

MRI Metal Artifact Reduction for Optimized Visibility Surrounding a Centinel Spine® prodisc® Cervical Total Disc Replacement

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The presence of a metallic implant in a magnetic resonance imaging (MRI) scan can result in image artifact and challenges with visualization of surrounding anatomy. This study sought to determine optimal MRI sequences for metal artifact reduction in patients implanted with a Centinel Spine prodisc cervical total disc replacement (TDR) implant.¹ Tissue-mimicking phantoms and cadaver specimens were utilized to understand the effectiveness of a variety of scan sequences and compare image artifact among Centinel Spine prodisc cervical device types. Scanning was performed with a 1.5 T Siemens Aera and 3 T Siemens Prisma. Image

artifact was reduced on the 1.5 T scanner compared to the 3 T scanner, due to the lower magnetic field strength. The most effective metal artifact reduction was achieved with MRI sequences with the Siemens WARP functionality enabled, the view angle tilt (VAT) set to 100%, and the SEMAC functionality also enabled (**Figure 1**). Similar metal artifact reduction sequences from other scanner manufacturers are available (i.e., MAVRIC for GE, O-MAR for Philips). These manufacturer-specific metal artifact reduction tools are recommended to reduce metal artifact associated with Centinel Spine prodisc cervical TDR implants.

Standard 3 T MRI Sequence without Metal Artifact Reduction



1.5 T MRI Sequence with Metal Artifact Reduction

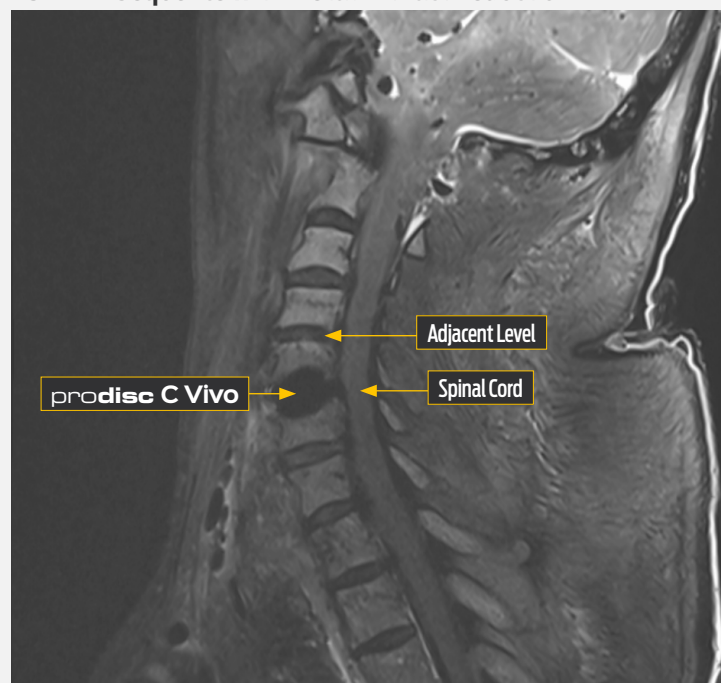


FIGURE 1: Sagittal MR images of a prodisc C Vivo, comparing a standard 3 T MRI turbo spin echo sequence (left) and a 1.5 T MRI sequence with WARP enabled, VAT set to 100%, and SEMAC enabled (right).

Parameter	Recommended Settings for Metal Artifact Reduction	
Magnetic Field Strength	1.5 T scanner produced optimal imaging results compared to a 3 T scanner.	
Scan Sequence	Variety of clinical spine imaging sequences can be used, particularly spin echo sequences with high bandwidth and thin slices, with the metal artifact reduction tools listed below.	
Metal Artifact Reduction Tools	Siemens scanners	WARP functionality enabled with 100% VAT and SEMAC. CS-SEMAC may be used to reduce scan time.
	GE Scanners	MAVRIC SL reduces in-plane and through-plane artifacts.
	Philips Scanners	O-MAR XD for in-plane and through-plane artifact reduction.

¹ Full report on file at Centinel Spine, titled MRI Metal Artifact Reduction for Centinel Total Disc Replacements, VAL-R-0241.

■ INTRODUCTION

The presence of a metallic implant in an MRI scan can result in artifact. To date, no image artifact reduction strategy has been established for Centinel Spine® **prodisc** cervical total disc replacement (TDR) implants.

■ OBJECTIVE

This study sought to determine optimal MRI sequences for metal artifact reduction in patients implanted with a Centinel Spine **prodisc** cervical total disc replacement (TDR) implant.

■ METHODS

prodisc cervical TDR implants were first inserted into agar-based tissue-mimicking phantoms. These phantoms were imaged with a variety of metal artifact reduction sequences based on literature findings and commercially available software packages from scanner manufacturers. Consistent results were observed across the nine **prodisc** devices tested. Subsequently, five **prodisc** cervical TDR implants were implanted into cadaveric specimens. These cadavers were imaged with the optimal MRI sequences determined in the phantom-based imaging phase of the study. A 1.5 T Siemens Aera and a 3 T Siemens Prisma were utilized.



■ RESULTS

Image artifact was reduced on the 1.5 T scanner compared to the 3 T scanner. WARP resulted in smaller artifact sizes on both scanner types. WARP sequences with VAT set to 100% were superior to VAT set to 50% in terms of metal artifact reduction. Finally, SEMAC resulted in the largest improvements. Representative figures (sagittal plane imaging in **Figure 1**, axial plane imaging **Figure 2**) demonstrate a marked difference in image artifact and corresponding visibility of surrounding anatomy between standard MRI sequences and sequences with metal artifact reduction tools.

■ DISCUSSION

According to analysis conducted by multiple spinal surgeons, adequate visibility of the spinal canal, adjacent discs, nerve roots, and neuroforamen was achieved with these optimized MRI parameters, allowing for interpretation of spinal decompression, foraminal stenosis, and endplate structure (**Figure 1**, **Figure 2**). The improved visibility was consistent across all Centinel Spine **prodisc** cervical TDR implants. Scanning at a magnetic field strength of 1.5 T produced optimal imaging results with minimal artifact compared to a 3 T scanner. The most significant metal artifact reduction was observed with the Siemens proprietary metal artifact reduction technique (WARP; SEMAC). WARP can be applied by specifying a View Angle Tilt (VAT) percentage (typically 50-100%), and increased VAT generally reduced artifact. SEMAC can be applied by specifying number of steps (typically 8-15) and can further be optimized with reduced scan time using compressed sensing (CS-SEMAC). Outside of metal artifact reduction tools, the specific scan sequence parameters used did not have significant effects on metal artifact, and therefore, a wide variety of clinical spine imaging sequences can be used in combination with metal artifact reduction tools, particularly turbo spin echo sequences with high bandwidth and thin slices.

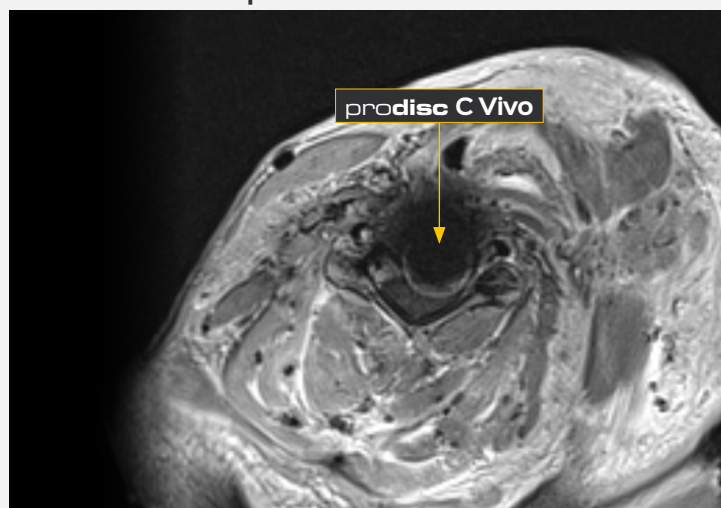
■ CONCLUSION

Overall, WARP with VAT set to 100% combined with SEMAC on a 1.5 T Siemens scanner was optimal for imaging Centinel Spine **prodisc** cervical TDR implants to reduce metal artifact. Similar metal artifact reduction tools from other scanner manufacturers are available (i.e., MAVRIC SL for GE scanners, O-MAR XD for Philips scanners) that also account for in-plane and through-plane metal artifact and are expected to produce similar results as the tools used in this study.

Dr. Rush J. Fisher of Penn Medicine noted:

“For years we have accepted image artifact as dogma and one of the limitations of many total disc replacement technologies. With this study, there is a clearly identified solution within reach of any imaging center.”

Standard 3 T MRI Sequence without Metal Artifact Reduction



1.5 T MRI Sequence with Metal Artifact Reduction

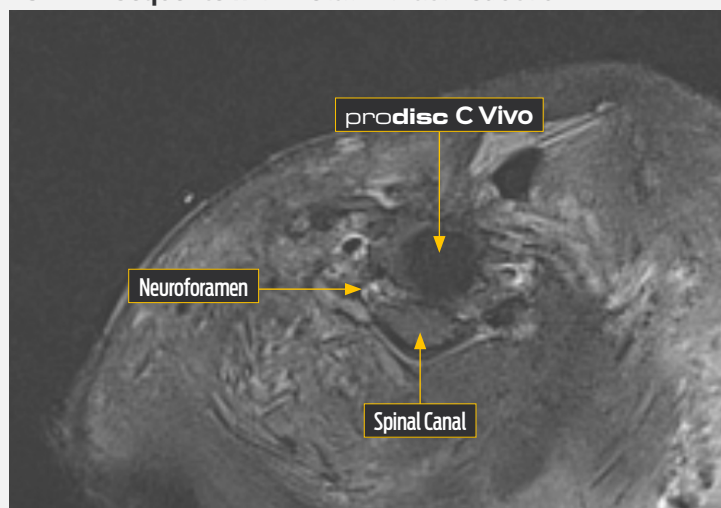


FIGURE 2: Axial MR images of a **prodisc C Vivo**, comparing a 3 T standard turbo spin echo MRI sequence (top) and a 1.5 T MRI sequence with WARP enabled and VAT set to 100% (bottom).