Evaluation of markers for catheter detection in MRI-guided gynecological brachytherapy

E. KAZA[1], R. CORMACK[1], I. BUZUROVIC[1]

1 Dana-Farber / Brigham and Women's Cancer Center, Harvard Medical School, Boston, MA, USA

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INTRODUCTION

In MRI-guided gynecological brachytherapy, CT imaging is still utilized for needle localization. MRI is only used for target and organs at risk delineation because plastic needles provide no signal on standard MR protocols.

Catheter lumen markers have been developed with the aim to increase catheter signal on MR images [1] but are not clinically implemented yet.

AIM

The goal of our study was to optimize 3D MR sequences for lumen marker detection on a poultry phantom, and to evaluate marker visibility for each applied sequence. In addition, we visually assessed brachytherapy template detection on the acquired images.

METHOD

A brachytherapy template with obturator and ProGuide Sharp Needles 6Fx294mm was introduced in the cavity of a cleaned turkey, partially filled with its neck and giblets. One Orion™ HDR MRI Lumen Marker was inserted in an interstitial needle and another in the obturator's top needle.

The phantom was imaged in a 3T SIEMENS Vida simulator using a Body 18 long and a spine matrix array coil. A 3D T1-weighted **MPRAGE** and a 3D T2-weighted **SPACE** sequence were acquired in sagittal orientation with parameters matching as well as possible marker manufacturer recommendations for marker visualization (table 1). Additionally, a 3D **PETRA** sequence which has demonstrated the ability to detect empty needles [2] and a 3D **Dixon** sequence were acquired in coronal orientation (table 1) .

Marker visibility was evaluated by assessing mean signal intensity of marker-filled catheters relative to mean signal intensity of ROIs in the turkey tissue and air cavity. Catheter-tissue and catheter-air intensity ratios (**IR_{ct}**, **IR_{ca}**, respectively) were calculated.

RESULTS

Figure 1 presents coronal views of the poultry phantom for the four acquired sequences at the same slice position, which contains the two interstitial needles filled with lumen markers. **Table 1** lists the computed intensity ratios of the catheter relative to tissue and air.

a) On **MPRAGE** images, markers were well visualized with elevated signal in air (IR_{ca} = 10.3 ± 1.5), but presented less overall signal than tissue (IR_{ct} = 0.6 ± 0.5). The brachytherapy template was slightly visible, with lower signal intensity than tissue.

b) On **SPACE** images, markers could be barely discerned by eye from the background (IR_{ca} = 8.4 ± 2.1), and were hypointense compared to tissue (R_{ct} = 0.4 ± 1.0). The template was not visualized as its signal was comparable to the background's.

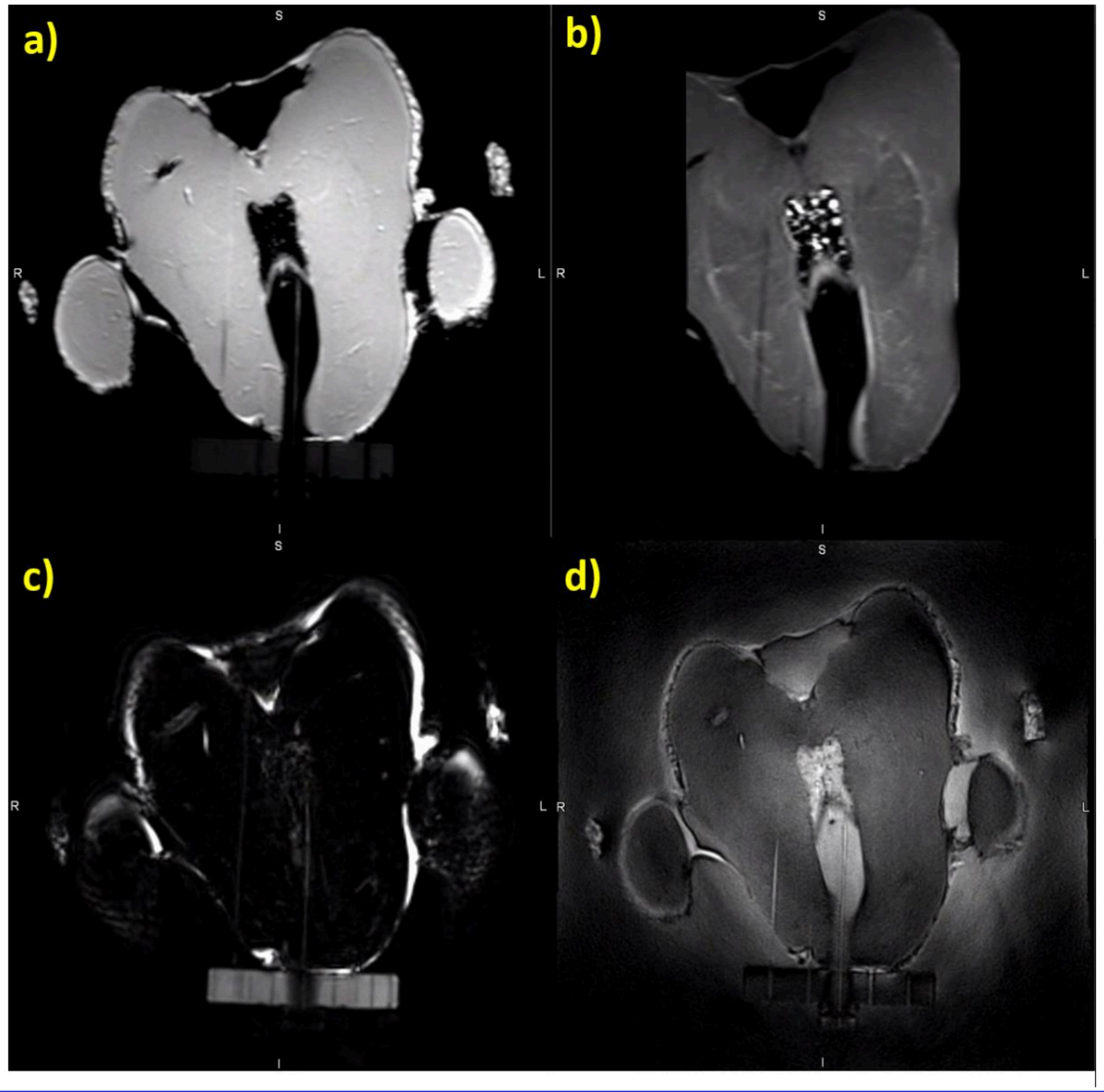
c) Among the image types produced by the **Dixon** sequence, **fat-only** images proved best for marker detection. Such images are displayed here and were used for catheter intensity ratios calculations. They provided good marker distinction from both air and tissue (IR_{ca} = 2.0 ± 1.0, IR_{ct} = 6.0 ± 0.9). Moreover, these images provided very good visualization of the applied template with high signal.

d) On **PETRA**, catheters with markers were identifiable in air only thanks to the dark border caused by the catheter material, as marker signal intensity was similar to air signal intensity (IR_{ca} = 0.9 ± 0.4). Nevertheless, markers were clearly detected in tissue, being hyperintense to it (IR_{ct} = 2.0 ± 0.5) similarly to empty needles. The brachytherapy template was discernible with lower signal intensity than tissue.

Table 1. Parameters of MR sequences used in this work, and intensity ratios of catheter-to-air (**IRca**) and catheter-to-tissue (**IRct**) signal (mean ± standard deviation).

	TR (ms)	TE (ms)	FOV (mm^2)	Voxel size (mm^3)	Bandwidth (Hz/px)	IR_{ca}	IR_{ct}
a) MPRAGE	1680	2.06	271 x 300	0.6 x 0.6 x 1.0	399	10.3 ± 1.5	0.6 ± 0.5
b) SPACE	1500	113	250 x 250	1.0 x 1.0 x 1.0	673	8.4 ± 2.1	0.4 ± 1.0
c) Dixon fat	3.9	1.24	280 x 360	1.3 x 1.3 x 3.0	1085	2.0 ± 1.0	6.0 ± 0.9
d) PETRA	3.32	0.07	300 x 300	0.9 x 0.9 x 0.9	400	0.9 ± 0.4	2.0 ± 0.5

Figure 1. a) T1-weighted 3D **MPRAGE**, **b)** T2-weigthed 3D **SPACE**, **c)** fat-only 3D **DIXON**, **d)** 3D **PETRA** coronal views of a turkey phantom at the same slice position, comprising one catheter with marker inside the tissue and one on the obturator top.



CONCLUSIONS

This study evaluated the visibility of new lumen markers for MRI-guided gynecological brachytherapy in a poultry phantom, using manufacturer recommended and user optimized protocols.

3D **Dixon fat-only** and **PETRA** sequences yielded improved marker contrast with higher signal intensity compared to tissue than standard protocols, while also providing marker detection in air. Moreover, the brachytherapy template was best visualized on the Dixon fat-only images.

Combination of such markers and imaging protocols would be useful for **MR-only treatment planning**.

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CONTACT INFORMATION

ekaza1@bwh.harvard.edu