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ORIGINAL ARTICLE

Comparisons of slice-encoding metal artifact correction and view-angle tilting magnetic resonance imaging and traditional digital radiography in evaluating chronic hip pain after total hip arthroplasty

Yimin Ma [a,*], Panli Zuo [b], Mathias Nittka [c], Xiaoguang Cheng [a], Hongyi Shao [d], Chen Wang [a]

[a] Department of Radiology, Jishuitan Hospital, Beijing, China
[b] Siemens Healthcare, MR Collaborations NE Asia, Beijing, China
[c] Siemens Healthcare GmbH, Erlangen, Germany
[d] Department of Orthopedics, Jishuitan Hospital, Beijing, China

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Metal artifact;
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Total hip arthroplasty

Abstract *Purpose:* The aims of this study were (1) to compare the areas of metal-induced artifacts and definition of periprosthetic structures between patients scanned with the slice-encoding metal artifact correction and view-angle tilting (SEMAC-VAT) turbo-spin-echo (TSE) prototype and those scanned with the standard TSE magnetic resonance (MR) sequences and (2) to further clarify the superiority of the SEMAC-VAT MR imaging technique at detecting lesions in patients after total hip arthroplasty (THA), compared with digital radiography (DR).
Materials and methods: A total of 38 consecutive patients who underwent THA were referred to MR imaging at our institution. All patients suffered from chronic hip pain postoperatively. Twenty-three patients of the 38 were examined with a 1.5-T MR scanner using a SEMAC-VAT TSE prototype and standard TSE sequence, and the remaining 15 patients were examined with the same 1.5-T MR scanner, but using the SEMAC-VAT TSE prototype only. The traditional DR imaging was also performed for all patients. Two radiologists then independently measured the area of metal-induced artifacts and evaluated the definition of both the acetabular and femoral zones based on a three-point scale. Finally, the positive findings of chronic hip pain after THA based on SEMAC-VAT TSE MR imaging and traditional DR imaging were compared and analysed.
Results: The areas of metal-induced artifacts were significantly smaller in the SEMAC-VAT TSE sequences than those in the standard TSE sequences for both the T1-weighted ($p < 0.001$) and

* Corresponding author.
E-mail address: 845547842@qq.com (Y. Ma).

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T2-weighted ($p < 0.001$) turbo inversion recovery magnitude images. In addition, 28 patients showed a series of positive signs in the SEMAC-VAT images that were not observed in the traditional DR images.
Conclusion: Compared with the standard TSE MR imaging, SEMAC-VAT MR imaging significantly reduces metal-induced artifacts and might successfully detect most positive signs missed in the traditional DR images.
Translational potential of this article: The main objective of this research was to show that MR sequences from the SEMAC-VAT TSE prototype provide a significant advantage at detecting lesions in patients after THA because of the excellent soft-tissue resolution of the MR imaging. SEMAC-VAT MR can evaluate chronic hip pain after THA and determine the cause, which can help the clinician decide on whether a surgical revision is needed.

Introduction

Total hip arthroplasty (THA) is widely performed to treat orthopaedic disorders of the hip joint such as end-stage osteoarthritis, severe fractures (especially for elderly patients) and bone tumours [1]. Although THA can relieve pain, maintain stability and restore activity of the hip joint, it also brings some periprosthetic-associated complications such as periprosthetic bone resorption, periprosthetic fractures and metal implant dislocations [2,3], which can cause hip pain to reoccur. Distortion-free magnetic resonance (MR) imaging around the metal has shown the great clinical potential for assessing patients suffering from continuous hip pain after THA.

Traditionally, patients after THA often undergo routine digital radiography (DR) and an additional computed tomography (CT) scan if necessary. As a standard imaging method for evaluating the clinical outcomes of an arthroplasty procedure, DR can clearly show the shape and location of the metal implant and the periprosthetic bone status. However, it has also been reported to have relative low sensitivity and specificity [4,5]. Moreover, the clinical application of CT is limited by its heavy metal-induced artifacts, high radiation dosage and low resolution of soft tissue [6]. Therefore, the ability to optimally assess individuals after THA has become an imperative goal.

MR imaging has become an important modality for assessing musculoskeletal disorders, especially THA, due to the high sensitivity in detecting soft-tissue lesions and differentiating imaging contrasts [6,7]. However, its application on routine examinations remains unknown based on the metal-induced artifacts in patients with THA. The predominant form of metal-induced artifacts is signal loss and signal pile-up, which are caused by large resonance frequency variations of the magnetic field [8—11]. These metal-induced artifacts can generally be categorised into two types: in-plane distortions (signal displaced within the plane) and through-plane distortions (signal displaced to other planes) [12]. Recently, view-angle tilting (VAT) and slice-encoding metal artifact correction (SEMAC) MR imaging techniques have been introduced to correct both in-plane and through-plane distortions to reduce metal-induced artifacts and to extend the clinical application of MR imaging for assessing patients with metal implants [12,13]. Previous studies have validated the use of SEMAC-VAT MR imaging to assess patients with THA [14—16]. However, few studies have clarified its superiority at detecting the pathological findings in patients with chronic hip pain after THA, especially with regard to a comparison with the traditional DR imaging.

The purpose of our study was to (1) compare the areas of metal-induced artifacts and definition of periprosthetic structures between patients scanned with a SEMAC-VAT turbo-spin-echo (TSE) prototype and with the standard TSE MR sequences and to (2) further clarify the superiority of the SEMAC-VAT MR imaging technique at detecting the pathological findings of patients with chronic hip pain after THA compared with the traditional DR imaging.

Material and methods

Patients

A total of 38 consecutive patients (12 men and 26 women; mean age: 53.89 ± 13.72; range: 29—80), who underwent THA with titanium alloy (cobalt—chromium included) metal-on-metal prostheses, were referred for MR imaging between July 2014 and October 2017 at our institution. Specifically, 29 patients had undergone unilateral THA, and the remaining nine had undergone bilateral THA. Of the 38 patients, 23 were examined with a 1.5-T MR scanner using a SEMAC-VAT TSE prototype and standard TSE sequence. The remaining 15 patients were examined with the same 1.5-T MR scanner but using the SEMAC-VAT TSE prototype only. All patients suffered from chronic hip pain postoperatively for more than 3 months.

MR and DR imaging

The SEMAC-VAT TSE prototype data of all patients were obtained using a 1.5-T MR scanner (MAGNETOM Espree, Siemens Healthcare, Erlangen, Germany) and an eight-channel hip coil. The parameters of the two SEMAC-VAT prototype sequences are given below: