Letters to the Editor

NEUROSURGICAL FORUM

Post-ACDF imaging in patients with metallic implants

TO THE EDITOR: We read with great interest the article by Dr. Elliott and colleagues (Elliott CA, Fox R, Ashforth R, et al: Magnetic resonance imaging artifact following anterior cervical discectomy and fusion with a trabecular metal cage. *J Neurosurg Spine* 24:496–501, March 2016).¹ The authors compared the MR images obtained in 29 patients who underwent anterior cervical discectomy and fusion (ACDF) with a tantalum (i.e., a trabecular metal material) interbody cage to images obtained in 34 patients treated with bone auto- or allograft. They concluded that turbo spin echo (TSE), a special MRI sequence, significantly improved nerve root visualization in patients who had metallic interbody implantation. They advocated use of this TSE sequence after ACDF to reduce the paramagnetic artifact in patients who had been treated with a metallic cage implant. The authors are to be congratulated for such an investigation of practical use. However, we respectfully point out that the improved interpretation of anatomy at the neuroforamen in these TSE MR images could be attributed to the relatively small sizes of the implanted metallic cages, which have less susceptibility artifact on TSE. In our institute, TSE has been routinely applied for every MRI study of the spine for more than a decade. Nevertheless, there are still many susceptibil-

ity artifacts on postoperative MR images obtained after ACDF with metallic cages. TSE does not always help in the evaluation of nerve roots in these patients.

The advantageous image quality of TSE around metallic implants demonstrated by the authors might not always be reproducible. For instance, an optimally installed artificial disc would drastically impede the MRI evaluation at both the spinal canal and neuroforamen, despite the application of TSE (Fig. 1). The trabecular metal cage used by Dr. Elliott and colleagues has some inherent advantages for MRI over other metal implants, such as artificial discs. The geometric center of an ACDF cage is usually placed slightly anterior to the center of the disc space during surgery. The trabecular metal cages most often implanted in ACDF procedures are 11 mm in depth, 14 mm in width, and 5–7 mm in height. Therefore, the trabecular metal cage is inherently farther anterior than a cervical artificial disc, which usually aims to cover the entire disc footprint.⁷ This is evident in the fact that the smallest artificial disc depth is 14 mm, and the most often implanted ones are 16 mm in depth, which is larger than the cages. The proximity of implants to both the spinal canal and the neuroforamen is very likely to cause artifacts on MRI, even with TSE. On the other hand, nonmetallic spacers are often MRI-compatible and produce less susceptibility artifact.

TSE is synonymous with fast spin echo (FSE); the term used varies among the manufacturers of MRI units, with TSE being used by Siemens and Philips. From the view-

FIG. 1. **A and B:** Lateral extension (A) and flexion (B) radiographs obtained in a patient who had a cervical artificial disc implanted at C5–6. **C and D:** Sagittal (C) and axial (D) FSE MR images obtained in the same patient. There are marked artifacts on both the sagittal and axial MR images, despite the FSE sequence.

point of radiologists, the most significant benefit of a FSE/TSE sequence is the acceleration of the scan time without sacrifice of image quality. T2-weighted imaging profits most from this technique. Therefore, in most clinical applications, FSE/TSE sequences have replaced conventional spin echo T2-weighted imaging. The FSE/TSE sequence has gained clinical popularity worldwide over several decades but still has limitations in the reduction of metallic artifacts. There are many causes of artifacts around metal implants, such as signal loss from dephasing, failure of fat suppression, geometric distortion, in-plane distortion, and through-slice distortion.³ Nonetheless, the FSE/TSE sequence can only avoid dephasing effects. There are new techniques, such as multiaquisition variable-resonance image combination (MAVRIC), slice-encoding for metal artifact correction (SEMAC), MAVRIC-SL (a combination of MAVRIC and SEMAC); and WARP (a combination of VAT [view angle tilting] and SEMAC techniques), developed to provide better reduction of metallic artifacts around the metal implants by MRI physicists. Good results have been demonstrated by the application of some of these new techniques on spine MRIs.^{2,4-7}

There is definitely need for either a new MRI sequence or new implant material to allow better evaluation of postoperative anatomy of the cervical spine. The authors are commended for sharing their experience with worldwide readers of the *Journal of Neurosurgery: Spine*. Further investigations on the imaging modalities for evaluation of the postoperative spine would certainly improve the outcomes of modern spine surgery.

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Disclosures

The authors report no conflict of interest.

Response

We thank Dr. Chang and colleagues for their thoughtful comments on our study evaluating the impact of postoperative MRI artifact of tantalum mesh cage versus bone graft in ACDF. We agree with their assertion that TSE may not always completely mitigate postoperative paramagnetic susceptibility artifact following implantation of metallic interbody implants. It certainly made a significant clinical and statistical difference in our study (nerve roots rated as assessable in 88% vs only 54% when only standard T2-weighted images were available, $p < 0.01$), albeit specific to one type of metallic interbody device (tantalum mesh cage). We note that the nerve roots were still not assessable in 12% of our patients. Clearly, the artifact reduction of TSE may not extend to other metallic interbody devices, especially those with a larger or more posteriorly located interbody footprint (e.g., an artificial disc, as illustrated by the figure provided by Chang et al.). Given that we did not find TSE imaging of the spine consistently used during our study period (it was used in only 45% of cases in our cage group), it is an important issue to emphasize. Careful selection of optimal imaging sequences including TSE in the context of metallic cervical implants is important and dependent on good communication between requesting clinicians and radiologists. Finally, we concur that continued development of artifact-reducing MRI sequences as well as MRI-friendly spinal implant materials is needed.

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