

MR guided Microwave Surgery for liver tumor with MR gradient-based tracking system

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Introduction: Using the guidance of open configuration magnetic resonance imaging (MRI) system, we can monitor the excellent soft tissue contrast appearances and temperature of the treated site during the surgical procedures as well as absence of ionizing radiation. We have performed more than 150 cases of microwave surgery for liver tumor. We have used a PC-based application tool, 'MR Navi', which has capabilities not only for surgical planning and image navigation, but also for control of the MR scanner and in-bore control functions. The locator system provides the position and orientation data of hand piece to MRI scanner. We use the optical locator system (Flash Point 5000™ system, IGT, Boulder, CO, USA) which is originally equipped for open MRI scanner. However, it's difficult to keep the line-of sight of infrared LED tracking system. The new locator system is the MR gradient-based tracking system (EndoScout™, Robin Medical, Inc., Baltimore, MD, USA), which can provide the real time 6-degree of freedom tracking during MR imaging and eliminate the line-of sight problem. In this study, we demonstrate that microwave surgery using the newly developed application with the MR gradient-based tracking system is a feasible and effective system in the treatment for liver tumor.

Patients and Methods:

Patient: Thirteen nodules of Hepatocellular carcinoma (HCC) in eight patients were treated by microwave surgery using a new real-time MRI navigation system with MR gradient-based tracking system at Department of Surgery, Shiga University of Medical Science. There were seven men and one woman. The mean age of patients was 64.0 years. According to Child-Pugh classification, all patients were classified as grade A.

3D Tracking system : The EndoScout™ tracking system provides the realtime 6-degree of freedom tracking during MR imaging. It uses the gradient fields (Bx, By, Bz) of the MR scanner as the reference fields for tracking. The hand piece of sensor has three pairs of 7.4 mm diameter orthogonal coils. The sensor detects the MRI scanner gradient field and the EndoScout™ calculates the current location and orientation of the sensor by comparing the measured signals to stored maps of the gradient fields of the MRI scanner.

MRI Navigation: All procedures were carried out on a 0.5T vertically oriented open MRI scanner (SIGNA SP/i, GE Medical Systems, Milwaukee, WI). Real-time MR images sampled by a matrix of 256 x 128 pixels with a SPGR protocol (TR/TE 14/3.4 ms at a refresh rate of 2 sec/image) and the scan plane is prescribed in reference to the position and orientation of the tracking point by EndoScout™ system. We developed the original MRI navigation system which consists of a personal computer. The virtual liver image was reconstructed of a previously acquired MRI or CT image. The composite image which contains the virtual slice image, real time MR image, thermal map image, virtual 3D image and endoscopic image is shown on the LCD monitor in the bore of MR scanner.

Microwave Surgery: Microwave coagulator (Microtaze, HSD-20M, Alfresa, Osaka, Japan) was used as the thermo-ablation device. The frequency of microwave is 2450MHz. The procedure was carried out under general anesthesia. MR compatible needle-type electrode (250 mm long, 1.6 mm in diameter) was introduced into the liver through an MR-compatible 14G needle (Daum Corporation, Chicago, IL) via a percutaneous puncture. Microwave ablations at 60 W for 60 seconds were repeated several times depending on the size and number of HCC. The extent of tumor coagulation were evaluated with contrast enhanced MRI or CT.

Results and Discussion: We checked the accuracy of the EndoScout™ system before clinical use in comparison with the optical tracking system (Flash Point 5000™ system). There was no significant difference between EndoScout system and Flash point system.

Three cases which liver tumors were located just below the diaphragm (S4, S7 and S8) were selected for thoracoscope-assisted microwave surgery. In the all cases, the needle could easily reach the liver tumors using the newly developed application with the MR gradient-based tracking system and the procedure was performed successfully without significant complication. The new locator system is the MR gradient-based tracking system, which can provide the real time 6-degree of freedom tracking during MR imaging and eliminate the line-of sight problem of the optical tracking system.

Conclusion: The microwave surgery using the newly developed navigation system with the MR gradient-based tracking system is a feasible and effective procedure in treatment of the liver tumor.

References:

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