

Comparison of optimized fast spin echo (FSE) magnetic resonance (MR) imaging to view angle tilt (VAT) FSE in the reduction of metallic susceptibility artifact surrounding arthroplasty.

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Introduction / Background: MR imaging of arthroplasty has traditionally been limited by the presence of artifact generated by the metallic components, which comparatively demonstrate higher magnetic susceptibility than the adjacent bone and soft tissue (1-3). The sources of these artifacts include induction of radiofrequency eddy currents in the metal, warping of the slice during slice selection, and in-plane off resonance chemical and susceptibility misregistration in the frequency-encoding direction. The intensity of the artifact is related to the degree of relative ferromagnetism of the components, their orientation relative to the external field, as well as the geometry of the implant (1). Metallic susceptibility artifact can be minimized with modification of MR pulse sequence parameters, including the use of a wider receiver bandwidth to minimize the chemical shift generated at the metal-bone and metal-soft tissue interface, as well as high spatial resolution in the frequency direction. View angle tilt (VAT) is an additional method aimed at reducing in-plane geometric distortion from off resonance by adding a gradient in the slice-select axis during signal readout (4,5). The purpose of this study was to make a qualitative comparison of optimized fast spin echo (FSE) MR images to images obtained with VAT.

Materials and Methods: 18 consecutive patients with arthroplasty were prospectively recruited for this IRB approved study. These included 9 knee, 8 hip and 1 shoulder arthroplasties. The composition of the majority of the arthroplasties was combinations of cobalt chromium and titanium. All MR imaging were performed on a clinical 1.5 Tesla unit with gradient amplitude ranging between 22-33mT/m (Twin Speed, General Electric Healthcare, Milwaukee, WI). Optimized FSE pulse sequences were performed in 3 planes of imaging using either a 4 channel phased array receive-only shoulder coil (shoulders and hips) or a 4 channel phased array transmit-receive coil (knees). Receiver bandwidth ranged between 83.3-100kHz over the entire frequency direction. In addition, VAT imaging was performed in one plane of imaging (sagittal plane for knee arthroplasty, coronal plane for hip arthroplasty and oblique coronal plane for shoulder arthroplasty). The exact same imaging prescription and pulse parameters, including receiver bandwidth, were utilized for VAT imaging, with alteration in only the repetition time (TR) as required to maintain an acceptable scan time. Following image acquisition, datasets were analyzed for comparative qualitative differences in the optimized FSE and VAT images, looking specifically for improved definition of metal-bone and soft tissue interface and the presence of blurring (if present).

Results: 13/18 patients demonstrated visibly better image quality using VAT with improvement of the metal-bone interface on select images (*Figure 1A and B*). In two of these 13 patients, the presence of osteolysis (in addition to the bone-metal interface) was also better defined (*Figure 2A and B*). In 3/18 patients, the FSE imaging was superior in demonstrating tissue-metal boundaries. In a further 2/18 patients, no visible difference is seen in image quality. With regards to blurring, in 2/18 cases there was subjective blurring on VAT; one of these utilized an 83.3 kHz receiver bandwidth. Blurring is known to occur from modulation by the transform of the slice profile when the readout time is longer than the duration of the main lobe of the RF pulse (5), and this was to be expected for the combination of 512 readout points and 83.3 kHz bandwidth.

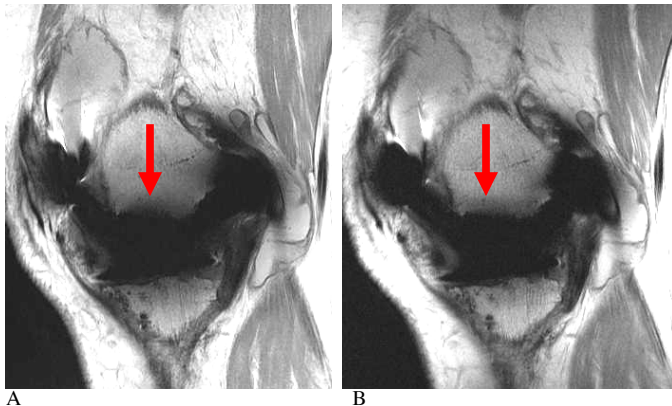


Figure 1: Sagittal fast spin echo (A) MR image of a knee arthroplasty demonstrates poor definition of metal-bone boundary, which is sharper on the VAT (B) image (arrows)

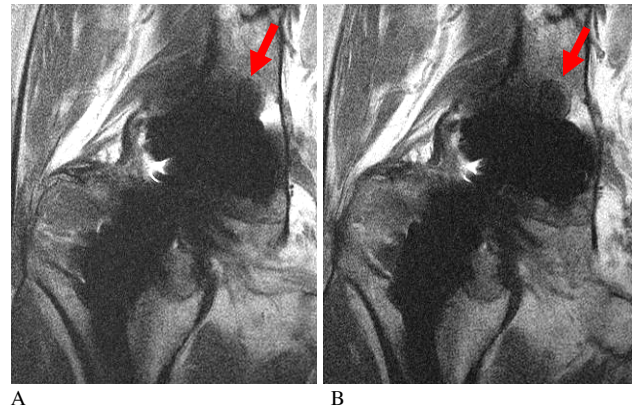


Figure 2: Coronal fast spin echo (A) MR image of a hip arthroplasty demonstrates poor definition of osteolysis of the acetabular dome, better seen on the VAT (B) image.

Conclusion: There is an observable, albeit inconsistent, improvement in imaging of arthroplasty with the use of VAT compared to optimized FSE in MR imaging of arthroplasty. Blurring may be minimized by strict attention to combination of receive bandwidth and number of frequency encoding points. MRI has been shown to be the most sensitive technique to detect and quantify the magnitude of particle disease, which is the ultimate factor that determines the longevity of joint replacement (1,3). The development of more powerful gradient systems is also expected to aid in the ability to sample wider receiver bandwidth off center in the imaging bore. VAT remains an important option in the attempt to improve image quality by reducing artifact in the presence of metallic hardware.

References:

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