

Overcoming MRI challenges

with metallic implants

White
Paper

Advanced techniques and technologies
to minimize scan artifacts

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Opportunity

Total hip and knee arthroplasty procedures are projected to increase by 175% and 673%, respectively, from 2005 to 2030¹. Likewise, revision surgeries of total knee and total hip replacements are estimated to grow exponentially over the same period. These impressive growth projections require accurate and cost-effective imaging techniques for post-operative surveillance and diagnosis of implant-related complications. Because magnetic resonance (MR) imaging delivers high spatial and contrast resolution of bone and periprosthetic soft tissues, it is well suited for imaging of arthroplasty implants and has great potential for short- and long-term growth of MSK referrals and generation of revenue.

Challenge

MR imaging of arthroplasty implants can assist physicians in detecting loosening, periprosthetic fractures, tendon tears, nerve injuries, and adverse reactions to metallic implant products with high accuracy²⁻⁴. However, metal-induced accelerated dephasing and displacement of MRI signals cause spatial distortions and suboptimal fat suppression⁵. The ensuing artifacts can obscure abnormalities and cause diagnostic inaccuracies⁶, which then may lead to delays in diagnosis, appropriate care and increased expenses.

Approaches

Successful MR imaging of tissues around metallic implants requires appropriate suppression of metal artifacts and fat. The combination of turbo spin echo (TSE) pulse sequences and high read-out bandwidth significantly reduces implant-induced artifacts and image distortions in the image plane; however, through-plane artifacts and distortions remain. The STIR (Short-Time Inversion Recovery) fat suppression technique is least susceptible to alteration of spin precession frequencies and thus is the method of choice to achieve reliable fat suppression around metallic implants. However, even STIR fat suppression can fail due to a mismatch between the bandwidth of radiofrequency pulses and the high read-out bandwidth. While this mismatch can be corrected with matching bandwidths⁷, residual through-plane artifacts can obscure STIR hyperintense abnormalities.

*The MRI restrictions (if any) of the metal implant must be considered prior to the patient undergoing an MRI exam. MRIs of patients with metallic implants bring specific risks. However, certain implants are approved by governing regulatory bodies to be MRI conditionally safe. For such implants, the previously mentioned warning may not be applicable. Please contact the implant manufacturer for the specific conditional information. The conditions for MRI safety are the responsibility of the implant manufacturer, not of Siemens Healthineers.

Solutions from Siemens Healthineers: **Advanced WARP** with SEMAC

Advanced WARP is the complete solution for MR imaging of arthroplasty and orthopedic metallic implants. Fully integrated in TSE pulse sequences, Advanced WARP combines high-bandwidth technique, VAT (view angle tilting), and SEMAC (Slice Encoding for Metal Artifact Correction) for a maximum reduction of metal artifacts and image distortions as well as solid fat suppression. Advanced WARP pulse sequences permit T1-, T2-, proton density-, and intermediate-weighted image contrasts as well as any field-of-view size due to powerful phase oversampling techniques. Metal artifact reduction MRI protocols with Advanced WARP afford a significantly smaller metal artifact and the detection of up to 50% more periprosthetic abnormalities⁸.

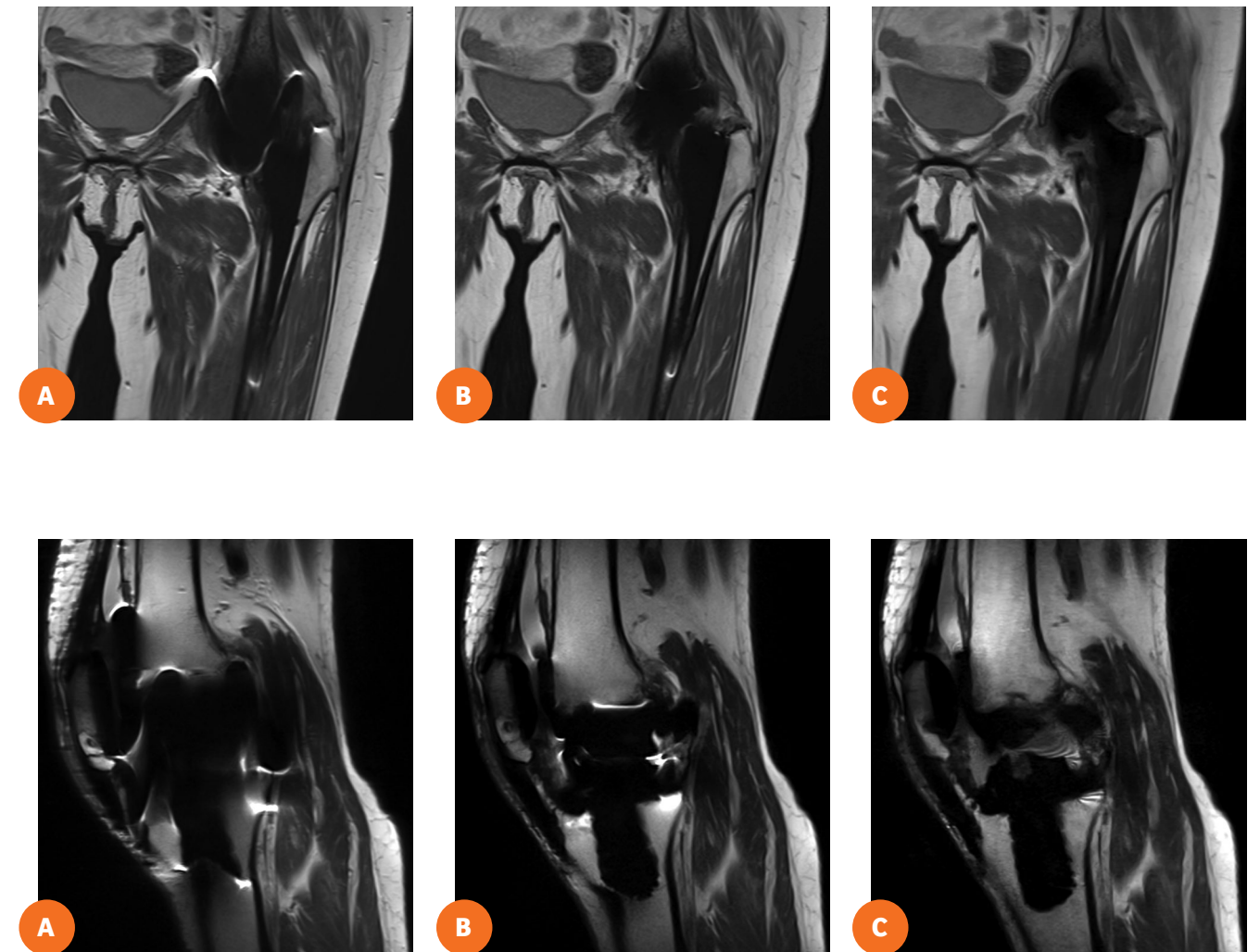
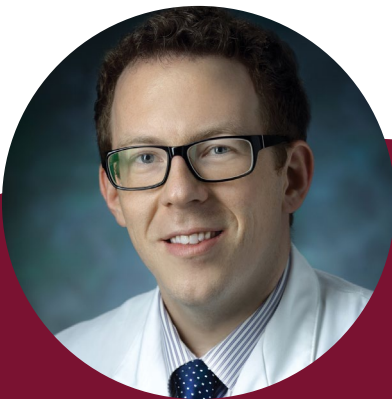


Figure 1. Hip and knee arthroplasty implants cause considerable metal artifacts and distortions with conventional fast and TSE techniques (A). High-bandwidth technique (B) causes substantial reduction of metal artifacts, while the addition of SEMAC technique (C) eliminated the majority of the metal artifact. Advanced WARP with SEMAC delivers exceptional image quality with minimal metal artifacts remaining (C). (Images courtesy of Dr. Jan Fritz, The Johns Hopkins University School of Medicine, Baltimore, MD)

How SEMAC works

SEMAC provides significant additional metal artifact reduction by correcting the through-plane displaced MRI signal that is otherwise unaddressed by conventional metal artifact reduction techniques. SEMAC is based on a TSE pulse sequence and involves multiple additional phase-encoding steps in the z-direction. Practically, this involves the creation of spatial bin images, which “collect” the signal that is displaced back into the imaging plane (Figure 2). Through the formation of a final composite image, the previously displaced signals substitute the signal voids and create MR images with unprecedented visibility of bone and soft tissues around hip and knee implants. Because these additional phase-encoding steps prolong the total scan duration, special consideration should be given when choosing the appropriate protocol for imaging metal implants.

Advanced WARP with SEMAC offers greater potential to expand MRI services in the field of orthopedic imaging. With Advanced WARP, Siemens Healthineers offers ready-to-use optimized protocols that can deliver unprecedented metal artifact reduction.



Watch the
on-demand
webinar to
learn more

Jan Fritz, MD, is a board-certified and fellowship-trained musculoskeletal radiologist attending at Johns Hopkins and a world expert in metal artifact reduction technologies. In the *Applied Radiology* Expert Forum, “Overcoming the Challenge of MRI Metal Artifacts around Orthopedic Implants,” Dr. Fritz discusses how he uses the SEMAC technique from Siemens Healthineers to reduce metal artifacts and dramatically improve MR image quality of patients with metallic orthopedic and arthroplasty implants.

Visit usa.siemens.com/mr-webinars for on-demand access to this and other MRI-related webinars.

Multiple Z-encoding steps

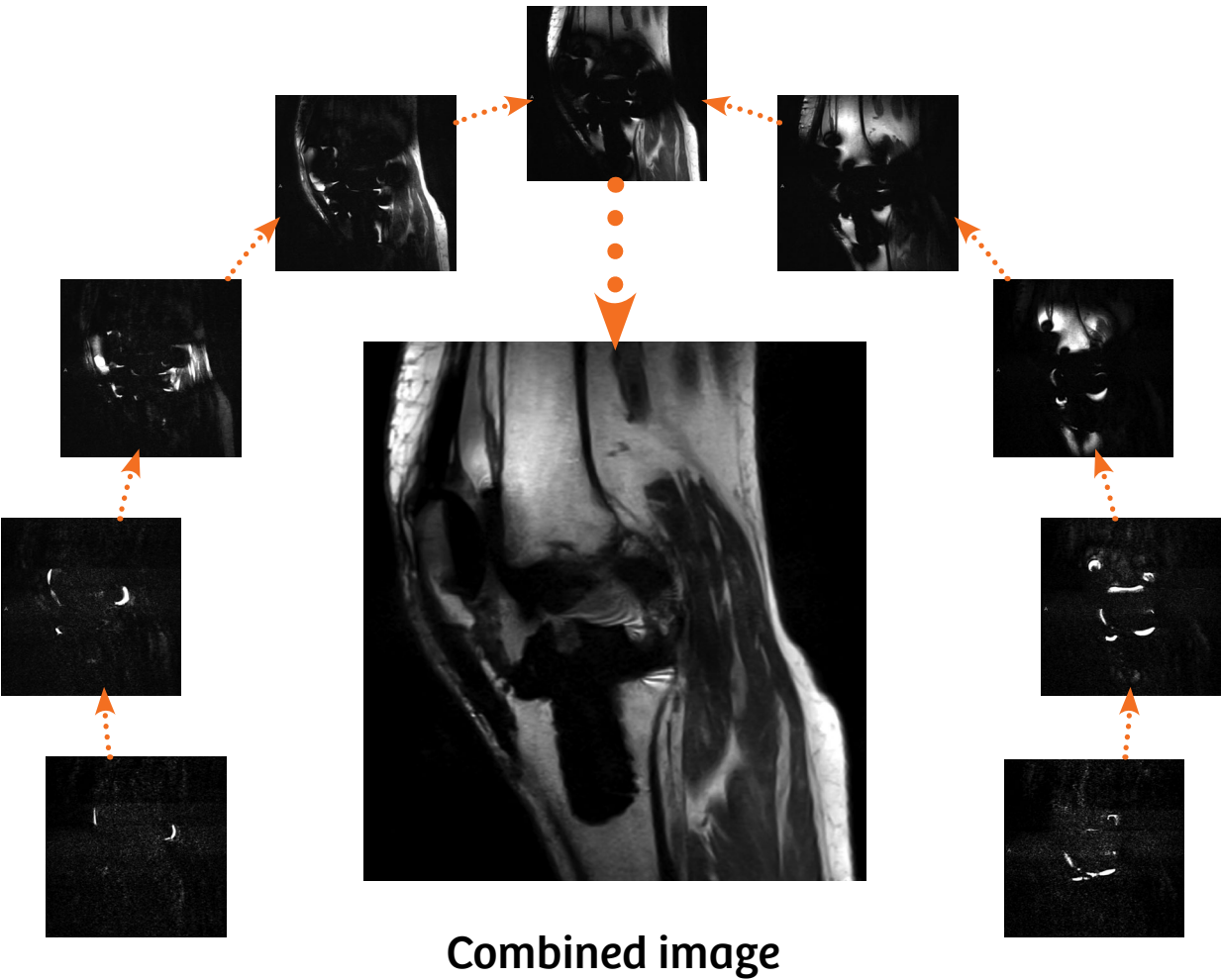


Figure 2. The SEMAC technique involves a two-dimensional TSE acquisition with multiple z-encoding steps spanning the extent of the implant-induced distortions. It then uses a sum-of-square algorithm to combine the multiple z-step images to generate a single two-dimensional TSE image with superior distortion correction and artifact reduction. (Images courtesy of Dr. Jan Fritz, The Johns Hopkins University School of Medicine, Baltimore, MD)

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