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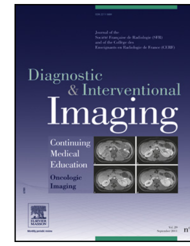

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Phantom evaluation of a navigation system for out-of-plane CT-guided puncture

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KEYWORDS
Computed tomography;
Phantom study;
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Abstract
Objective: The purpose of this phantom study was to assess a new real time electromagnetically-guided navigation system and compare it to standard computed tomography (CT) guidance.
Material and methods: A prospective, randomized, comparative study was carried out over a two-day period. Operators without prior experience on the new navigation system sequentially attempted to puncture two 6 mm-diameter targets (one attempt for each target) with out-of-plane trajectories using both the standard CT-guided method and the new navigation station (NAV method).
Results: Intention-to-treat analysis was performed for 54 operators. Twenty-two operators out of 54 (40.7%) reached the target on first attempt with the NAV method versus none (0%) using CT-guidance ($P < 0.001$). The median distance of the puncture from the center of the target was 3.7 mm [Q1—Q3 = 2—6.7] using NAV versus 15 mm [10—20] using CT-guidance ($P < 0.001$). Overall planning and puncture time were shorter using NAV: 76 s [50—118] versus 214 s [181—264] using CT-guidance ($P < 0.001$).
Conclusion: Novice operators consistently performed faster and more accurate phantom punctures with out-of-plane trajectories using the electromagnetically-guided navigation system than with the standard CT-guided method.

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The development of new therapeutic options using interventional radiology has led to an increased number of image-guided biopsies [1—6]. In the same time, the difficulties related to actually performing such biopsies have resulted in the development of various innovative guidance systems. The last few years have seen substantial progress, as new technology developed for computer-assisted medical interventions has become available. These new techniques have been adapted to computed tomography [7—14] and are now successfully used to facilitate needle placement (in particular for out-of-plane trajectories), improve the accuracy of biopsies and reduce the amount of radiation that the patient receives.

The purpose of the present phantom study was to assess the performances of a large population of operators with no prior experience on new electromagnetically-guided system for biopsy needle placement on an out-of-plane trajectory, and to compare them with the standard CT method.

Material and methods

General description of the navigation system

The present study was carried out to assess the IMACTIS® navigation station (Grenoble, France). This system uses a magnetic field generator placed on the patient near to the puncture site and a detector contained within a needle holder to track the needle trajectory in real time using CT imaging. Following acquisition of the volume of interest, DICOM images are automatically transferred to the navigation station. During the procedure, the acquisition volume can be examined three-dimensionally by moving the needle holder directly over the patient. The most appropriate puncture site can therefore be localized in real time, just before attempting to reach the target. A video showing a CT-guided biopsy performed using this system can be accessed on the product page of the Imactis website: http://www.imactis.com/.

Study design

The present study was a prospective, randomized and comparative phantom study assessing the performances of operators with various degrees of experience. Users' performances with the electromagnetic IMACTIS® navigation system (NAV group) were compared to those with the standard CT method (CT group). The study protocol imposed ''one-shot'' target puncturing, without allowing repeated intraprocedural CT acquisitions. Assessment therefore focused on the initial stage of the puncture procedure, analyzing the accuracy of trajectory planning and of initial positioning of the needle.

Protocol for phantom punctures

The phantom (Fig. 1) contained three targets. Users had to follow a double oblique, out-of-plane trajectory to approach the targets through the pre-pierced PVC plates contained in the phantom. The targets were 6 mm-diameter holes located at a depth of approximately 10 cm from the surface of the phantom. Punctures were considered successful if the needle crossed the target. Helical scans of the phantom were obtained using a Brilliance 64 CT scanner (Philips Medical Systems, Eindhoven, The Netherlands). The first target was used to train operators on both the navigation system and the post-processing console (IntelliSpace Portal, Philips Medical Systems). Performances were then assessed using the two remaining targets (A and B) of similar difficulty.

Because puncture attempts were carried out without concurrent CT monitoring, the operators had only one attempt to reach the target and could not alter their trajectory once the approach had started, nor perform intraprocedural CT scans to check on the position of the

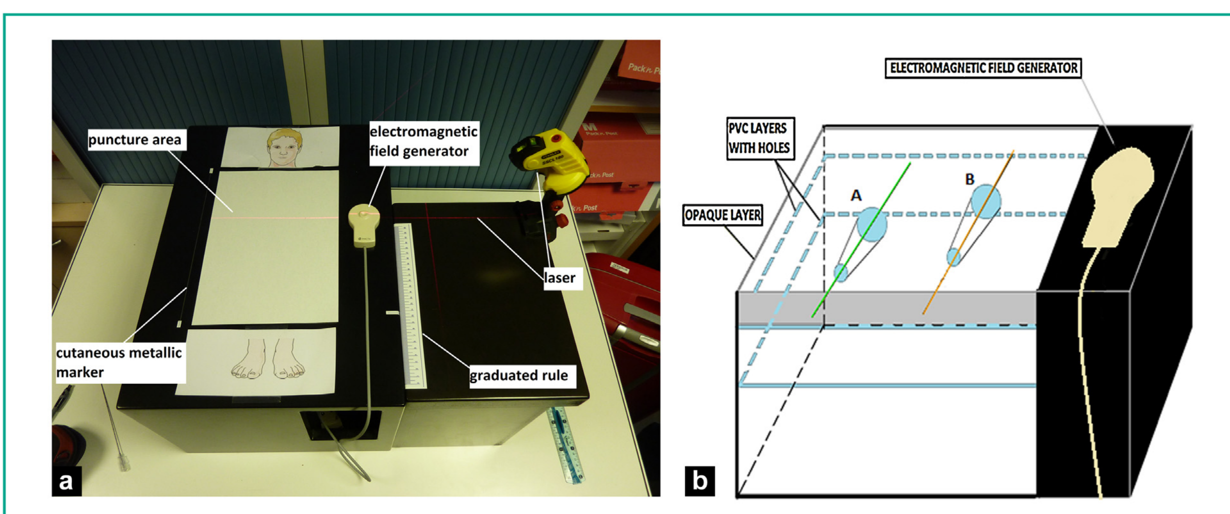

Figure 1. Puncture assessment phantom: a: puncture phantom. The magnetic field generator localized on the ''patient'' was used to perform punctures with the NAV system. CT group punctures were performed by simulating the position of the couch of the CT scanner using a graduated ruler, and visualizing the plane of the CT slice using a laser. A metal wire placed on the ''patient'' is used as a landmark for the entry point; b: trajectories and targets. Transparent 3D view of the inside of the phantom showing the 2 targets and the out-of-plane trajectories (A and B) that have to be achieved to reach them (represented by holes drilled through PVC layers).