Magnetic Resonance Imaging 37 (2017) 159–163

Contents lists available at ScienceDirect

Magnetic Resonance Imaging

journal homepage: www.mrijournal.com

Original contribution

MR visible localization device for radiographic-pathologic correlation of surgical specimens☆

Sonja Kinner [a,b,*,1], Tilman B Schubert [a,c,1], Elisabetta A Nocerino [a], Shannon Hynes [d], Timothy J Colgan [a,e], Agnes G Loeffler [f], Christopher Brace [a,e], Scott B Reeder [a,d,e,g,h], Emily Winslow [i]

[a] Department of Radiology, University of Wisconsin-Madison, Madison, WI, USA
[b] Department of Diagnostic and Interventional Radiology and Neuroradiology, University Hospital Essen, Germany
[c] Clinic of Radiology and Nuclear Medicine, Basel University Hospital, Basel, Switzerland
[d] Department of Biomedical Engineering, University of Wisconsin-Madison, Madison, WI, USA
[e] Department of Medical Physics, University of Wisconsin-Madison, Madison, WI, USA
[f] Pathology Clinic, University of Wisconsin-Madison, Madison, WI, USA
[g] Department of Medicine, University of Wisconsin-Madison, Madison, WI, USA
[h] Department of Emergency Medicine, University of Wisconsin-Madison, Madison, WI, USA
[i] Department of Surgery, University of Wisconsin-Madison, Madison, WI, USA

ARTICLE INFO

Article history:
Received 22 November 2016
Accepted 25 November 2016
Available online xxxx

Keywords:
Small lesions
Detection
Characterization
Ex vivo

ABSTRACT

Purpose: The detection of small parenchymal hepatic lesions identified by preoperative imaging remains a challenge for traditional pathologic methods in large specimens. We developed a magnetic resonance imaging (MRI) compatible localization device for imaging of surgical specimens aimed to improve identification and localization of hepatic lesions ex vivo.

Materials and methods: The device consists of two stationary and one removable MR-visible grids lined with silicone gel, creating an orthogonal 3D matrix for lesion localization. To test the device, five specimens of swine liver with a random number of lesions created by microwave ablation were imaged on a 3 T MR scanner. Two readers independently evaluated lesion coordinates and size, which were then correlated with sectioning guided by MR imaging.

Results: All lesions ($n = 38$) were detected at/very close to the expected localization. Inter-reader agreement of lesion localization was almost perfect (0.92). The lesion size estimated by MRI matched macroscopic lesion size in cut specimen (± 2 mm) in 34 and 35, respectively, out of 38 lesions.

Conclusion: Use of this MR compatible device for ex vivo imaging proved feasible for detection and three-dimensional localization of liver lesions, and has potential to play an important role in the ex vivo examination of surgical specimens in which pathologic correlation is clinically important.

1. Introduction

Accurate identification and anatomic localization of small parenchymal lesions during pathologic sectioning of surgical specimens remains a challenging task. Ex vivo identification of lesions found on in vivo imaging can be particularly demanding due to deformation and altered orientation of the resected specimen. Furthermore, even if there were standardized methods of pathologic evaluation, especially with hepatic resection [1], it is difficult to discriminate lesions from adjacent parenchyma, leading to missed lesions.

In an explanted liver or hemi-specimen pathologists will generally perform 5–6 representative sections of the liver parenchyma including a cut at the resection margin, a cut at the hilum and a representative cut of the gall bladder. If hepatocellular carcinoma (HCC) lesions are known to be present clinically, additional sections of these regions are performed and a special silver staining is performed. In explanted livers that might carry additional lesions, each cut is searched grossly for additional lesions. Other pathologists cut the entire specimen in 5 mm slices and or even smaller intervals when needed. Unfortunately, pathologists do not routinely review the information about additional lesions that are suspected radiologically. In view of the clinical importance of the detection of all lesions [2–5], it is of significant interest to understand whether all radiographically identified "lesions" are indeed malignant.

☆ Grant sponsors: NIH (UL1TR00427, K24 DK102595, RC1 EB010384), as well GE Healthcare who provides research support to the University of Wisconsin. Emily Winslow is supported by the Society of Surgery of the Alimentary Tract Award for Clinical/Outcomes/Education Research. Tilman Schubert is supported by a fellowship grant (Helmut-Hartweg-Fonds) from the Swiss Academy of Medical Sciences.

* Corresponding author at: Department of Radiology, University of Wisconsin-Madison, Madison, WI, USA.
E-mail address: SKinner@uwhealth.org (S. Kinner).

[1] These two authors contributed equally to this work.

http://dx.doi.org/10.1016/j.mri.2016.11.021
0730-725X/

Similarly, it would be of clinical importance to know if all lesions detected pathologically are identified by preoperative imaging [6].

In order to facilitate lesion detection and improve direct comparison of histopathologic specimens with prior in vivo imaging, we developed an MRI compatible localization device, with MR-visible fiducial marks for ex vivo imaging to facilitate radiographic-pathologic correlation. The primary purpose of the present study was to first develop and then to test the feasibility of this device. Our secondary aim was to evaluate the sensitivity and specificity of its use in localizing simulated lesions in animal livers.

2. Materials and methods

2.1. Imaging device description

The device was constructed from Plexiglas and designed to consist of two stationary MR grids (along x, y-axis) and one removable grid (along z-axis) that together create a 3D matrix (Fig. 1). Total size of the device is $27 \times 14 \times 14$ cm^3. Along the bottom and two sides, laser-etched grid lines and labels were filled with silicone gel (Dow-Corning, Midland, Michigan, US) to facilitate MR-visible fiducial landmarks. A small amount of red dye was added to the silicone to improve visibility of the edges and labels by eye. Laser etched numbers (1 — 11) were oriented along the width, upper case letters (A-W) along the length and lower case letters (a–l) along the height. All grid lines were spaced 1 cm apart (Fig. 2). This design facilitated three-dimensional localization and labeling within a 1.0 cm^3 volumes, with the combined lettering/numbering coding, for example "3, D, f" would be the code for a lesion located within that volume identified by the 3D grid.

When examining ex vivo tissue specimen, alginate is used to externally stabilize the tissue (e.g. liver) during imaging and to facilitate sectioning. The alginate used was Accu-Cast 880-B (Accu-Cast, Bend, Orgeon, US). After preparation as described in the manual, the bottom of the box is covered when the Accu-Cast starts to set (1–5 min, depending on the amount of Accu-Cast). Thereafter, the liver specimen is placed in the box and the remainder of the alginate is poured over the specimen casting it from all sides. Afterwards, the top piece (also imprinted with upper case letters and numbers, is placed, and gently imprinted onto the top surface of the alginate, marking a grid pattern. Once the alginate hardens to a soft solid within several minutes, MR examination of the device containing the tissue specimen is performed. Accurate localization of lesions in three dimensions is determined by referencing the lesions in space relative to the three dimensions of the MR-visible grid.

After lesion identification radiographically, the top piece and the vertically oriented grid along the length of the box are removed. Slicing of the specimen within the box is now enabled in a guided fashion through prefabricated grooves spaced 1 cm apart (Figs. 2 and 3) along the y-direction (width of the box). The slice positions correspond to the grid lines of the device. The grooves accommodate any commercially available sectioning knifes.

2.2. Imaged specimen

To test the device, five separate specimens of swine liver were used for radiographic-pathologic correlation. In each specimen, lesions were

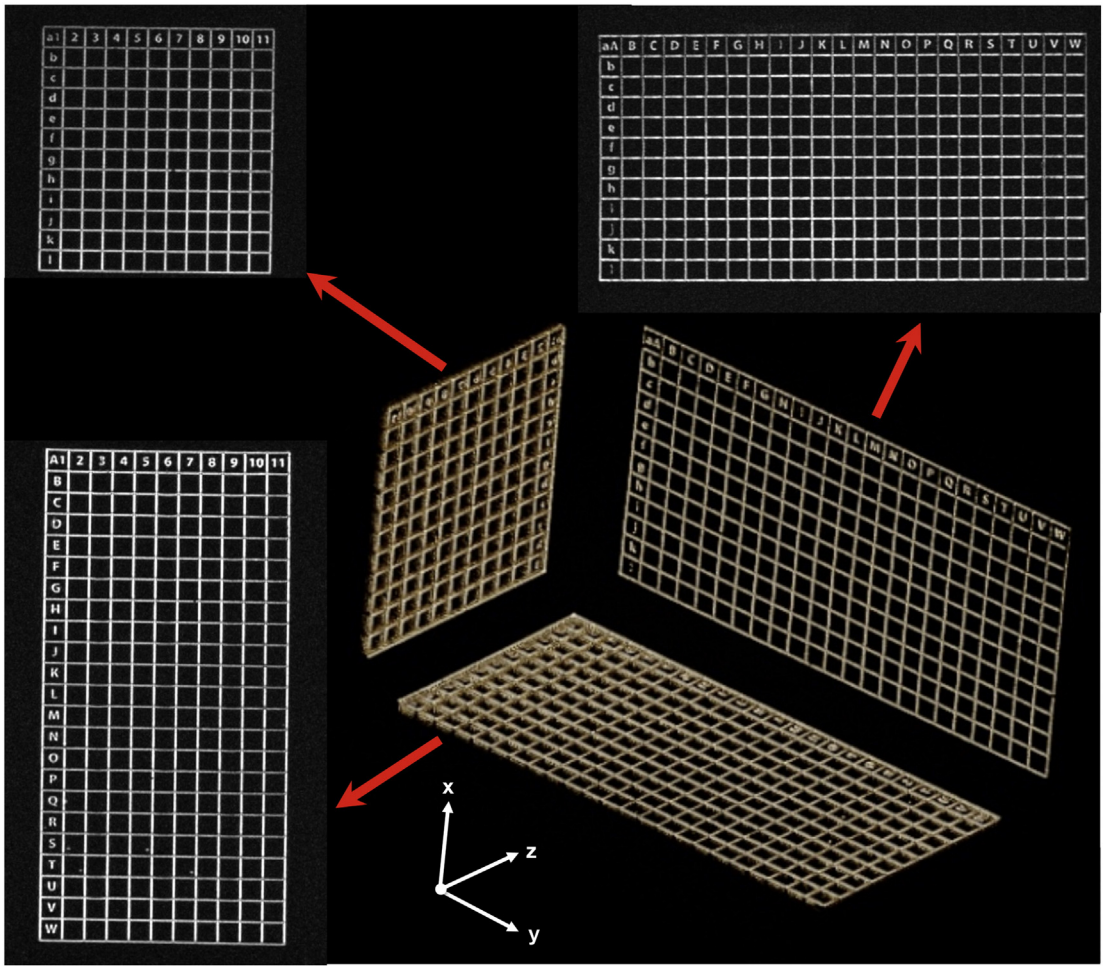

Fig. 1. Box components shown how they appear on MR Imaging. All engraved letters and numbers can clearly be seen on MRI. The schematic three-dimensional coordinate system shows how width, length and heights are labeled.