

MRI Guided Needle Insertion - Comparison of Four Techniques.

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Purpose:

To compare four assistive techniques used in percutaneous needle placement procedures with closed high-field MRI scanners.

Materials:

Four manual techniques were compared: 1) image overlay that projects MR image and virtual needle guide on the patient, 2) biplane laser with needle trajectory marked by intersecting transverse and oblique sagittal lasers, 3) handheld protractor with pre-angled guide sleeve, and 4) conventional freehand insertion as a control. All techniques feature: manual needle placement in laser-marked transverse plane, translating patient out of the scanner for insertion, and skin fiducials to determine puncture point. They are all equivalent in controlling out-of-plane angle and depth, and these aspects are not included. Two series of experiments were conducted with 1.5T GE Signa and 18G beveled needles. Test 1 used an abdominal phantom, n=4 insertions per technique, and MRI-based validation. Test 2 used a phantom filled with tissue-equivalent gel and five 4 mm plastic targets covered in neoprene skin, n=30 insertions per technique, and C-arm fluoroscopy to determine in-plane tip position and angle error.

Results:

In test 1, all insertions were visually successful, but needle artifact and lack of distinct targets made quantitative measurement inconclusive. In test 2, technique made a significant difference in tip position error ($p=0.015$) and angle error ($p=0.053$). With 90% CI, overlay yields better tip placement accuracy than protractor and unassisted techniques; with 80% CI, overlay and biplane laser have better angular accuracy than protractor and unassisted techniques.

Conclusions:

Enhanced needle insertion techniques provide substantial benefit over conventional needle insertion, with image overlay producing the best accuracy and repeatability.

Needle Insertion Accuracy of Four Techniques				
Technique	Avg. Position Error (mm)	Std. Dev. Position Error	Avg. Orientation Error (deg)	Std. Dev. Orientation Error
Freehand	5.27	5.56	4.07	4.11
Protractor	5.37	7.36	3.35	3.34
Laser Guide	2.90	2.62	2.02	2.22
Image Overlay	2.00	1.70	2.41	2.27