Faster Needle Insertion using a 1.5 T Interventional Scanner and Tri Orthogonal Plane Guidance

J. J. Derakhshan[1], S. Paul[2], J. O. Heidenreich[2], J. L. Sunshine[2], M. A. Griswold[2], J. L. Duerk[1,2], and S. G. Nour[1,2]

[1]Biomedical Engineering, Case Western Reserve University, Cleveland, OH, United States, [2]Radiology, University Hospitals of Cleveland, Cleveland, OH, United States

Introduction: MRI has been used to guide needle manipulations in animal models and human patients. Many studies have been performed on low field (0.2 - 0.5 T) open scanners, where needle guidance can take tens of minutes to perform and image quality can be poor. Typically, single-plane scanning during device navigation is followed by position confirmation in an orthogonal plane[1]. Although orthogonal plane acquisitions are used as anatomical localizers, they have not been exploited for interventional guidance. We hypothesize that by using a new high field (1.5 T) short and wide bore interventional scanner in combination with tri orthogonal plane (two parallel to the needle and one perpendicular at the targeted depth) guidance, safe, time-efficient needle insertion with high image quality can be achieved.

Methods: TSE, HASTE, FLASH and TrueFISP sequences were implemented with three slice groups, one in each orthogonal plane relative to the needle axis, on a short and wide bore 1.5 T interventional MR scanner (Siemens Espree, Erlangen, Germany). The repetition time (TR), flip angle, resolution, number of averages and slice thickness were varied and the sequences were run on a healthy anesthetized pig. The resulting images were judged based on acquisition speed, resolution, device contrast and lack of saturation due to orthogonal slice excitation. The best sequence was used to guide a 3 cm exposed tip, 17 gauge titanium RF electrode (Radionics Inc., Burlington, MA) to one of the two adrenal glands in six asymptomatic, anesthetized pigs prior to ablation. Following RF ablation, high resolution TSE, STIR and T1W SE sequences were acquired to delineate the ablation zone. In one of the pigs, tri plane guidance was used to introduce an 18 gauge MR compatible biopsy needle (MRI Histology Needle, E-Z-EM, Inc., Westbury, NY) into 2 renal cysts in the contralateral kidney. In all procedures, the interventionalist was presented with sequentially updated orthogonal guidance slices with alternating planes on the in room monitor. Needle insertion time (from skin puncture until placement of RF electrode/biopsy needle was deemed satisfactory), procedure time (from time of first imaging to time RF ablation probe was removed after ablation) and any adverse events were recorded.

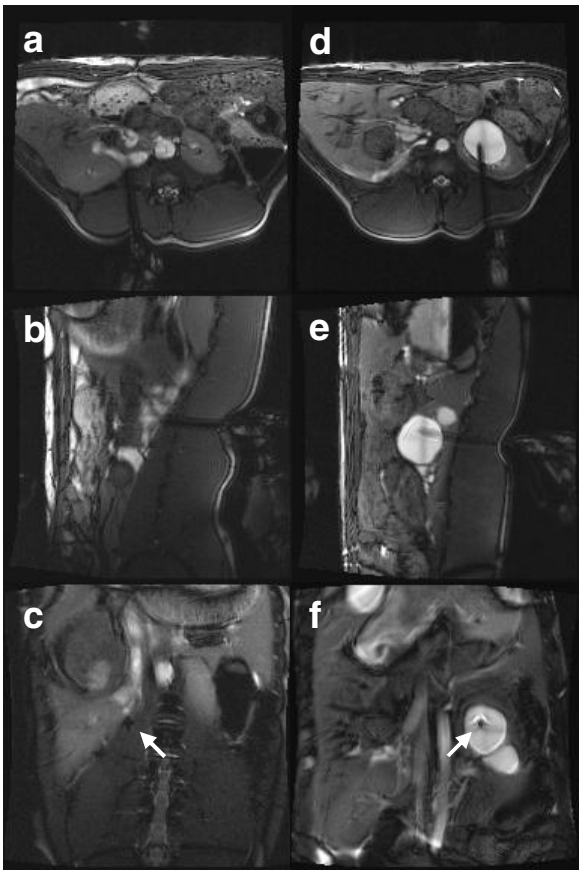

Fig. 1. Axial, sagital and coronal consecutive frames acquired during the guidance phase of adrenal gland RF ablation **(a-c)** and renal cyst alcohol ablation **(d-f)**. Arrows indicate the tip of the needles which have reached the targeted depth.

Results: TSE was too slow (8 sec/slice) and HASTE produced too much blurring (interventionalist could not confidently identify targets) to be useful for guidance. FLASH and TrueFISP both suffered from orthogonal excitation plane saturation. By averaging 3 consecutive acquisitions before switching to next scan plane the orthogonal plane saturation was eliminated. FLASH (10.9 sec/3 slices) was slower than TrueFISP (6.9 sec/3 slices, both with 3 averages) and was abandoned. TrueFISP produced good tissue and needle contrast (CNR = 13). The final acquisition parameters were TrueFISP contrast, 60˚ flip angle, 3 averages, 192 matrix, 5 mm slice thickness and 4.0 msec TR. Figure 1 shows guidance imaging results. The guidance image quality is obviously better than previous low field guidance images. The ablation zones covered the targeted adrenal gland region in all cases. The cysts were successfully drained and filled with alcohol solution. Mean needle insertion time was 3.87 ± 1.13 min, mean procedure time was 60 ± 19 min, and there were no complications. Previous needle insertion times associated with RF ablation procedures in humans on a 0.2 T open scanner at our institution were 21 minutes[2]. Therefore, an 81% improvement in needle insertion time was achieved (in porcine).

Conclusion: The guidance image acquisition time of 2.3 seconds per frame was judged favorably in terms imaging speed balanced with the physician's ability to process the information on the image before being shown the next orthogonal slice. By using a 1.5 T interventional scanner as well as updating device position and orientation in three orthogonal planes, it is possible to safely perform needle based interventions with high guidance image quality using only the standard software. There is a significant reduction in needle insertion time.

References:

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[2] Lewin JS et al. Radiology 2004; 232:835-845.