Preliminary evaluation of accuracy and clinical feasibility of the MR-compatible image overlay system for musculoskeletal interventions

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PURPOSE

- To evaluate the needle insertion accuracy in phantoms and cadavers.
- To test feasibility and to assess the work-flow of the MR overlay system.

METHODS

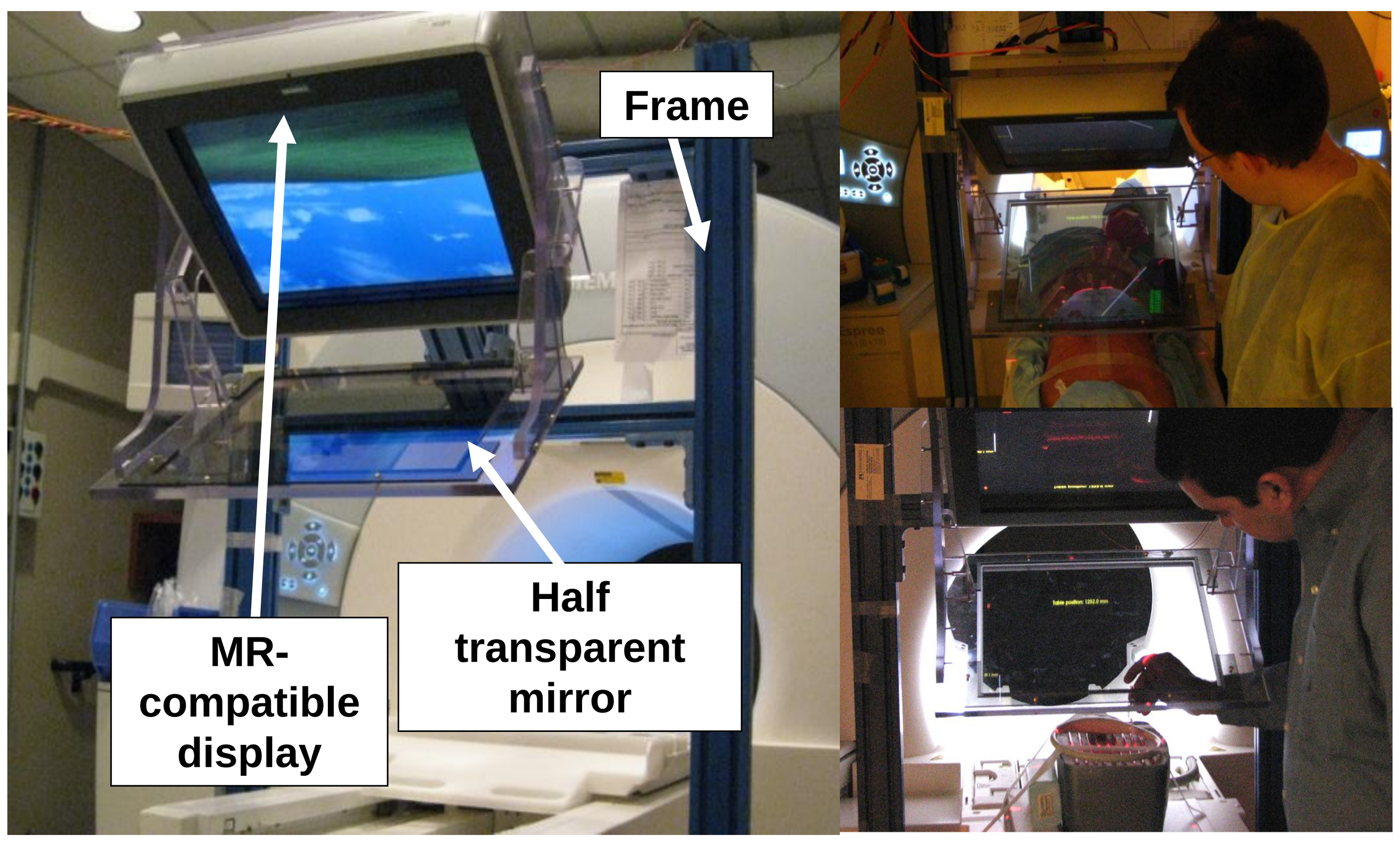


Figure 1: (Left)Experiment setup; (top right) Cadaver, (bottom right) Cervical spine phantom

- We acquired MR images from a 1.5T MRI scanner (Magnetom Espree, Siemens Medical Systems) with the 1x1x1 voxel size. Calibration and planning steps were performed on a stand alone laptop with 3D Slicer based software called Perk Station Module [1], as shown in Figure 3.
- Cervical spine phantoms and a torso cadaver were used in our study as shown in Figure 2.

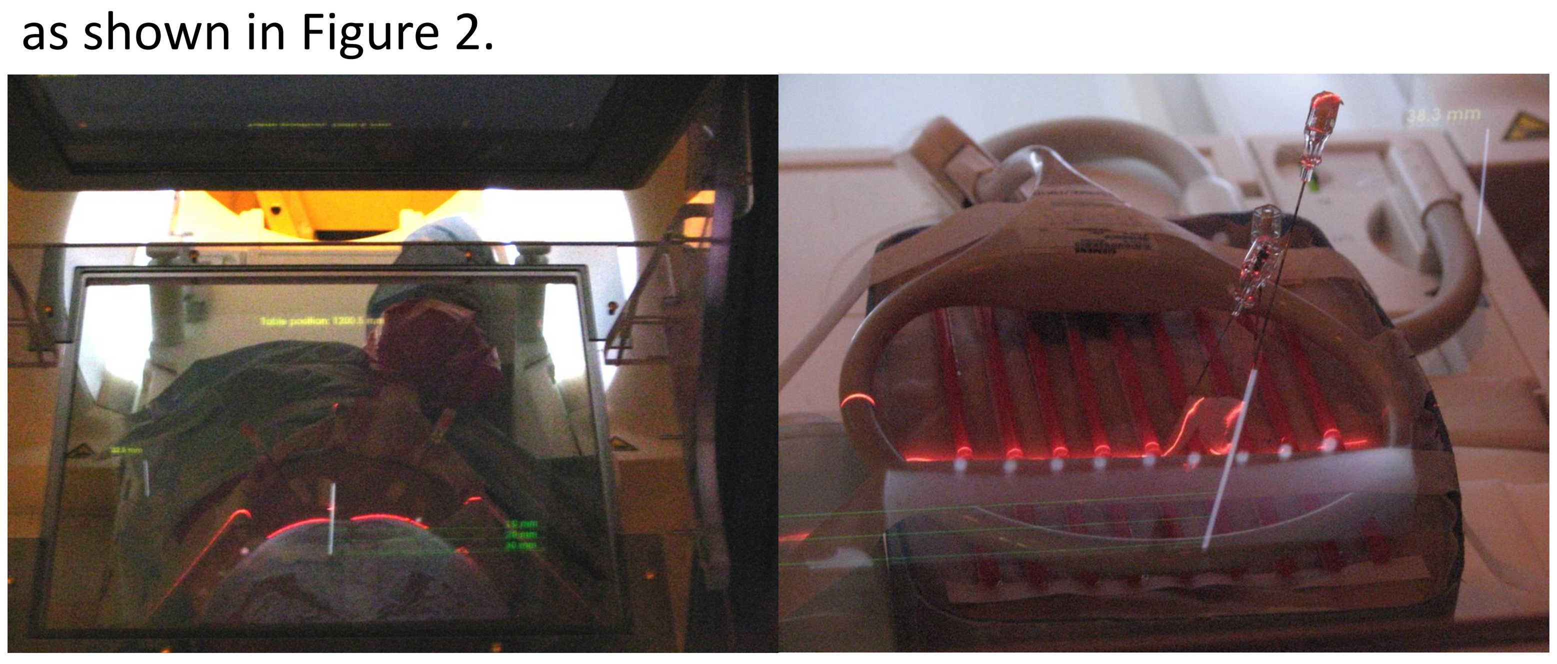


Figure 2: Subjects with needles inserted; (left) Cadaver, (right) Cervical spine phantom

- A series of experiments were performed on the subjects with 5 targets for the cadaver and 9 targets for phantoms, employing one insertion per target.
- We used various needles to find out which needle shows less artifacts on the image. There are 20G and 22G from Somatex (Somatex, Teltow,Germany), 22G from E-Z-EM (E-Z-EM Inc., Westbury, NY, USA), 20G and 22G from Cook (Cook Incorporated, Bloomimgton, IN, USA), and 20G Invivo (Division of Philips Medical Systems, Schwerin, Germany). We also used the 22G of carbon fiber needle as a reference.

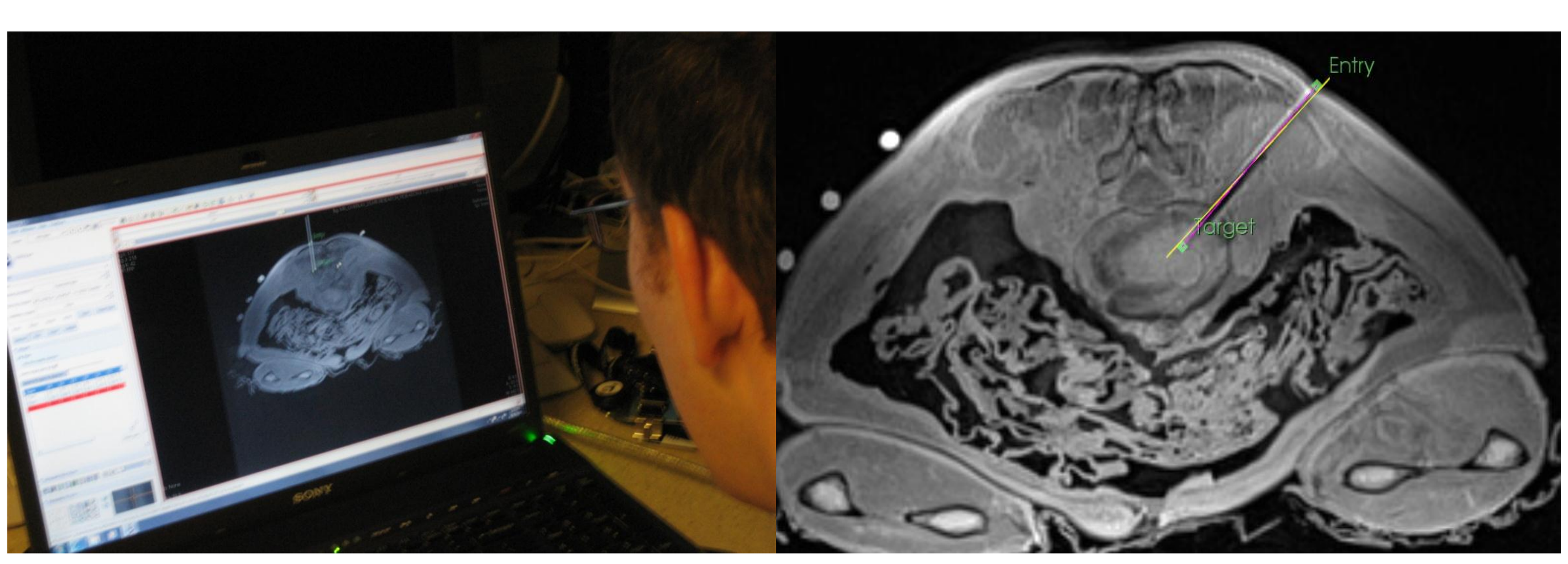


Figure 3: (Left) Surgeon located the needle entry and target point on a stand alone laptop; (right) validating the result by using Perk Station Module based on 3D Slicer

- We reacquired MR images and validated on our software as shown in Figure 3.
- The software recorded the elapsed time for each step.

Figure 4: (Left) Successfully needle insertions on a cadaver, (right) successfully needle insertions on two cervical spine phantoms

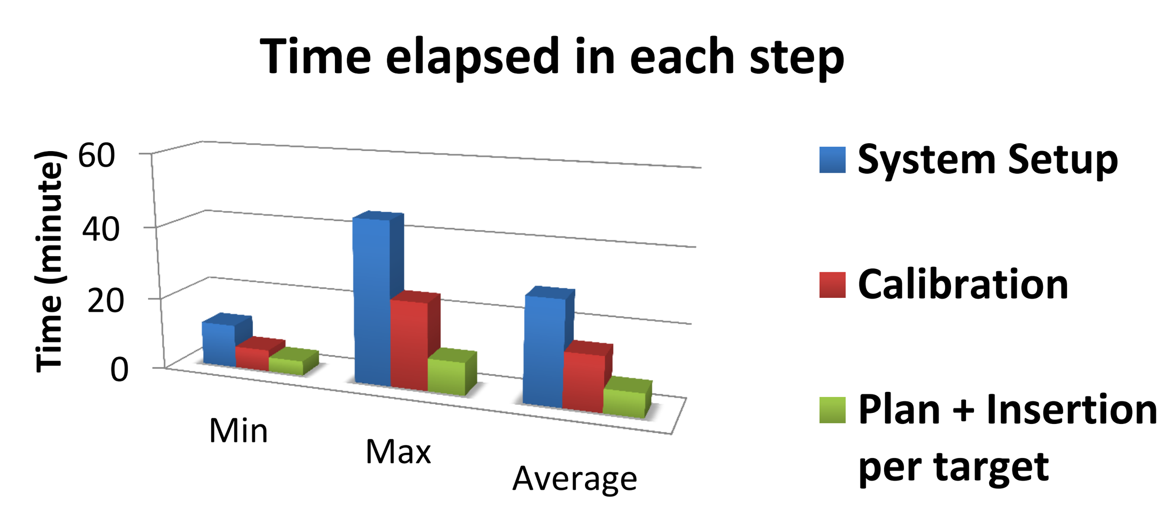
RESULTS

- The results from insertions show the average error about 1.9 mm for phantoms and 3.5 mm for the cadaver, as shown in Table 1.
- All the insertions yield successful results as shown in Figure 4.
- The elapsed time in each step was measured from 11 experiments and summarized in chart 1.
- The measurements of needle artifacts are shown in Table 2.

Cervical spine phantom		*Cadaver*	
Insertion #	*Error (mm)*	*Insertion #*	*Error (mm)*
1	2.2	1	3.1
2	2.1	2	4.0
3	2.1	3	2.7
4	1.4	4	3.5
5	0.9	5	4.3
6	3.7		
7	2.8		
8	0.8		
9	0.8		

Average Error (mm)	
Cervical phantom	*Cadaver*
1.9	3.5

Table 1: Target error from insertions



	Min	*Max*	*Average*
System Setup	12	45	28.5
Calibration	6	24	15
Plan + Insertion per target	4	9	6.5

Chart 1: Summary of the time consuming in each step calculated from 11 experiments.

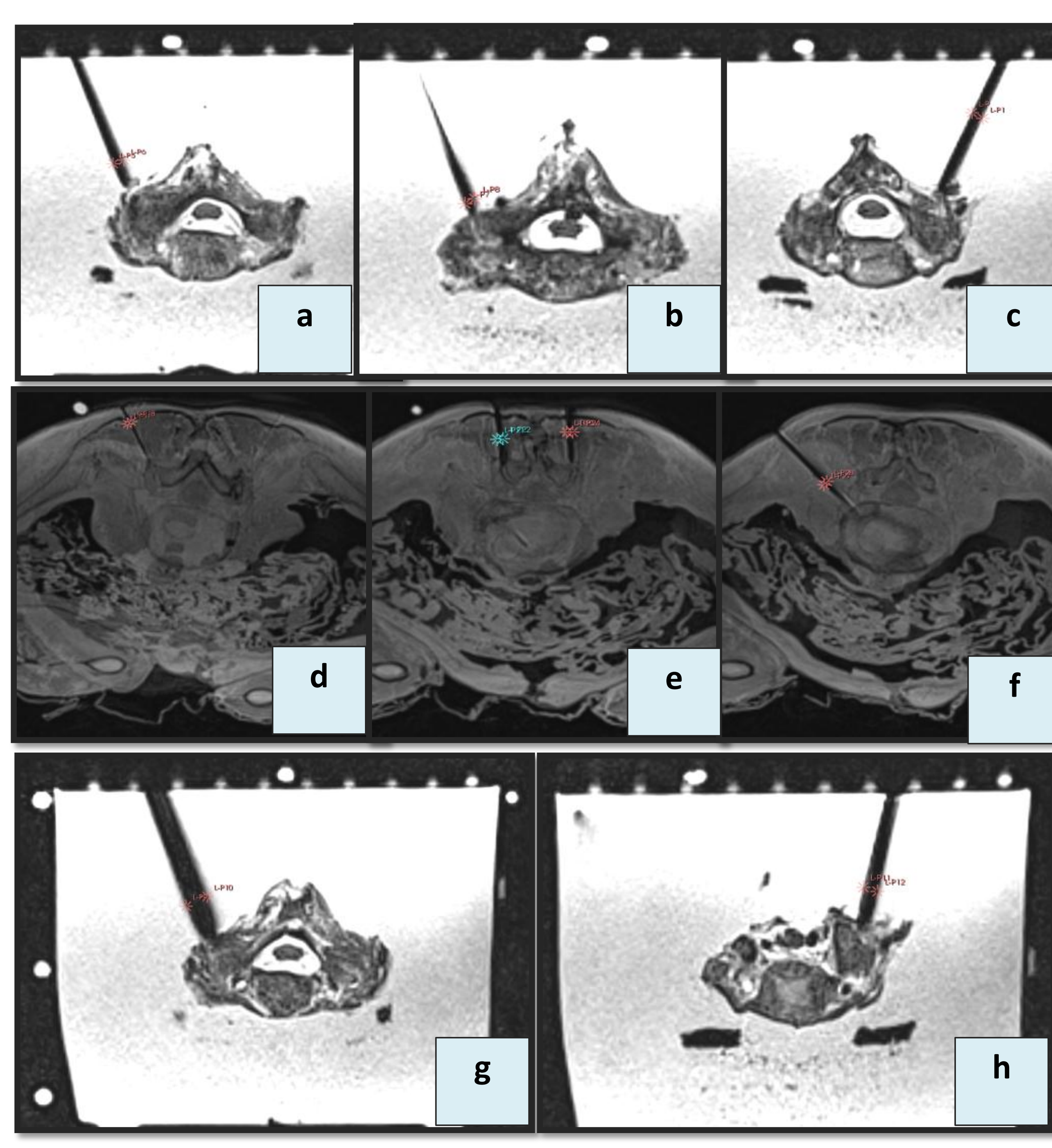


Figure 5: Needle artifacts in the subjects for 20G-22G followed by Table 2 from a) to h)

Needle size-22G		
Needle	*Artifact (mm)*	*Subject*
Carbon fiber	2.1	d) Cadaver
COOK	4.5	a) Phantom
	2.1	e) Cadaver (blue)
E-Z-EM	3.9	b) Phantom
	2.7	e) Cadaver (pink)
SOMATEX	4.8	c) Phantom
	2.7	f) Cadaver

Needle size-20G		
Needle	*Artifact (mm)*	*Subject*
Invivo	9.3	g) Phantom
SOMATEX	5.5	h) Phantom

Table 2: Measurement of needle artifacts

CONCLUSIONS

- The results from phantoms and cadavers are clinically acceptable.
- Calibration and system setup are the most time consuming steps in the procedure.
- Cook's needle shows the least artifact. E-Z-EM and Somatex show similar artifact results as shown in Table 2.

FUTURE WORK

- To continue and improve our results, we will continue cadaver experiment and collect additional data .

REFERENCE

[1] Vikal, S., P. U-Thainual, J. Carrino, I. Iordachita, G. Fischer, and G. Fichtinger, "Perk Station-Percutaneous surgery training and performance measurement platform", Computerized Medical Imaging and Graphics, vol. 34, pp. 19-32, Dec, 2009.