

Clinical Assessment of Knee MRI in the Presence of Metal Implants Comparing MAVRIC-SL and FSE at 1.5T and 3T

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Introduction: A major limitation of magnetic resonance imaging (MRI) is the difficulty of depicting the anatomy in the presence of metallic orthopedic implants. 3D Multi-Spectral Imaging (MSI) techniques such as MAVRIC⁽¹⁾ and SEMAC⁽²⁾ are currently being investigated to improve MR imaging in the presence of metal hardware. Recent investigations have shown the utility of MSI in assessing soft tissue surrounding metallic implants at 1.5T⁽³⁾. However, there have been limited applications for 3T as image degradation caused by metallic implants increases with field strength. In this study, we investigated the performance of MAVRIC-SL⁽⁴⁾ (MAVRIC-SEMAC hybrid) at 1.5T vs. 3T compared to standard 2D fast spin-echo sequences in the presence of metallic hardware in twelve pig knee specimens.

Methods: Twelve porcine knee specimens were purchased from a local abattoir. Metallic screws from clinically utilized standard orthopedic hardware sets, composed of Titanium and Cobalt Chromium, were implanted before imaging. The hardware was placed using a medial approach at the shaft of the femur, the femoral condyles, inferior of the tibia plateau and at the tibia shaft. Cartilage lesions and drill holes simulating lytic bone lesions were created in the proximity of the hardware in a defined number of compartments (Fig. 1).

All specimens were scanned at a GE 1.5T Excite scanner using a Quadrature Knee Coil, and at a GE 750 3T scanner using an 8-channel T/R Knee Coil. MAVRIC-SL and 2D fast spin-echo sequences were acquired with both proton density (PD) weighting and inversion recovery (STIR). For MAVRIC-SL, 24 spectral bins covering a range of ± 12 kHz off-resonance frequencies were acquired with an echo train length of 24 and readout bandwidth of ± 125 kHz. The scan time was 4 minutes for MAVRIC-SL PD and 6 minutes for MAVRIC-SL STIR at either field strength. All images were randomized and read out by a board-certified radiologist blinded to the image information. The compartments defined around the screws were each evaluated for the presence of lesions with a 5 grade score (definite/probable absence/presence of a lesion; query). Based on the lesion detection rates, Receiver Operation Characteristic (ROC) analysis was performed to investigate the performance of each sequence used. Artifact size was evaluated by measuring the extent of signal loss around the tibia plateau screw (anterior - posterior and cranio-caudal).

Results: Figure 2 shows exemplary images with lesions revealed by the artifact reduction in MAVRIC. The preliminary analysis of the ROC data clearly indicates better lesion detection in MAVRIC due to the distortion reduction compared to the conventional clinical sequences. Comparing areas under the ROC curves as shown in Figure 3 for lesion detection rates: 3T MAVRIC PD vs. 3T 2D FSE: $p < 0.014$, 1.5T MAVRIC STIR vs. 1.5T 2D FSE: $p < 0.001$. No significant differences in the lesion detection rates were found comparing MAVRIC sequences at 1.5T and 3T. Artifact size measurements demonstrated larger metal induced artifacts at 3T compared to 1.5T, and less extensive artifacts in MAVRIC sequences compared to conventional sequences at both field strengths.

Conclusion: MSI imaging near metal performs better than conventional sequences at both field strengths. Comparing 1.5T to 3T, no significant differences were found in the lesion detection rates, but artifact sizes were measured larger at 3T. The data suggests that MAVRIC can be successfully applied at 3T without significant differences in diagnostic performance compared to 1.5T.

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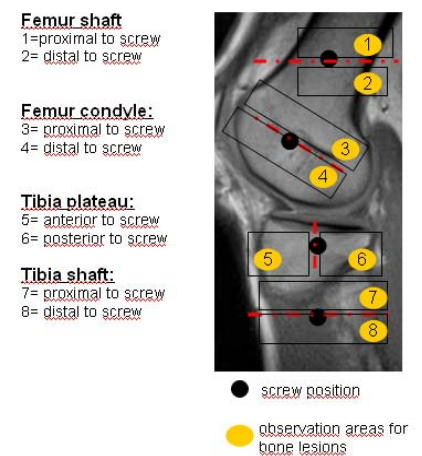


Figure 1: Compartments defined around the metal hardware (screws) for the created bone lesions

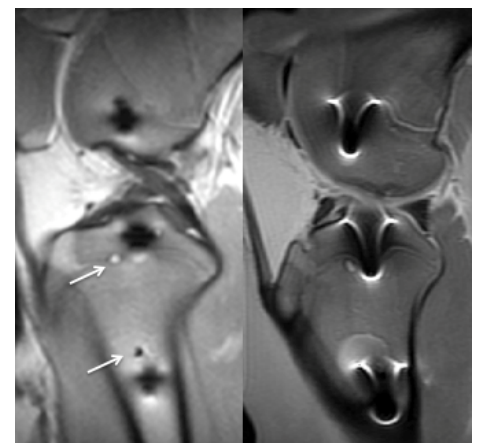


Figure 2: MAVRIC-SL image (left) and PD-weighted image (right) at 1.5T demonstrating bone lesions (arrows) in the proximity of 3 cobalt-chromium screws

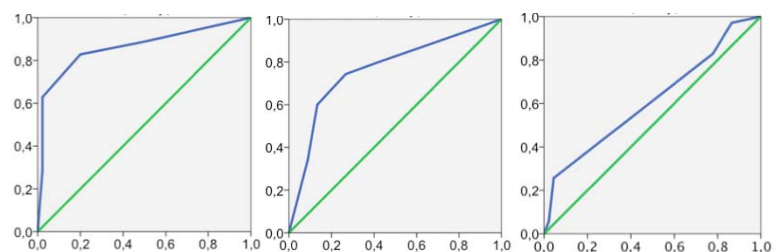


Figure 3: ROC Curves of lesion detection rates for different sequences: 3T MAVRIC STIR (left) area under the, 1.5T MAVRIC STIR (middle) and 3 T 2D FSE (right)