, we have suggested an integrated MR-endoscope system to perform MR imaging during endoscopy and to show the images obtained by using both of modalities. For this MR-endoscope system, two primary components are required; one component is an intraluminal RF coil, which should be inserted into the gastrointestinal tract in order to obtain a high spatial resolution MR image of an organ; the other component is navigation software that enables the system to show the scope location with orientation inside the human body in an MRI and to indicate the MR image with a scope view. This software has been developed to show the scope view with a bird's-eye view, in which we can see the relative position of the scope and the organ visualized as an MR volume data [1]. In order quickly perform an MR procedure, a fast and proper setup of the MR scanning range and plane is needed. Additionally, it is desirable to use MR scanning to obtain a high resolution image of the tissue and a more precise diagnosis is possible if the image can be seen with a scope view. Therefore, a technique that facilitates the ability to quickly detect the MR scanning location and show the MR image chosen selectively from the MR volume data was developed and examined using dissected animal organs.

Methods and Materials

We used a 2-turn surface coil as the intraluminal RF coil. This coil was designed to have a flexible structure, approximately 40 × 50 mm in length [2, 3], and was tuned for a 1.5T MR scanner (Signa EXCITE TwinSpeed 1.5T ver.11, GE Healthcare, USA). The dissected porcine stomach with liver was placed in the MRI and the intraluminal RF coil was placed on the gastric mucosa. At first, MR volume images with a large field of view (FOV) of 30 × 30 cm were obtained using a 5-inch surface coil placed near the tissue on a T2-weighted Fast Spin Echo (T2FSE). Secondly, the coordinates at three different points on the RF coil were measured to calculate the centroid coordinates of the RF coil plane. These coordinates were indicated on the MR volume data with a large FOV. Next, the centroid location should be used as the center of FOV. This location should also be considered the scanning range for the MR imaging when using the intraluminal RF coil. The MR scan was then conducted with the T2FSE: TR = 3000 ms, TE = 115 ms, ET = 20, RBW = 15.6 kHz, slice thickness = 2.0 mm, slice gap = 0.0 mm, FOV = 8 × 8 cm, acquisition matrix = 256 × 256, and the number of slices = 30. To measure the coordinates mentioned above, the tracking system (EndoScout, Robin Medical, Inc., USA) was used to detect the location and orientation in the MR scanner. A tracking sensor 15 mm in length and 2 mm in diameter was attached to the tip of an MR-compatible endoscope (XGIF-MR30C, Olympus Medical Systems, Japan) (shown in Fig. 1). The coordinates on the RF coil surface were detected by bringing the scope tip near the coil surface. The navigation software was modified to calculate the centroid coordinate of the intraluminal RF coil plane. Additionally, a function was developed to show the MR image selectively chosen from the MR volume data with high spatial resolution obtained by using the intraluminal RF coil. This software was designed to acquire the tracking system data through the TCP/IP communication.

Results

The centroid coordinate of the RF coil plane was derived from the three positions detected on the coil surface in real-time, and these positions were indicated on the MR volume data with a large FOV (Shown in Fig. 2). The setup for scanning with the intraluminal RF coil through the measurement of the coordinates at three different points on the coil was performed in around 40 seconds without using the general localization procedure. Consequently, the high spatial resolution images of the porcine stomach with liver could be obtained. These images were used for the MR volume data on the bird's-eye view. One of the images could be chosen selectively and indicated on the pop-up view (Fig. 3).

Conclusions

This study demonstrated that it is possible to calculate the centroid coordinate of the RF coil in order to quickly execute the MR procedure. Furthermore, the function that facilitated the ability to show the MR image selectively chosen from the MR volume data was also found to be useful for precise diagnosis. In future research, the feasibility of this system should be examined with an animal experiment *in vivo*.

References

[1] S. Aizawa, et al., Proc. 8th Interventional MRI Symposium, pp. 288-290, 2010

[2] Y. Matsuoka, et al., Proc. 16th ISMRM, p. 278, 2008

[3] H. Yoshinaka, et al., J Gastroenterol 45:600-7, 2010

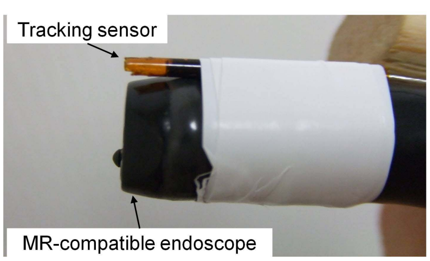

Fig. 1. The tracking sensor attached to the MR-compatible endoscope.

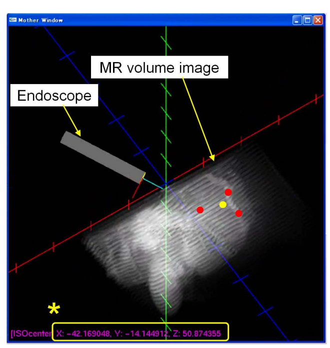

Fig. 2. The bird's-eye view with the centroid coordinate on the RF coil. The yellow dot shows the centroid position and the red dots indicate the points measured by the tracking sensor. * indicates the centroid coordinate.

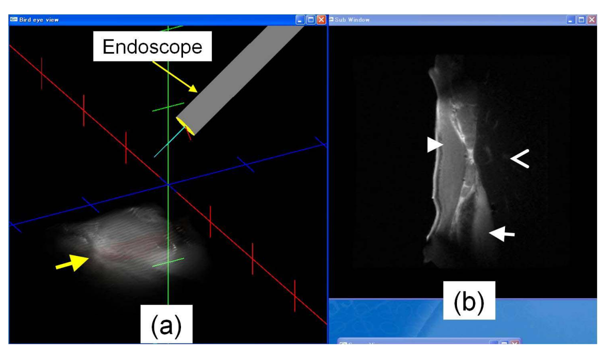

Fig. 3. (a) The bird's-eye view with detailed MR volume data and (b) a pop-up view. The red-colored plane in (a) shows the chosen slice selectively and depicts the image details. In (b) the white arrowhead indicates the porcine gastric wall and the white arrow and the open arrowhead show the gallbladder and the liver.