Interactive MR image scan guidance with a capability of motion compensation using Endoscout sensor

H. A. Haque[1], S. Morikawa[2], S. Naka[3], and K. Murakami[3]

[1]Japan Applied Science Laboratory, GE Yokogawa Medical Systems Inc., Hino, Tokyo, Japan, [2]Biomedical MR Science Center, Shiga University of Medical Science, Ohtsu, Shiga, Japan, [3]Department of Surgery, Shiga University of Medical Science, Ohtsu, Shiga, Japan

INTRODUCTION

MR image guided surgery (IGS) becomes more popular due to its multi-planner capability and better soft tissue contrast compared to other modalities. However, longer scan time is an important bottleneck to use it in real-time navigation. To solve such a problem, faster reformatting of the pre-acquired interoperative image volume has been usually used [1]. IGS relies on the assumption that the images acquired preoperatively accurately represent the morphology of the tissue during the surgical procedure and the surgical guidance is based on them. In many instances, however, this assumption is invalid, as preoperative data provide a static view without indicating the tissue deformation and patient movements caused by surgery. To overcome this problem a single tiny electromagnetic sensor was used to track the motion of the interoperative volume. The motion correction function, with which reformatted images follow the real-time image, will be useful for the inter-operative image guidance.

MATERIALS AND METHODS

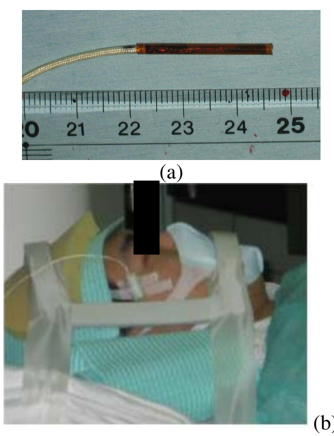
MR data were collected on a double-doughnut MR scanner 0.5 T SIGNA SP/i system (GE Medical Systems, Milwaukee, WI). Initially, 3D T_2-weighted MR images of a volunteer's head were acquired and used as interoperative image volume. Real-time MR images were acquired using a spoiled gradient echo (SPGR) sequence with TR/TE=14/3.4 ms (T_1-weighted). Image planes were interactively controlled with Flash-Point (FP) optical tracking hand piece. An electromagnetic 6-coil-catheter-sensor (Robin Medical, Baltimore, MD) of Endoscout (ES) (Fig. 1a), 2 mm in diameter and 26 mm in length, was fixed on the face bone as shown in Fig.1b to track the head motion. The ES utilizes gradient signal during MR scanning for position and orientation measurement. Software implementation was made on MR image guided navigation application MRNavi, which receives location and orientation data from FP and ES every 100ms. A baseline transformation matrix of 3D interoperative volume was built with ES. After the movement, updated position and orientation of ES were used to transform the interoperative volume, 3D tumor volume and footprint object placed. Image reformat was done subsequently with FP data on the transformed volume, assuming that ES does not move relative to the volume. During the experiment the volunteer head was moved up / down and turned left / right and pitted into / out of the gantry.

RESULTS AND DISCUSSION

With this new system, reformatted images correctly followed the real-time MR images even if the volunteer's position was changed. No need to reacquire 3D interoperative volume data, which will result in reduced procedure time. Fig. 2a and 2b shows MRNavi navigation views during initial position and after head movement, respectively. Upper two windows in the left side show the real-time images of inplane0 and inplane90 correspond to the FP position and lower windows show the reformatted images from the interoperative volume. These reformatted images respond much quicker than the real-time scan plane. This technique can be very useful also for pit-in pit-out procedure and interoperative (T2W) image will be automatically registered with the intraoperative real-time image (T1W). In addition, since the ES gradient tracking sensor is small and does not require any line of sight clearance, the sensor can be placed at any locations on the volume. Motion compensation using ES sensors will be feasible for the interventional procedures using real-time MR image navigation. We are looking forward to use the motion compensation system in some surgical procedure where patient is required to change the position during the surgery.

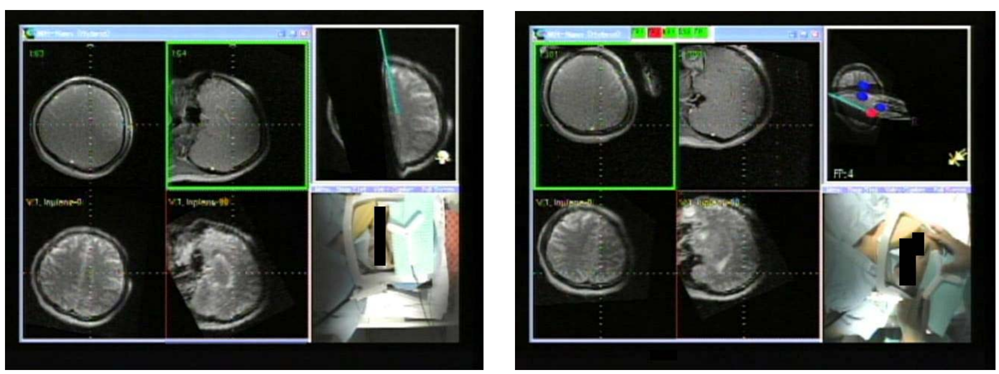
REFERENCES

[1] Morikawa S, Inubushi T, Kurumi Y, et al. Acad Radiol 10:180-188, 2003.



(a) (b)

Fig 1. (a) Endoscout 6-coil catheter sensor (b) Endoscout attached to the rigid face bone of the volunteer.



(a) (b)

Fig 2: Result of MR image guidance with motion compensation of the patient head movement. (a) Image guidance before movement (b) after head movement