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A novel labeling modality of intra-abdominal lesions with Magseed magnetic marker and extirpation by Sentimag probe navigation

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SUMMARY

OBJECTIVE: This study aimed to evaluate our experience with the use of Magseed, the magnetic metallic marker, as a localization technique followed by Sentimag probe detection in patients with solitary intra-abdominal local metastases with subsequent resection of the lesions.

METHODS: Five patients underwent resection after the lesion was marked with the Magseed magnetic marker. Prior to the surgery, a computed tomography scan of the chest and abdomen and/or positron emission tomography was performed to rule out the dissemination of the disease. The indication for surgery was evaluated in a meeting of a multidisciplinary team, and the placement of the magnetic marker under computed tomography control had been performed the day before the planned procedure.

RESULTS: The present preliminary outcomes have revealed that Magseed might be a promising technique that is feasible and safe, particularly when the postsurgical anatomic conditions in the abdominal cavity are altered and the lesions are not visible or palpable. Surgical extirpation of lesions occurred without complications in each case. In all the cases, the resection was complete and curative, and one wound infection in all (20%), without any major complications, had occurred. The mean hospital stay was 6.6 days.

CONCLUSION: Magseed utilization, as a localization technique, followed by Sentimag probe detection in intra-abdominal tumors has not been reported before. Improving the visualization and, consequently, the precise marking of the lesion with subsequent radical removal can prevent insufficient or excessive removal of healthy tissue, leading to a faster diagnosis and better overall clinical outcomes.

KEYWORDS: Magnetic. Magseed. Sentimag. Thyroid gland. Thyroidology.

INTRODUCTION

Perioperative localization and surgical removal of intra-abdominal local recurrences can be technically difficult because recurrent lesions may be small and localized in relatively inaccessible areas or surrounded by necrotic, adipose, or other tissue. The lesions are usually not easily visible or palpable. Accurate localization is important because resection of recurrences can improve survival; conversely, inaccurate targeting of the lesion can lead to either insufficient excision with an increased risk of recurrence or excessive removal of healthy tissue.

Localization and surgical treatment of nonpalpable lesions of the breast, lung nodes, liver, and other parts of the body are often performed by preoperative marking with wire, the harpoon technique, a contrast agent such as indocyanine green (ICG), liquid markers, a radioactive iodine seed, or, as in our case, a magnetic seed, Magseed. Magseed (Endomagnetics Ltd., Cambridge, UK) is a 1 mm × 5 mm magnetic metallic marker that is preloaded in a sterile 18-G needle. The seed is detectable using the Sentimag probe and can be detected from any direction, regardless of seed orientation. The Sentimag probe produces an alternating magnetic field that transiently magnetizes the iron oxide particles within the Magseed. The probe shows a numerical count and produces an audio tone related to the strength of the magnetic field and, therefore, to the distance of the seed in the tumor from the detector probe. The seed is cylindrical with no barbs, has no moving parts, and cannot be

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damaged when implanted. Magseed is usually and frequently used in patients with nonpalpable breast tumors for tumor localization before surgery[1].

METHODS

This study was conducted in accordance with the Declaration of Helsinki and followed the ethical standards of the country of origin. We retrospectively analyzed data from five patients who had undergone surgery for intra-abdominal local recurrences of different cancers from October 2021 to May 2022. The age of the patients (three males and two females) was between 60 and 74 years, and all had previously undergone an oncological surgery procedure, presenting recurrences during the follow-up. The primary tumors were recognized as colorectal adenocarcinomas (3/5), endometrial carcinoma (1/5), and neuroendocrine tumors (1/5). A thoracoabdominal computed tomography (CT) scan and/or positron emission tomography (PET) scan was performed in all the cases in order to exclude disseminated disease or the presence of multiple nodules, which was correlated with specific tumor markers. The indication for surgery was evaluated at a meeting of a multidisciplinary team. Placement of a CT-guided magnetic seed, Magseed, was undertaken after the patient's written consent was obtained, and they were admitted 1 day before surgery when the radiological procedure was performed under local anesthesia. The lesions were localized by CT scan, and the puncture route was anterior (2/5), lateral transperitoneal (2/5), or dorsal (1/5). For the procedure, the patient was positioned depending on the lesion location and seed placement. The site of entry was then cleansed, prepped, and draped in a sterile manner, and the magnetic seed was placed less than 1 cm from the lesion. Correct placement and settlement of the Magseed was checked by CT scan (Figures 1 and 2). The patients were transferred back to the surgical ward, and the position of the marker was directly checked using the Sentimag magnetic probe. The same control was also used directly before the surgical procedure (Figure 3). Depending on the location of the lesions, a conventional surgical approach through a median laparotomy (one patient), a lateral (one patient), or a transverse approach (three patients) was performed. To this end, the lesions were easily located using the Sentimag probe and then resected.

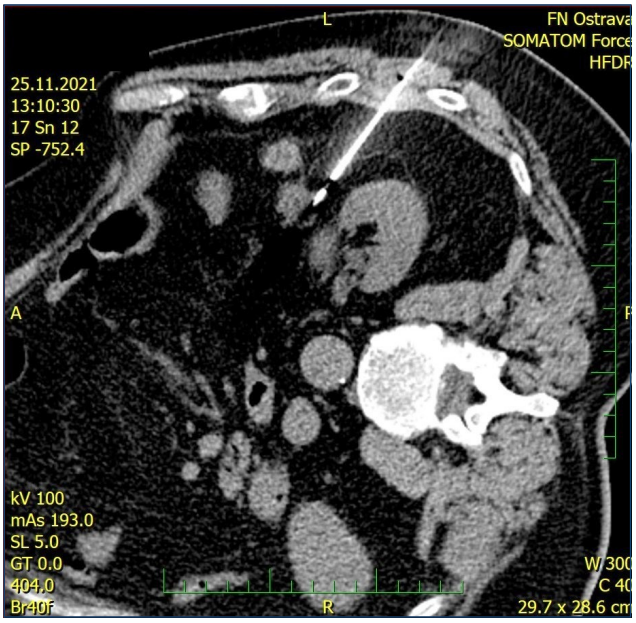

Figure 1. Placement of the Magseed via a CT scan navigation.

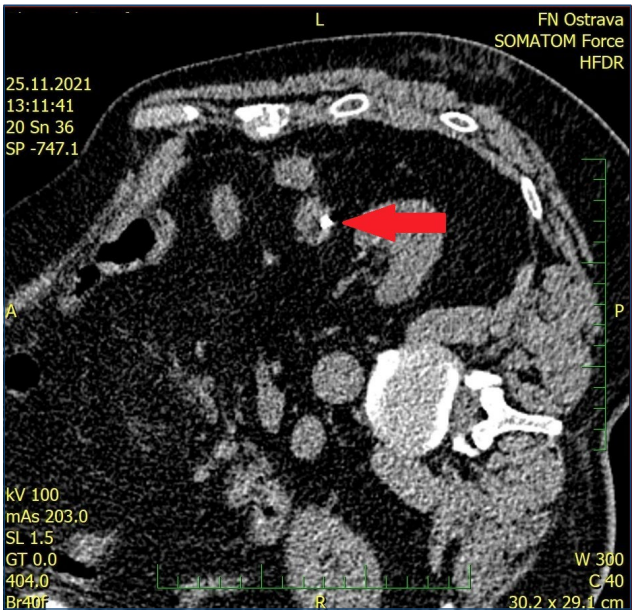

Figure 2. Settlement of the Magseed, utilizing a CT scan.

RESULTS

The Magseed placement was successful in all five patients. No patients reported pain during the radiological procedure. No placement-related complications had been noted, and no intra-abdominal organ injuries occurred. In all cases, the tumor was located near the seed, and the seed was extirpated with the tumor lesion. A safety margin of healthy tissue of at least 1 cm was excised together with the lesion. A colon resection was necessary for one patient due to neoplastic infiltration, and this case also involved resection and primary suture with partial resection of the spleen. One patient necessitated a resection of tail of the pancreas. Surgical excision of the lesions

Figure 3. Diagnostic settlement of the Magseed, directly checked using a magnetic Sentimag probe prior to the surgical procedure.

was performed without perioperative complications in any case. One (20%) patient had a wound infection with secondary healing. The mean hospital stay was 6.6 days. Resection was complete and curative in all cases. In addition, four (80%) cases exhibited the metastatic lesions:

I. Two of them were metastatic adenocarcinomas.
II. One was an endometrioid carcinoma.
III. One was a neuroendocrine metastatic cell, all possessing negative margins of more than 1 mm. In one patient, there was a histopathological finding of pseudocyst with eosinophils, with a positive preoperative PET/CT scan finding that was suspicious for metastatic disease from the primary colon tumor.

DISCUSSION

The development of interventional radiology (IR) in the past decade has often paved the way for new therapies that are later performed routinely and not only by interventional radiologists. For instance, based on long-term results, minimally invasive ablative techniques, originally proposed as alternative surgical options, are now recommended treatments in many indications, such as in the liver and kidneys[2].

IR focuses on anatomical localization using ultrasound (US), CT, and magnetic resonance imaging (MRI) to improve the accuracy and specificity of diagnosis. It is also desirable to avoid excessive medical treatment and waste of clinical resources[3]. Percutaneous approaches can be performed under the guidance of US, x-rays, CT, MRI, or even PET/CT[4].

The main anatomic parts of *Homo sapiens* in which image-guided localization techniques are useful are the breast, lung, liver, thyroid, parathyroid, kidney, and other soft tissues and organs such as lymph nodes. Localization studies remain significant in neck-endocrine surgery and thyroidology to date and provide vital clues for both surgeon-performed US examinations and all thyroidologists[5-9]. In breast lesions, the main indications are preoperative localization of nonpalpable lesions that are only visible on imaging; this imaging guides surgeons for a safe intervention aiming at an R0 resection and a good cosmetic result. Another indication is the permanent marking of a tumor in candidates for neoadjuvant therapy when, after complete tumor regression, the surgeon is able to identify and remove the "tumoral bed." Frequently used methods are wire localization, radioactive-seed localization, magnetic seed localization, carbon marking, US-visible hydrogel-based markers, and radiotracer injection[10].

In lung lesions, it is convenient to mark those that are small or deeply located. In addition, during video-assisted thoracoscopy, only the tactile sensation of the thoracoscopic instruments can be applied, and this is sometimes not informative enough. There are also multiple techniques used in the thoracic cavity to localize tumors, such as percutaneous hook-wire placement, which is mainly used for lesions ≤10 mm in size and located >5 mm from the pleural surface; dyes such as ICG, indigo carmine, and methylene blue; an ethiodized oil like Lipiodol; or a radioisotope. A radiopaque metallic marker has been used before stereotactic body radiotherapy (SBRT) of lung tumors[10].

In liver lesions, an ethiodized oil (Lipiodol) is used to mark hepatocellular carcinoma before the thermal ablation procedure, and implanted fiducial markers as surrogates for liver tumors are frequently used before SBRT of liver tumors. This procedure is usually performed under US and/or CT guidance, depending on the imaging modality that better exhibit the lesion, but it can also be performed during laparoscopy or laparotomy in case of an inoperable tumor. For better results, two or more fiducials should be placed <2 cm from the tumor[11]. In addition, for soft-tissue lesions, frequently used markers include liquids, metallic coils, and hook and curved-end wires. Liquid markers are not used, because they have a tendency to distribute nonspecifically into the adjacent tissue[12].

Lymph nodes are usually marked before the initiation of neoadjuvant chemotherapy when it is necessary to mark the node for later surgical removal. The insertion of different markers is typically performed under US guidance. Markers are standard hook and curved-end wires, low-activity radioactive seeds using the ^{125}Iodine, or a Magseed magnetic seed[13].

The technique for locating intra-abdominal local recurrences with this CT-guided placement technique is similar to CT-guided fine-needle aspiration (FNA) of intra-abdominal masses. The duration of the procedure and patient tolerance are also similar. The incidence of possible secondary complications of seed placement can be extrapolated from the incidence of

FNA, which is about 1.3%[14]. Complications like hemorrhage and bile peritonitis in liver FNA or biopsy can be recognized within 4 h after FNA application. Post-liver biopsy bleeding can occur in 0.32–0.35% of patients, with morbidity related to hemorrhage at 0.24% and mortality from severe bleeding at around 0.11%[15]. To the best of our knowledge, in English-language literature, the mortality from FNA has been reported as 0.006%, occurring mainly in the liver and pancreatic biopsies[16]. Pulmonary complications post-liver biopsy are considered to be rare, which may occur as the needle biopsy passes through the costophrenic angle above the reflection between the parietal and visceral pleura. The patients can develop pneumothorax and hemothorax[17]. The incidence of pneumothorax is in the range of 0.08–0.28%, and the symptoms are usually mild, with pulmonary collapse not exceeding 10%[18]. Hemothorax post-liver biopsy is also scarce, accounting for 0.18–0.49%, and can be managed conservatively without thoracotomy[17]. In our series, we had not encountered any complications during radiological placement of the seed or during the surgical extirpation. We have not recognized any complications from the Magseed placement or during the surgery. It is usually used to preoperatively localize the nonpalpable breast lesions or as a marker of lymph nodes before the neoadjuvant chemotherapy in patients with breast carcinoma[19]. To the best of our knowledge, this series of the Magseed placements in intra-abdominal lesions and the lesions' extirpation by Sentimag probe navigation is the first to be reported in English-language literature, to date.

CONCLUSION

Effective treatment requires the optimal placement of targeted treatment devices without affecting other organs. The precise marking of the lesion can improve preoperative planning by providing the surgeon with valuable information regarding the optimal incision and lead to a less invasive and more biologically sparing excision. The use of Magseed, a magnetic metallic marker, as a localization technique followed by Sentimag probe detection in patients with solitary intra-abdominal local metastases with subsequent resection of lesions can prevent insufficient or excessive removal of healthy tissue and thus speed up treatment and improve overall clinical results.

AUTHORS' CONTRIBUTIONS

DT: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Validation, Visualization, and Writing – original draft. **IS:** Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, and Writing – review & editing. **OK, PG:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Validation, Visualization, and Writing – original draft. **TJ:** Investigation, Project administration, Resources, Software, Validation, Visualization, and Writing – review & editing. **JP:** Conceptualization, Investigation, Methodology, Project administration, Resources, Validation, Writing – original draft, and Writing – review & editing. **LT:** Conceptualization, Data curation, Formal analysis, Methodology, Project administration, Validation, Visualization, and Writing – original draft. **PI:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Resources, Software, Validation, Visualization, and Writing – review & editing. **AP**: Investigation, Project administration, Validation, Visualization, and Writing – review & editing. **DS:** Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, and Writing – review & editing.

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