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Prosthetic metallic artifact reduction with iMAR

By Damita L. Thomas, MD
Data courtesy of New Century Imaging, Oradell, New Jersey, USA

History

A 62-year-old woman with a prior history of left hip replacement following a fracture injury in 2004 recently sustained prosthetic migration. In order to better plan for the scope and complexity of the planned procedure, preoperative imaging was acquired in order to evaluate for intrapelvic organ injury and pelvic vasculature damage. The study was performed on a Biograph™ Horizon PET/CT scanner with a whole-body contrast computed tomography (CT) scan (110 kV, 100 mAs).

Findings

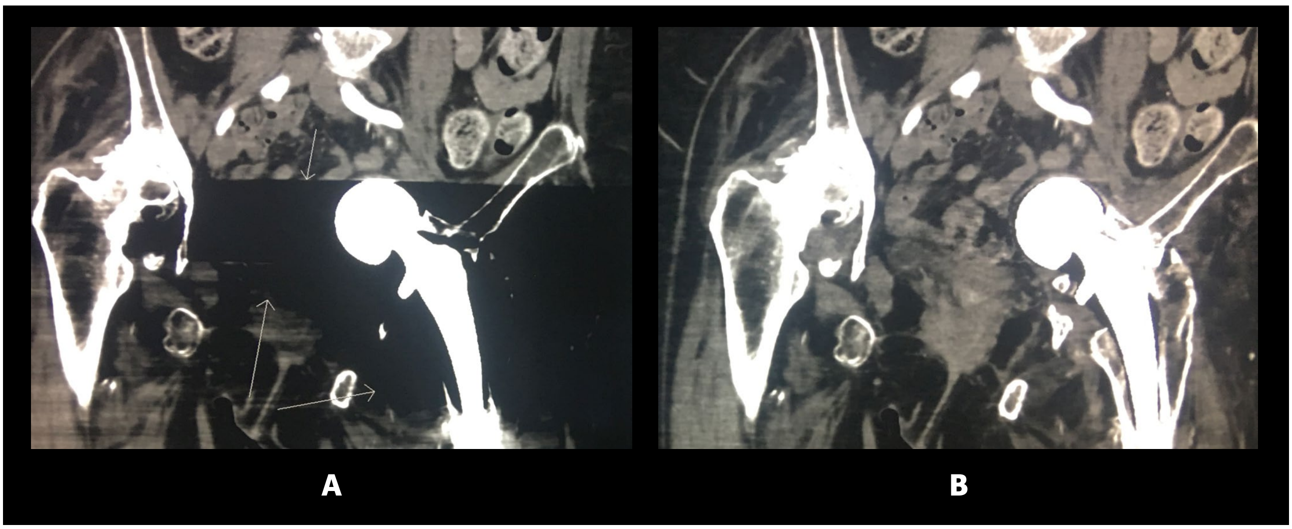
Contrast-enhanced CT and angiography were acquired without and with the application of iterative metal artifact reduction (iMAR). Both data sets demonstrate gross misplacement of the left hip prosthesis through the left acetabulum. On images without the application of iMAR, there is black banding and streak artifact that obscures assessment of intrapelvic soft tissue damage and pelvic vasculature injury. Images with iMAR, however, clearly allow visualization of the intra-pelvic contents, demonstrating that the femoral vessels are intact and the absence of organ damage.

Comments

Total hip arthroplasty (THA) is one of the most common elective surgical procedures performed in orthopedics.[1] Refining of the technique as well as significant advances in technology has made the surgery incredibly effective in the treatment of hip damage since its inception in 1960.[2] It is projected that the number of THAs performed globally will increase by 170% by the year 2030. This increase is in part due to increasing life expectancy, higher diagnosis rates, and improvements in treatment of advanced arthritis, which is the most common cause of hip damage that leads to THA.[3] Complication rates for THA are generally less than 10%, with aseptic loosening, infection, and prosthetic dislocation being among the more common complications. Along with an aging population of hip replacement patients who often outlive the life of the prosthesis, it is no surprise that revision procedures account for up to 12% of hip surgeries.[4]

To evaluate postsurgical complications or preoperatively plan for revision procedures, CT is often used. However, metal prostheses can cause significant streaking artifacts on CT. These artifacts are caused by the prosthetic exerting four physical effects on the X-ray beam, namely: scatter, beam hardening, undersampling, and photon starvation. Scatter and beam hardening result in dark bands resulting from scatter of photons and attenuation underestimation, respectively. Undersampling artifacts result in thin white streaking emanating from the prosthesis due to the significant difference between the density of the implant and surrounding tissue. Photon starvation is simply the lack of photons that are able to traverse a given density to reach the detectors, resulting in noisy images. When the images are reconstructed, image noise is further amplified resulting in streaks in the image. The end result of these four effects is the obscuring of anatomy, important pathological findings, and can even result in images that are deemed non-diagnostic.[5] In this clinical case, significantly black banding and streaking artifact from the prosthesis precludes evaluation of organ injury and vessel damage. Without iMAR, the accurate reflection of the pelvic contents cannot be accurately ascertained. This issue becomes even more problematic in oncology patients with pelvic pathology because not only are pathological findings at risk of being missed, errors in dose calculation at radiation planning can occur.[6]

With the prevalence of hip replacements on the rise as discussed above, there has been increasing interest in developing methods to reduce metal artifact on CT imaging. The solution to this challenge is iMAR software, the only artifact reduction software that uses a combination of three research-proven algorithms to address all four physical effects that can degrade image quality. iMAR is also versatile, as it has the ability to correct an artifact caused by a variety of metal implants regardless of size. This includes dental implants, surgical screws, neurological coils, as well as larger joint prostheses of the shoulder, hip, and knee. It was also shown to be effective when used to reconstruct the co-registered CT images of PET/CT scans. In this case, iMAR allowed a more accurate assessment of the pelvic organs and vessels, resulting in better surgical planning.

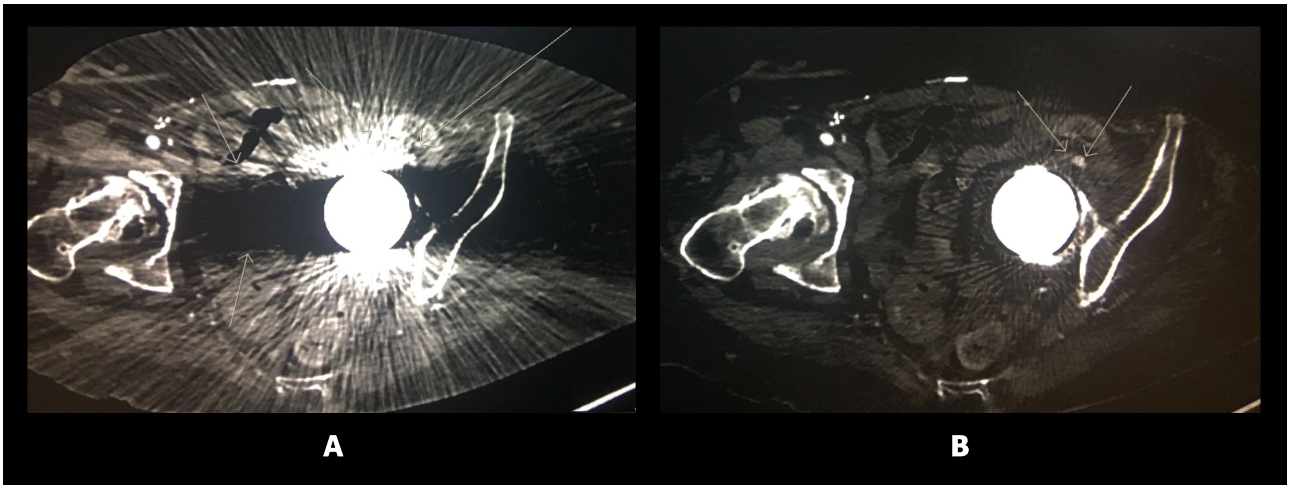


1 Coronal images without and with iMAR application.

A) Image without iMAR, demonstrating large bands of blackness reflecting artifact from prosthesis, obscuring soft tissue detail.

B) With iMAR, soft tissue structures are visualized.

Data courtesy of New Century Imaging, Oradell, New Jersey, USA



2 Axial images without and with iMAR application.

A) Image without iMAR, arrows delineating black band and white streaking artifact from prosthesis, which obscures vasculature structures.

B) With iMAR application, there is visualization of the contrast-enhanced left femoral artery, revealing that the vessel is intact.

Data courtesy of New Century Imaging, Oradell, New Jersey, USA

Conclusion

iMAR software effectively addresses not one, but all four physical effects of metal hardware on the X-ray beam that cause artifact. iMAR can therefore result in improved image quality, better anatomical evaluation, enhanced detection of pathology, and more accurate dose calculation with radiation therapy planning in the presence of a wide variety of metal implants. It has also been shown to be effective when applied to the co-registered CT scan of PET/CT studies.

References

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[3] Kremers HM, Larson DR, Crowson CS, et al. Prevalence of total hip and knee replacement in the United States. *J Bone Joint Surg Am.* 2015;97:1386-1397.

[4] Dargel J, Oppermann J, Brüggemann G-P, Eysel P. Dislocation following total hip replacement. *Dtsch Arztebl Intl.* 2014;111:884-890.

[5] Barrett JF, Keat N. Artifacts in CT: recognition and avoidance. *Radiographics.* 2004;24:1679-1691.

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Examination protocol

Scanner: Biograph Horizon

CT	
Tube voltage	110 kV
Tube current	100 eff mAs
Slice thickness	5 mm

Siemens Healthineers Headquarters
Siemens Healthcare GmbH
Henkestr. 127
91052 Erlangen
Germany
Phone: +49 9131 84-0
siemens-healthineers.com

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Siemens Medical Solutions USA, Inc.
Molecular Imaging
2501 North Barrington Road
Hoffman Estates, IL 60192
+1-847-304-7700
siemens.com/mi