Correction of Metal-Induced MRI Artifacts in Total Knee Replacements with MAVRIC and SEMAC

INTRODUCTION
Magnetic resonance imaging (MRI) is ideal for musculoskeletal imaging, due to its superb soft tissue contrast and three-dimensional reformating ability. Unfortunately, post-surgical imaging is often limited to plain radiography, as the metal in surgical implants distorts the main magnetic field, producing artifacts such as signal loss and distortion that limit the diagnostic value of MRI for post-operative complications. We have developed 2 three-dimensional MR imaging prototypes that correct for these artifacts, Slice Encoding for Metal Artifact Correction (SEMAC) and Multi-Acquisition Variable-Resonance Image Combination (MAVRIC). SEMAC corrects for distortion and artifact by building on the view-angle tilting technique to align resolved excitation profiles to their actual voxel locations using additional phase encoding in the slice direction. MAVRIC minimizes distortion and artifact by limiting the excited bandwidth, then uses multiple resonant frequency offset acquisitions to cover the full spectral range. We compared artifact size measured on SEMAC and MAVRIC images to that measured on conventional two-dimensional fast spin echo (FSE) images of the knee.

METHODS
After obtaining informed consent and IRB approval, nine knees of 8 volunteers with total knee replacements (TKR) were imaged in the sagittal plane using a GE Signa Exite HDx 1.5T MRI scanner and an 8-channel knee coil. All images were acquired with bandwidth +/-125Hz and slice thickness 3mm. Field-of-view was adjusted for knee size, ranging from 16x12cm to 18x14.4cm. FSE was acquired with repetition time/echo time (TR/TE) =3000/6.4ms, resolution 320x256, 2 NEX, 36 slices, and an average scan time of 5 minutes. MAVRIC was obtained with TR/TE=3446/11.3ms, resolution 256x192, 0.5 NEX, 36 slices, and an average scan time of 8:23. MAVRIC was acquired with TR/TE=3650/39.6ms, resolution 320x256, 2x auto calibrated parallel imaging (ARC), 40 slices, and an average scan time of 11:23.

RESULTS
In all metal joint compartments, SEMAC and MAVRIC were both significantly better at artifact reduction than FSE (all P<0.03), while being statistically equivalent to each other (all P>0.1, Figure 3). For the model of the knee, Table 1 lists the percent deviation between the measured and true A/P and M/L dimensions of the TKR.

DISCUSSION
Results from the human volunteers and TKR knee model demonstrate that both SEMAC and MAVRIC correct for metal-induced distortion and artifact, allowing them to accurately measure metal implant geometry. FSE images suffered from statistically larger artifacts, particularly around the femoral component. In conclusion, MAVRIC and SEMAC are promising MR imaging techniques that may allow for improved musculoskeletal follow-up imaging of metallic implants and soft tissue structures surrounding metal in the knee.

REFERENCES