Evaluation of accuracy and clinical feasibility of the MR-compatible image overlay

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Objective

The goal of this project is to test if closed, high-field MRI scanners are available for guiding needle placement with 2D Image Overlay technique. The concept for image overlay guidance technique is successfully proven in our previous work [1]. In this pilot study, we evaluated the accuracy and clinical feasibility of our new system of MRI overlay in a clinical setup on human subjects.

Materials and Methods

To accomplish our study, we acquired images from a 1.5T MRI (Magnetom Espree, Siemens Medical Systems, and Erlangen, Germany) scanner. A series of experiments was performed on the cervical spine phantom with 4 targets, employing one insertion per target. To overcome the damaging interaction of the scanner magnetic field on the monitor, we used an off-the-shelf 19" LCD display, retrofitted to be MRI safe and RF shielded. In our early experiments, standard LCD monitors failed to function if placed closer than 140 cm to the magnet bore. Because of this limitation, and the fixed length of the scanner table, we had just around 10 cm common range on the table and the image overlay laser plane, meaning that we could use just limited length of the phantom/cadaver for experiments. In some clinical situations, this prevents the execution of the needle placement. In order to eliminate this problem, we designed and built the second image overlay prototype using a full 18" MRI compatible monitor from Siemens Research Inc. (Figure 1). We haven't found MRI compatible monitors on the market, but they can be modified by some companies. With a very high quality RF shield this device is heavier than the later one. Comparatively with the benefits of this device, the extra weight was a minor problem, easy to manage with the existing fiber glass frame.

Software prototype, as an open-source module for the Slicer framework, has been developed to execute the high level workflow [2]. Insertions were successfully carried out as shown in Figure 2, as confirmed by post-insertion MR and DynaCT scans.

In our evaluation experiments with the new system, we used phantom with fixed cadaver parts embedded in soft gel.

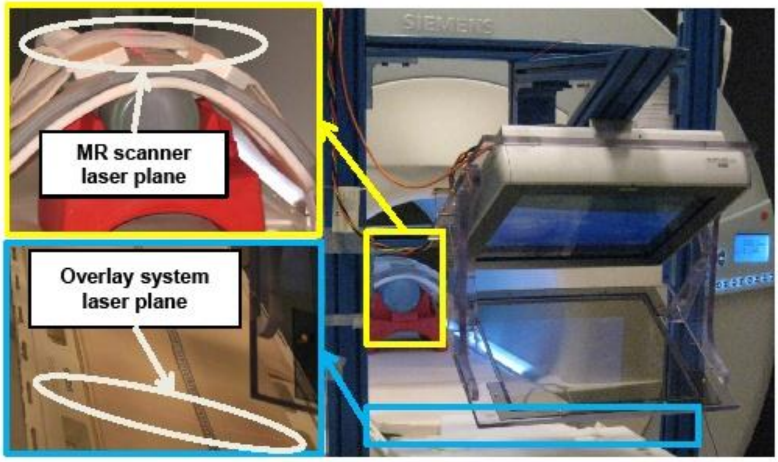

Figure 1. Current Image Overlay System with the new monitor: Experimental setup for MRI compatibility in 1.5T scanner.

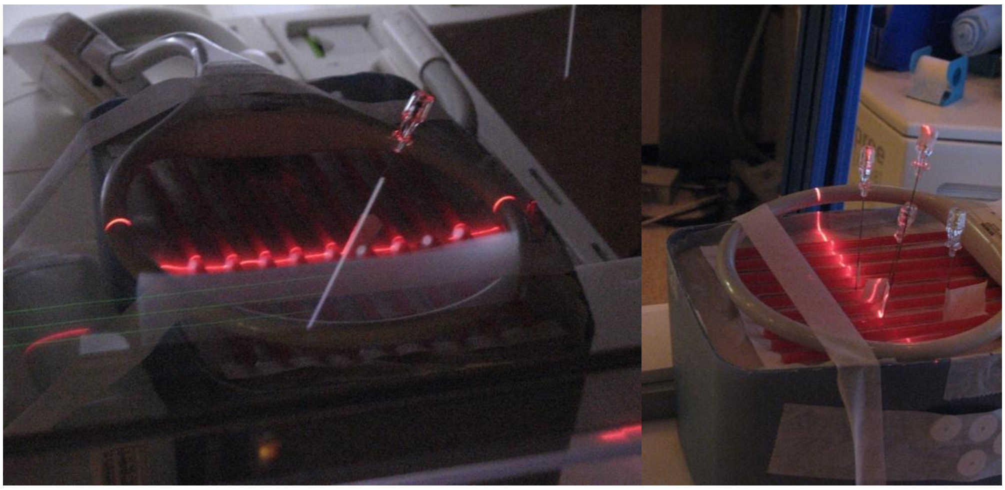

Figure 2. Needle insertion with image and needle guidance overlaid on the cervical spine phantom (left), needles were sucessfully inserted onto the cadaver phantom (right)

Results

All four needle insertions were carried out successfully. Target errors ranged from 1.4 to 2.2 mm, as shown in Table 1.

Table 1 Needle insertions results

Insertions	*Error (mm)*
Insertion #1	2.2
Insertion #2	2.1
Insertion #3	2.1
Insertion #4	1.4

The results shown above are performed by two physicians. (Followed by insertion 1-2 and insertion 3-4)

Conclusion

During the experiments for the procedural workflow we found these phantoms very useful in determining the anatomical position, which is a very important feedback. The experiment was successfully carried out and the results are clinically acceptable as shown in Table 1.

References

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