Evaluation of an MRI-Positive HDR Lumen Marker for HDR Brachytherapy Treatment Planning

Duke Radiation Oncology
Duke University School of Medicine

N. ECLOV[1], O. CRACIUNESCU[1], J. CHINO[1], Z. CHANG[1],
1 Duke University Medical Center, Durham, NC

AAPM 2019 JUL 14–18
BUILDING BRIDGES. CULTIVATING SAFETY. GROWING VALUE.
61ST ANNUAL MEETING & EXHIBITION | SAN ANTONIO, TX

INTRODUCTION

MRI is the preferred imaging modality for sites typically treated with HDR brachytherapy, particularly gynecological cancers. However, because they appears as negative contrast, HDR applicator source channels cannot be localized accurately on MRI.[1] Therefore, treatment planning often requires MRI for target and volume delineation as well as an additional CT study for applicator localization, increasing the burden on both clinical resources and the patient. The desire for treatment planning based solely on MRI has led to the development of a novel HDR lumen marker for applicator localization. This marker uses a cobalt dichloride-N-acetyl cysteine (C4) contrast agent studied previously in the context of prostate seeds.[2] An initial study has examined the markers in a 1.5T MRI setting.[3] We sought to determine the utility and longevity of the C4 MRI-positive HDR lumen marker for performing localization of the HDR applicator during treatment planning.

METHOD

- Two Orion™ Positive-Signal HDR MRI Lumen Markers (C4 Imaging) inserted into a Varian plastic MR-compatible HDR ring applicator.
- Applicator was placed in a uniform water phantom
- MR studies were acquired using the following sequences (*used in gynaecological HDR treatment planning):
  - T1-weighted 3D Spoiled Gradient Echo*
  - T2-weighted 3D SPACE*
  - T2-weighted 2D Turbo Spin Echo
  - CISS 2D
- CT images were acquired for comparison.
- Markers were received one week after production.
- Scans were performed 3 times a week throughout the one-month FDA approved lifespan of the marker.
- Contrast to noise ratio (CNR) compared to background water signal was evaluated for each MRI study.

RESULTS

- Images of the MRI-positive lumen markers inside a plastic ring HDR applicator were acquired using the phantom set-up shown in **Figure 1**.
- Without a contrast agent, the HDR applicator appears as a black hole (negative contrast) on MRI images (**Figure 2**).
- Sagittal 3D T1- and T2-weighted images of the applicator with markers inserted demonstrate strong signal from the marker on T1 and no apparent signal on T2 (**Figures 3-4**).
  - On T1-weighted images, the mean CNR during that time was 5.83 (range 1.88-9.29).
  - T2-weighted images showed no apparent signal at the marker location
  - CISS sequence images showed a low signal compared to the water phantom background.
- T1-weighted images can be used for localization of the HDR applicator (**Figure 5**) while contouring of organs and treatment volumes can be performed on the registered T2-weighted images acquired as part of the same study.
- **Figure 6** shows the contrast marker localization performed on MRI corresponds to the applicator channel as displayed on a registered CT scan.
- **Figure 7** shows that contrast to noise ratio (CNR) of the marker was variable but did not noticeably decline during the FDA-approved one-month lifespan of the marker.

Figure 1: Water phantom set-up with plastic ring HDR applicator and MRI-positive markers inserted.

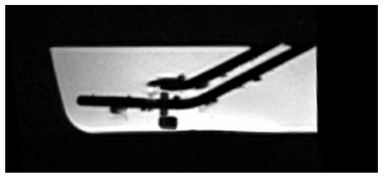


Figure 2: Negative contrast of HDR plastic applicator on T1-weighted MRI scan.

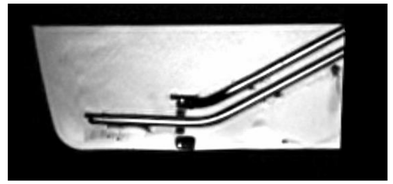


Figure 3: T1-weighted image of water phantom demonstrating contrast of the MRI-positive marker.

Figure 4: T2-weighted image of water phantom showing no apparent signal from the marker.

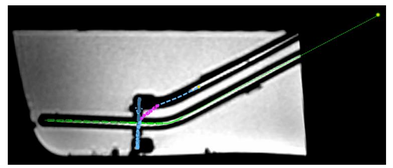


Figure 5: Localization of the HDR applicator channel using the MRI-positive contrast marker on a T1-weighted image.

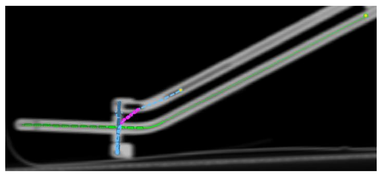
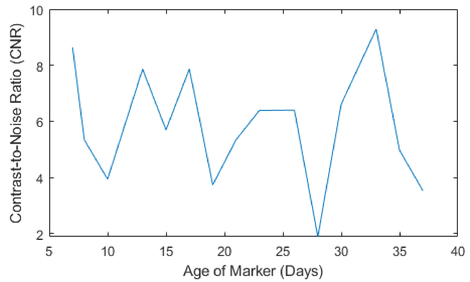


Figure 6: Localization of the HDR applicator channel from MRI in Figure 5 displayed on corresponding registered CT scan of the applicator in the water phantom.

Figure 7: The CNR of the MRI-positive contrast marker did not noticeably degrade over a 30-day period following the marker's production date. The marker's FDA approval expired at 30 days post-production.



CONCLUSIONS

This work demonstrates that an MRI-positive HDR lumen marker can be used for HDR applicator localization during brachytherapy treatment planning, allowing all planning to be conducted on MRI images and eliminating the need for a CT scan of the patient. This finding could result in streamlined delivery of HDR brachytherapy for patients, with reduced cost and burden on clinical resources.

FUTURE DIRECTIONS

Further investigation of CNR using a more tissue-like phantom than the water phantom used in this study may provide further insight into the clinical performance of the lumen marker on 3T MRI, particularly for 2T-weighted images used in organ and treatment volume contouring for gynecological brachytherapy treatment planning.

ACKNOWLEDGEMENTS

Thank goes to Andrew Bright and Bill Anderson. for supplying test materials and advice for this study. Also thanks to Wandra Davis for assistance in image acquisition for this work.

REFERENCES

1 **van Heerden LE et al**. Image Distortions on a Plastic Interstitial Computed Tomography / Magnetic Resonance Brachytherapy Applicator at 3 Tesla Magnetic Resonance Imaging and Their Dosimetric Impact. *International Journal of Radiation Oncology* Biology* Physics. 2017 Nov 1;99(3):710-8.*

2 **Lim TY et al**. Lim TY, Stafford RJ, Kudchadker RJ, Sankaranarayanapillai M, Ibbott G, Rao A, Martirosyan KS, Frank SJ. MRI characterization of cobalt dichloride-N-acetyl cysteine (C4) contrast agent marker for prostate brachytherapy.. *Physics in Medicine & Biology. 2014 Apr 28;59(10):2505.*

3 **Wang L et al**. A Novel Positive Contrast Magnetic Resonance Imaging Planning Marker for High Dose Rate Image Guided Brachytherapy. *Brachytherapy. 2018 Jul 1;17(4):S23-4*

CONTACT INFORMATION

Neville Eclov (Neville.Eclov@duke.edu)