

## Multimodality phantom targeting fluoroscopically occult lesions in the fluoro suite using 3D MRI/CT overlay guidance

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**TARGET AUDIENCE:** Medical physicists, radiologists, interventional radiologists, researchers working on image fusion

**INTRODUCTION:** MRI and CT provide high quality diagnostic images. Some medical conditions need biopsy confirmation or minimally invasive image-guided interventions. MRI and CT are attractive for image guided interventions, but both have drawbacks. MRI enables high soft tissue contrast and multi-parametric imaging techniques that provide excellent visualization of anatomical structures and pathology plus functional imaging with no ionizing radiation. Unfortunately, restricted MRI physician access and limited MRI-compatible clinical equipment are problematic. CT guided procedures allow high spatial and temporal resolution without equipment restrictions and have better physician access, but radiation exposure to operator and patient can be significant.

Fluoroscopy is an excellent modality for image-guided procedures. Fusion/overlay of MRI and fluoroscopy suite cone-beam CT (CBCT) potentially combine the diagnostic quality of 3D MRI/CT imaging with the ease of fluoroscopy. This approach could thus improve accuracy and speed of image guided procedures while avoiding MRI logistical problems or CT radiation exposure.

**PURPOSE** Develop a multimodality phantom to test the feasibility of projecting MRI-CBCT fused data onto real-time fluoroscopic images in order to enhance the biopsy of fluoroscopically occult lesions.

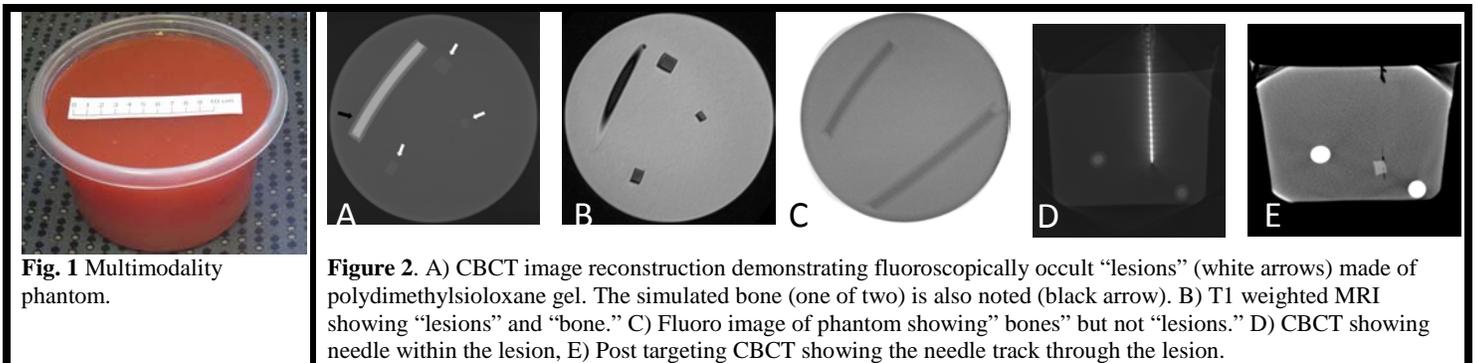
**METHODS:** Our phantom comprises an agarose base and silicone gel simulated lesions that are fluoroscopically occult but MRI and CBCT [DynaCT, Siemens AG Healthcare sector, Forchheim, Germany] visible. It contains simulated bones visible under all modalities. The agarose base is a water solution of 1% agarose, 0.5g/L CuSO<sub>4</sub>, 2% Omnipaque Injection (iohexol) [GE HealthCare, Mississauga, Ontario] and 0.125% red food coloring. The simulated lesions were made of Sylgard® 527 Primerless Silicone Dielectric Gel [Dow Corning, Midland, MI] and 0.05% Na<sub>6</sub>Al<sub>6</sub>Si<sub>6</sub>O<sub>24</sub>S<sub>4</sub> blue oxide pigment [The Earth Pigments Company, Cortaro, AZ] by weight. Two sizes of simulated lesions were made measuring 5mm and 10mm average diameter. Bone models were 10 cm lengths of polyvinyl tubing (6 mm OD, 2 mm wall) containing iohexol in water solution.

CBCT and MRI images of the phantom were co-registered using the simulated bones as fiducial landmarks. The 3D/3D registration of MRI to CBCT coupled with the 3D/2D calibration based registration between the CBCT images and the projection images allow the lesions segmented on the MRI datasets to be overlaid onto live fluoroscopy.

**RESULTS:** Using path planning software for needle navigation [iGuide, Siemens AG Healthcare sector, Forchheim, Germany], we targeted the “lesions” segmented on the fused MR images and performed biopsy of the “lesions.” CBCT images were obtained with the biopsy needle in the “lesion” and after each biopsy. 10 “lesions” were successfully biopsied.

Fig. 1 shows the visually opaque multimodality phantom. Figs. 2A and 2B are, respectively, a CBCT and an MRI reconstruction showing simulated bones and lesions. Fig. 2C is a fluoro image in which the simulated bones, but not the simulated lesions, are visible. Thus biopsy of simulated lesions had to be done under guidance by the iGuide image fusion system. Fig. 1D is a CBCT image of the biopsy needle passing through a lesion, and Fig. 1E is post-targeting CBCT image showing the needle track through the lesion.

**CONCLUSIONS:** By constructing a multimodality phantom with simulated lesions of constant size located throughout the phantom, we were able to test the hypothesis that 3D MRI and CBCT image data can be projected onto 2D fluoroscopic images to guide biopsy and minimally invasive therapies. Using the MRI overlay technique, 5 mm and 10 mm fluoroscopically occult lesions were successfully biopsied using real time fluoroscopic guidance. In each case the biopsy specimens contained portions of the colored silicone lesions and the post-biopsy images demonstrated a needle track through the lesion.



**Fig. 1** Multimodality phantom.

**Figure 2.** A) CBCT image reconstruction demonstrating fluoroscopically occult “lesions” (white arrows) made of polydimethylsiloxane gel. The simulated bone (one of two) is also noted (black arrow). B) T1 weighted MRI showing “lesions” and “bone.” C) Fluoro image of phantom showing “bones” but not “lesions.” D) CBCT showing needle within the lesion, E) Post targeting CBCT showing the needle track through the lesion.

**Reference.** Goldstein DC *et al.*, Invest Radiol. 1987;22(2):153-7. Supported by a grant from Siemens AG Healthcare.