Dual MRI-Tracking/SJM NavX Electro-Physiology Catheters for Navigation inside an MRI: Initial Experience

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PURPOSE
Accurate and reliable tracking of the position of multiple catheters is a key requirement for conduction of MRI-guided Electrophysiology (EP) procedures. Multiple device tracking was shown to be possible using the MR-Tracking technique [1, 2], where 3 devices were simultaneously tracked during diagnostic and ablative EP procedures in the Left Atrium. Use of non-MRI based tracking systems could be useful in reducing the tasks on the MRI system, for conducting procedures which are partially conducted outside the MRI, such as XMR procedures and also for validating MRI–based tracking versus regulatory-cleared benchmarks. In this study, we utilize EP catheters with both St Jude Medical EnSite NavX electrodes and MR-tracking micro-coils on their shaft, and perform simultaneous tracking using both methods within the MRI suite.

METHODS
A 7.5 Fr EP catheter was constructed with 5 MRI–tracking micro-coils [Figure 1A]. The tip and ring electrodes, as well as the pull-wire, were all constructed as previously described [1], and were entirely MRI-compatible. These two electrodes also serve as NavX tracking electrodes. The NavX tracking system [3, 4] is based on the placement of 6 large electrodes on the body surface, at Superior, Inferior, Left, Right, Anterior and Posterior positions. A 5.8 KHz current is placed sequentially between pairs of opposing surface electrodes (such as the Superior and Inferior ones), and detected by the catheter electrodes, which are in contact with the surrounding fluid. Assuming a constant electrical impedance along the path between the electrodes, the voltage gradient is linear, and the voltage between the catheter and one of the surface electrodes then reflects the relative distance along the given direction (such as Z). This process is then repeated in the other two orthogonal directions, and allows for tracking of 64 devices at rates of ≥20 frames-per-second (fps). The NavX technique has advantages due to the ability to locate multiple devices (and multiple electrodes on each device), the dual-use of sensing/ablation electrodes for positioning. Its major shortcoming is that it measures relative, and not absolute, distances. It also has inaccuracies at transitions between differing tissue electrical impedances, or when the electrical conduction path does not follow a straight path [3].

A plastic phantom was constructed, mimicking the human atrium within the human torso. The plastic atrial wall model [Figure 1B] contained multiple holes in its walls, allowing for multiple electrical conduction paths into the atrial lumen. The atrial phantom is entirely submerged in conductive saline, and placed within a cylindrical plastic case. The 6 NavX surface electrodes are positioned on the inner walls of the plastic case. Since the Ensite NavX system console is not MRI-compatible at this time, it was left outside the MRI scan room, and all the surface and catheter connections were then made utilizing coaxial feed-throughs in the penetration panel, each equipped with low-pass filters to prevent the conduction of RFI into the MRI room.

In conclusion, dual NavX-MR-Tracking catheters may be useful for tracking EP procedures both within and outside the MRI scanner. Simultaneous use of Navx and MRI-tracking is currently possible, although high-bandwidth RT imaging is not. MR-Tracking compliments NavX in providing a more realistic view of the atrial anatomy. Current work focuses on performing procedures in animals using the above system.

REFERENCES: