Unintended Consequences: Review of New Artifacts Introduced by Iterative Reconstruction CT Metal Artifact Reduction in Spine Imaging

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ABSTRACT

SUMMARY: Metal hardware serves as a common artifact source in spine CT imaging in the form of beam-hardening, photon starvation, and streaking. Postprocessing metal artifact reduction techniques have been developed to decrease these artifacts, which has been proved to improve visualization of soft-tissue structures and increase diagnostic confidence. However, metal artifact reduction reconstruction introduces its own novel artifacts that can mimic pathology.

MAR Technique and Its Benefits

MAR is an automated postprocessing, projection-based technique developed by GE Healthcare that addresses metal artifacts in 3 stages. First, metal artifacts are identified in the source tomoscan projection using a density threshold. Second, the data lost from metal artifacts are reconstructed into an inpainted projection with corrected data, which is generated by estimation from artifact-free areas. Finally, the corrected projection is formed by combining the inpainted projection and the original projection, which reveal details of structures obscured by artifacts. MAR reconstruction has been shown to significantly improve visualization of obscured soft-tissue structures and diagnostic confidence compared with the standard weighted filtered backprojection reconstruction method. Paraspinal soft tissues adjacent to the fusion hardware are obscured on traditional images, while the MAR image allows adequate visualization of the underlying structures.

MAR-Related Artifacts and Limitations

MAR-induced artifacts have been described in the hip and elbow, but there are limited descriptions of these artifacts in the spine where MAR artifacts frequently mimic pathology. The primary artifacts include the following: perihardware lucency, pedicle screw lucency, factitious subarachnoid material on myelography, and misrepresentation of intraosseous cement.

Perihardware Lucency. Perihardware lucency (Fig. 2A, white arrow) is concerning because it usually signifies loosening of the hardware; however, this is not visualized in the non-MAR images.
More troublesome is that these artifacts persist in multiple planes as shown in the axial plane (Fig 2C–D).

**Pedicle Screw Lucency.** Pedicle screw lucency occurs when the implanted hardware fatigues and fractures (Fig 3A, white arrow), which is not seen on the non-MAR image (Fig 3B). This artifact is not uniform throughout the MAR series, and adjacent images demonstrate that adjacent screws are unaffected.

**Subarachnoid Material on Myelography.** Factitious subarachnoid material can be seen on myelograms when MAR is applied, particularly in areas of concentrated intrathecal contrast. There is hypodense material in the dorsal spinal canal (Fig 4A, white arrow), which is not seen on the non-MAR image (Fig 4B). This artifact could be mistaken for arachnoiditis, tumor, or layering debris and may lead to unnecessary further work-up.

**Intraosseous Cement Abnormal Distribution.** Postvertebroplasty cement configuration can appear irregular and fragmented with indistinct margins (Fig 5A, white arrow) and an internal heterogeneous pattern of vertebral body filling; however, in the non-MAR image (Fig 5B), the bone cement has a normal uniform distribution with clearly defined margins.

**CONCLUSIONS**

MAR is a useful imaging reconstruction technique that can minimize metal artifacts, thus improving soft-tissue visualization and diagnostic confidence in the setting of spinal hardware; however, it is critical to understand the generated artifacts to render a correct interpretation. One limitation of this article is that we exclusively used GE Healthcare scanners. While MAR techniques of different vendors may have overlap in method (ie, projection modification is used by GE Healthcare and Philips Healthcare), each vendor ultimately has its own proprietary algorithm. All can potentially...
At our institution, we include a set of standard images along with the MAR postprocessed images (from a single CT acquisition) on the PACS to allow confident identification of MAR artifacts and true pathology or postoperative complication. Given the widespread use of MAR techniques and the implication of misinterpreting artifacts, it is crucial that radiologists recognize these artifacts exist.

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FIG 3. A, Sagittal CT image of posterior spinal fusion of the MAR protocol demonstrating lucency through the pedicle screw (white arrow). This lucency clearly mimics a fracture, hence could be called a “pseudofracture” if non-MAR images are not available. B, Image without the MAR application shows a normal appearance of the pedicle screw.

FIG 4. A, Sagittal MAR CT image with fusion hardware in the lumbar and sacral spine demonstrates apparent hypodense material (white arrow) in the dorsal spinal canal not seen in the non-MAR image. This filling defect could be mistaken for arachnoiditis, tumor, or layering debris and lead to unnecessary further work-up. B, Non-MAR image without evidence of material within the spinal canal.

FIG 5. A, Axial CT image with MAR applied demonstrating an irregular fragmented appearance of bone cement with indistinct margins (white arrow). B, Non-MAR counterpart image with normal appearance of bone cement with accurate representation of vertebral filling.

simulate undersampling due to oversmoothing by the MAR algorithm in areas where dense objects interface with bone, as shown in previous phantom modeling demonstrating distortion of hardware.17