Augmented Reality Visualization Using Image-Overlay for MR-guided Interventions: Shoulder and Hip Arthrography in Cadavers at 1.5 Tesla

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Background and Purpose

Augmented reality navigated interventional magnetic resonance (MR) imaging can help to overcome a fundamental limitation of MR arthrography, namely the spatial separation of the two interdependent procedures of intra-articular injection of a Gadolinium-based contrast agent and diagnostic MR imaging of the respective joint. Therefore, we prospectively tested the hypothesis that a novel augmented reality Image-Overlay system provides accurate navigation for MR-guided shoulder and hip arthrography in human cadavers at 1.5 Tesla.

Materials and Methods

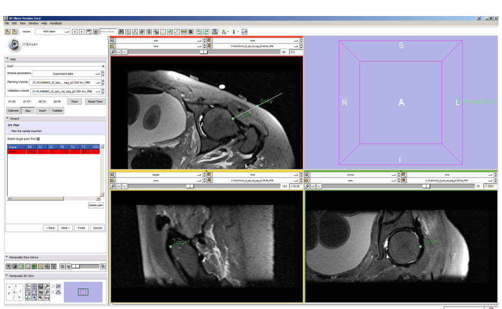
A prototype augmented reality Image-Overlay system was used in conjunction with a clinical 1.5-Tesla MRI system. A total of 24 shoulder joint and 24 hip joint injections were prospectively planned in 12 human cadavers. Two operators participated. A high-resolution MRI data set (1x1x1 mm spatial resolution) was used for planning of needle paths using the PerkStation module of 3D Slicer software (left figure). Needles were placed under augmented reality MRI navigation (center figure). MR imaging was used to confirm needle positions and to monitor injections (right figure). MR arthrography images were finally obtained to visualize the injectant. Technical performance parameters assessed included needle adjustment rate, target error of the final needle tip location, intra-articular injection rate, and arthrography time. A Bonferroni corrected p-value of less than 0.025 was considered significant.

Results

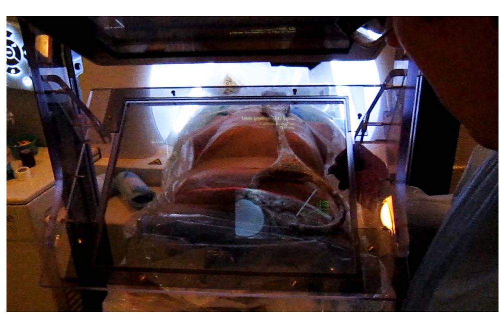
Forty-five arthrography procedures (45/48, 94%) were performed, whereas three subjects had joint prostheses (3/48, 6%). Of the executed procedures, 23/45 (51%) were shoulder arthrographies (Operator A, 12/23, 52%; Operator B, 11/23, 48%) and 22 (49%) were hip arthrographies (Operator A, 12/22, 54%; Operator B, 10/22, 46%). A total of seven (7/45, 16%) needle adjustments were performed (Operator A, 2; Operator B, 5). The target error was 3.1±1.2 (0.9-6.4) mm. The intra-articular injection rate was 100% (45/45 joints). Average arthrography time was 11 (6-25) min for shoulder arthrographies and 15.5 (7-27) min for hip arthrographies ($p=0.264$). Target error and arthrography time were not statistically different between operators ($p=0.067$ and $p=0.222$, respectively).

Conclusions

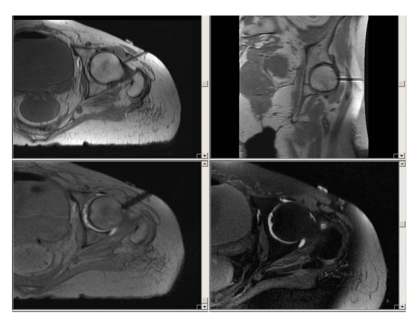
The Image-Overlay System provides accurate and reproducible MRI guidance for successful shoulder and hip arthrography in human cadavers, supporting further evaluation with clinical trials.



Planning of needle path to left hip with PerkStation



Augmented reality navigated left hip puncture



Needle control, injection and MR arthrogram