



MRI-guided fiducial marker implantation as a method of tagging an ultrasound- and non-enhanced CT-invisible liver tumor before thermal ablation

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ABSTRACT

Some liver tumors are not visible on ultrasound or non-enhanced computed tomography (NECT) which are the main modalities used in image-guided ablations. This is a report of magnetic resonance-guided implantation of a fiducial marker to tag a neuroendocrine tumor metastasis in a patient with renal insufficiency precluding the use of a contrast-enhanced CT during ablation. The marker was well visible on NECT which allowed for precise needle placement and complete ablation which was confirmed in 12-month follow-up.

Image-guided thermal ablation is a recognized method of liver tumor treatment. It is usually performed under ultrasound or computed tomography (CT) guidance. The CT-guided procedures are typically performed under non-enhanced CT (NECT) guidance because post-contrast enhancement lasts only for a few minutes which is not long enough to perform the entire procedure. However, in some patients, tumors are visible neither on NECT nor on ultrasound imaging.

Technique

This is a report of magnetic resonance imaging (MRI)-guided nitinol fiducial marker placement prior to microwave ablation of a neuroendocrine tumor (NET) liver metastasis. The patient is a 67-year-old male, and the nodule was detected on MRI in the left lobe of the liver but it was visible on neither ultrasound nor NECT. No contrast-enhanced CT was done due to renal function impairment.

The operators decided to place a fiducial marker under MR guidance (1.5T MAGNETOM Avanto; Siemens Healthcare). There was no liver-specific MR-compatible marker implantation device on the market, so a U-shaped nitinol clip marker dedicated for use in breast lesions (Tumark MRI) was used. An 18 G 12 cm needle was used, with approval by the Institutional Bioethical Committee. This study was performed in accordance with the principles outlined in the 1964 Declaration of Helsinki and informed consent was taken from the patient.

Pre-procedural MRI was done after placing MR-compatible skin markers on the patient's skin in the abdominal area. TrueFISP (true fast imaging with steady state precession) sequence was chosen as it causes fewer artifacts than T1-weighted images (Figure 1) and was quicker than T2-weighted images with fat saturation, while still maintaining good visibility of the lesion. MR-compatible skin markers were used to indicate the site of needle insertion on the skin (Figure 1a). The needle (18 G, 12 cm) was inserted in 1-2 cm steps and a scan (TrueFISP) was repeated after every step.

During the procedure, the patient reported anxiety and shortness of breath while inside the magnet. The marker was implanted in the vicinity of the lesion because the patient refused to continue the procedure, so there was no opportunity to reposition the needle. After the marker implantation and needle withdrawal, a final scan was performed which demonstrated a small hypointense element in the vicinity of the lesion corresponding

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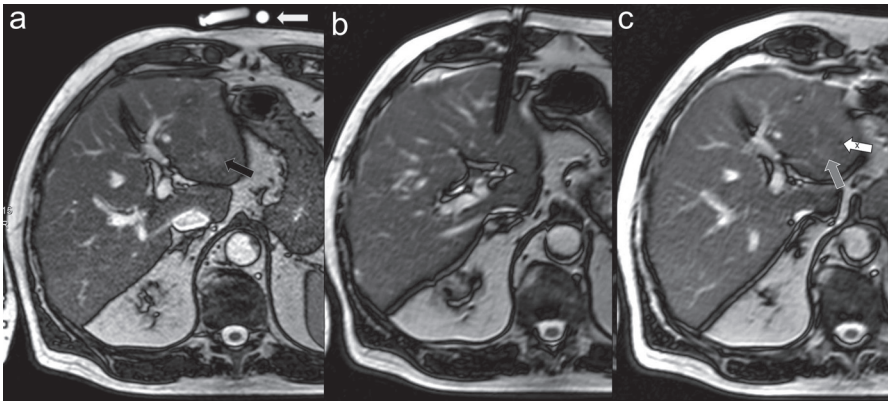


Figure 1. a-c. TrueFISP images of the procedure. (a). Neuroendocrine tumor metastasis (*black arrow*) and skin markers (*white arrow*) are visible. (b). Needle. (c). Lesion (*grey arrow*) and the marker (*white arrow with X mark*).

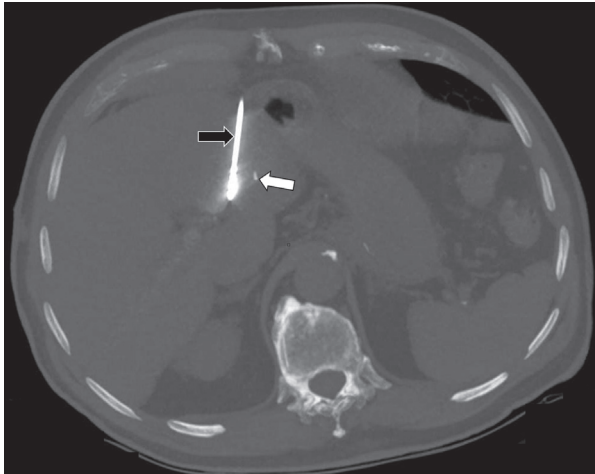


Figure 2. Non-enhanced computed tomography (CT) during ablation. Ablation antenna (*black arrow*) and the marker (*white arrow*).

to the implanted marker (Figure 1c). The patient's anxiety symptoms resolved completely after the procedure.

Clear visibility of the marker in NECT (Figure 2) allowed to set the target area of ablation by comparing MR and NECT images and measuring the distance between the marker and the lesion. CT-guided microwave ablation (Solero;

AngioDynamics) was performed with the following settings: 2 zones, 140 W for 4 minutes each. No contrast-enhanced CT was

done after the procedure due to patient's renal function impairment. In 6-week and 12-month follow-up MR examinations, no residual tumor tissue or recurrence was reported (Figure 3).

Discussion

In most patients, ultrasound, non-enhanced CT, or a combination of both is sufficient to perform precise image-guided thermal ablation. However, some tumors are not visible on ultrasound and NECT, and percutaneous procedures are very difficult in such cases.

There are several management protocols for patients with lesions that are not visible on ultrasound or NECT. One of them is fusion of ultrasound and MR images,¹ but this does not always provide accurate results due to movements of the liver, including its rotation and deformation, when the patient is anesthetized. Also, not all radiology departments have this option available. There are few reports on MR-guided ablation, but the results are encouraging.^{2,3} Such procedure may be useful in difficult locations (e.g., subdiaphragmatic lesions) or tumors that are not visible on NECT or ultrasound. MR guidance may provide more precise targeting and monitoring of the procedure and give better results than CT-guided ablation.³

Chemoembolization of hepatocellular carcinoma is an efficient way to mark the tumor before ablation since lipiodol is very conspicuous on NECT and CT guidance providing good results in such cases. However,

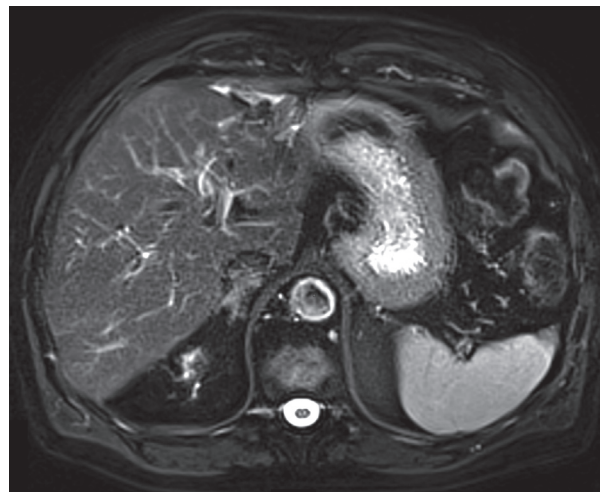


Figure 3. Follow-up magnetic resonance imaging (MRI) 12 months after ablation – no recurrence of the tumor.

Main points

- Magnetic resonance-compatible fiducial markers can be used to tag ultrasound- and non-enhanced computed tomography (NECT)-invisible liver tumors.
- TrueFISP sequence seems to be most appropriate in simultaneous marker and needle and tumor visualization.
- The markers are very clearly visible on NECT which allows for precise ablation needle placement.

this method is not routinely used in neuro-endocrine tumors.

Contrast-enhanced ultrasound (CEUS) can also be used as a method of increasing conspicuity of liver lesions,⁴ but it is highly operator-dependent. Sometimes, location and patient's habitus can limit the use of CEUS, for example, subdiaphragmatic nodules in obese patients. Also, the ablation zone is not easily visualized with ultrasound due to gas bubble formation causing artifacts.⁵

The marker used in this patient is dedicated to breast disease and it is licensed as a long-term implant. It was used to tag this liver lesion because there are no liver-specific MR-compatible markers available on the market. This application was approved by the institutional bioethical committee. No adverse reactions (e.g., allergy) were expected since the marker is licensed for

use in other tissues. However, one possible complication that does not seem relevant in breasts but is possible in the liver is the migration of the marker into the blood vessels. If the marker gets into the portal vein branch, it will get implanted in the liver parenchyma carried by the blood flow. However, if it gets into the hepatic vein, it will get to the right heart and possibly the lungs. It is important to make sure that the device is deployed away from the blood vessels when the clip marker is released. The needle length of 12 cm is a limitation that precludes reaching deeply located lesions.

MR-guided fiducial marker placement is a feasible method of tagging ultrasound- and NECT-invisible tumor before CT-guided thermal ablation. A study on a large number of patients is necessary to confirm the consistency of these results.

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