

Improving the Assessment of the Postoperative Spine with 0.55T MRI: A Case Report

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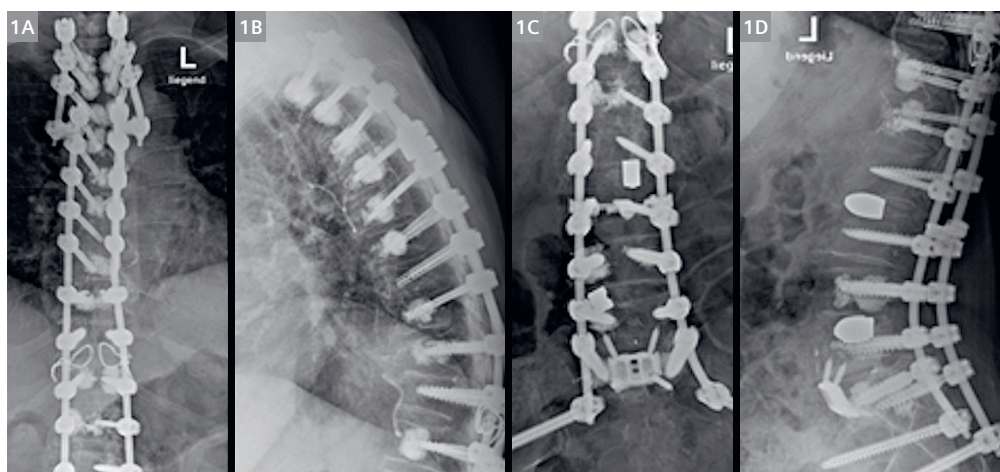
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Introduction

Acute and chronic back pain are common complaints and a major burden for healthcare systems worldwide [1]. With aging populations, the number of patients requiring spinal decompression or stabilization surgery related to trauma or degenerative changes is rising. As a result, the number of patients with spinal metal implants¹ requiring follow-up imaging is also increasing [2, 3]. Since magnetic resonance imaging (MRI) is the gold standard for spinal imaging in most practices, growing numbers of metal implants are creating diagnostic limitations caused by inevitable susceptibility artifacts. Besides the continual improvements in metal artifact reduction techniques for the assessment of the postoperative spine over the last few decades, another

promising approach for increasing diagnostic accuracy of MRI is the use of low-field systems [4]. While 1.5T and 3T MRI systems currently dominate clinical routine, low-field MRI systems are experiencing a renaissance after their initial use in the 1980s and 1990s. In particular, innovations in coil design, gradient systems, and image reconstruction techniques offer new opportunities for the use of low-field MRI systems in patients with metal implants [5].

This case report aims to highlight the potential of a newly commercially available 0.55T low-field MRI system in postoperative spinal imaging, compared to MRI systems operating at field strengths of 1.5T and 3T. It is based on our recent experiences with a 76-year-old female patient with multiple prior spinal stabilization surgeries.



1 AP (1A, 1C) and lateral (1B, 1D) radiographs of a 76-year-old female patient following lumbopelvic fusion and posterior spondylodesis up to the T2 level.

¹The MRI restrictions (if any) of the metal implant must be considered prior to patient undergoing MRI exam. MR imaging of patients with metallic implants brings specific risks. However, certain implants are approved by the governing regulatory bodies to be MR conditionally safe. For such implants, the previously mentioned warning may not be applicable. Please contact the implant manufacturer for the specific conditional information. The conditions for MR safety are the responsibility of the implant manufacturer, not of Siemens Healthineers.

Case presentation

Imaging was performed within the scope of a prospective study that was approved by the local ethics committee (BASEC 2021-00166). Written informed consent was obtained.

A 76-year-old female patient was referred to our hospital for a progressive paraparesis of the lower extremities after posterior decompression and stabilization surgery of the thoracic spine had been performed at another institution.

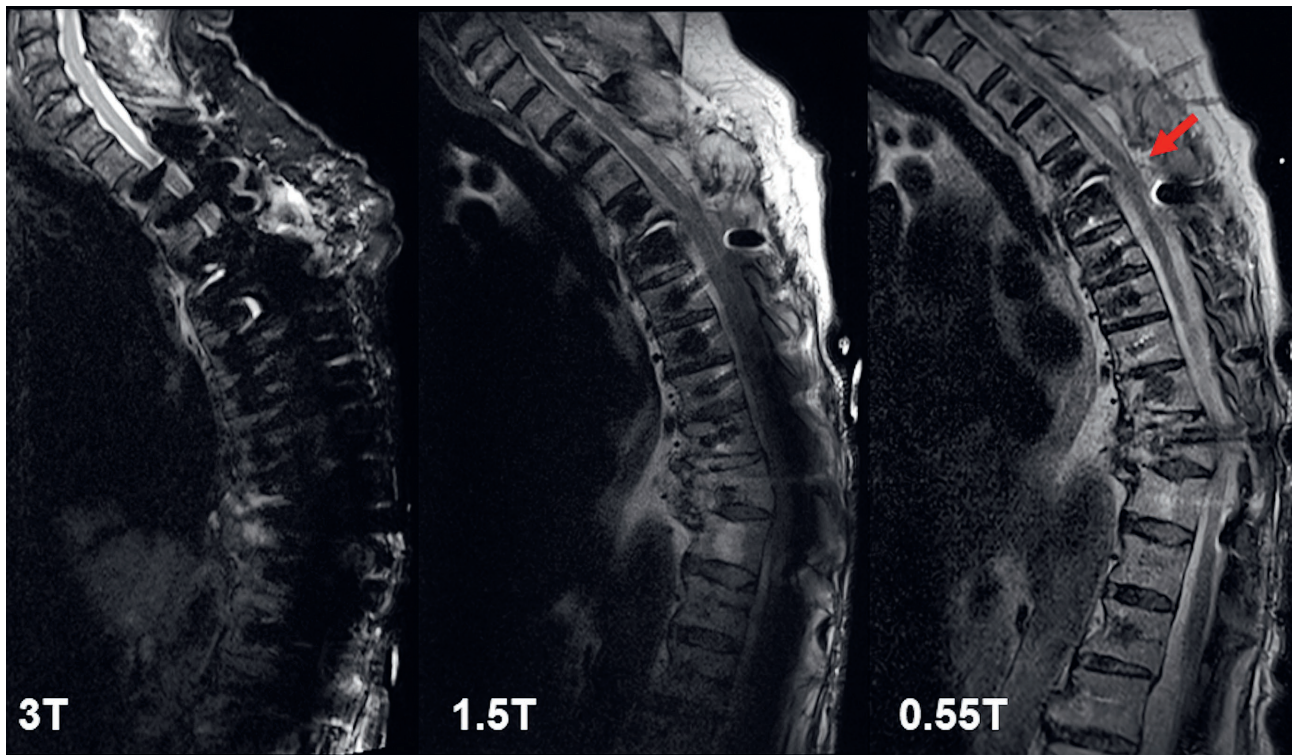
The patient history comprises multiple prior spinal surgeries. Initial single-level lumbar fusion of the L5–S1 segment was performed more than ten years ago. In October 2019, loosening of the pedicle screws in S1 as a result of pseudarthrosis made it necessary to perform anterior lumbar interbody fusion of the L5–S1 segment, and corrective posterior spondylodesis and lumbopelvic fusion. Progressive degeneration of the adjacent motion segments required extension of the posterior spondylodesis with cement-augmented pedicle screws up to the T5 level in September 2021. This was followed in October 2021 by a further posterior decompression and revision of the spondylodesis with extension up to the T2 level due to an acute T4 compression fracture with resulting spinal canal stenosis. The extent of the posterior instrumentation is shown in Figure 1. The aforementioned progressive paraparesis developed after the latter surgery, and the patient was ultimately transferred to our institution for further treatment. After initial clinical assessment, the spine surgery team ordered an MR examination of the whole spine to rule out a compressive postoperative spinal hematoma.

Imaging

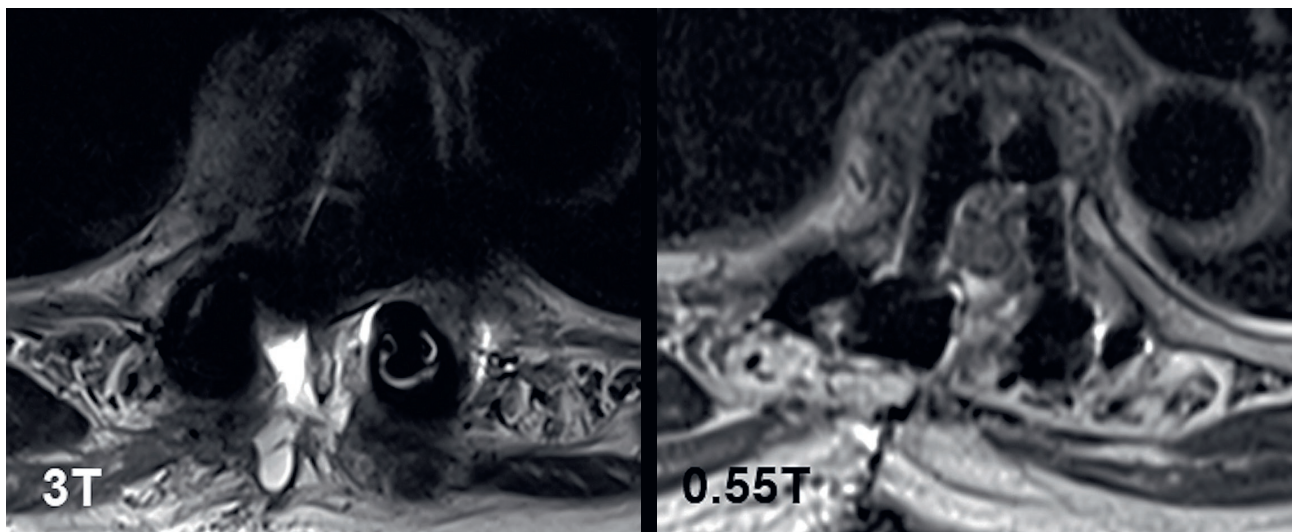
Given the patient's symptoms, the resulting potential indication for urgent spinal decompression surgery, and the lack of availability of a 1.5T MRI system at the time of presentation, initial imaging was performed on a 3T MRI scanner (MAGNETOM Skyra, Siemens Healthcare GmbH, Erlangen, Germany). Even though metal artifact reduction sequences were used during the examination, the severity of the susceptibility artifacts caused by the posterior instrumentation prevented assessment of the spinal canal. To rule out or confirm a postoperative compressive spinal hematoma, an additional MR examination of the whole spine was performed at 1.5T (MAGNETOM Avanto Fit, Siemens Healthcare GmbH, Erlangen, Germany). Metal artifact reduction sequences were again used to reduce artifact severity. However, the MR examination had to be stopped following the acquisition of the sagittal T1- and T2-weighted sequences, as the patient reported unbearable back pain whilst lying down. An image review by musculoskeletal radiologists and a discussion with the spine surgery team resulted in agreement that a final diagnosis could not be made with sufficient certainty, even though the ability to assess the spinal canal had improved on the 1.5T MRI system. In particular, the exact craniocaudal extent of the suspected postoperative hematoma, which would affect the surgical approach, could not be determined on the available sequences. It was therefore decided to repeat the MR examination with sufficient analgesia and take advantage of the newly installed low-field 0.55T MRI system (MAGNETOM Free.Max, Siemens Shenzhen Magnetic Resonance Ltd., Shenzhen, China). The examination at 0.55T was completed according to protocol (Table 1).

Sequence	B0 Field [T]	FOV [mm ²]	Matrix	TR [ms]	TE [ms]	Bandwidth [Hz/px]	TA [min:s]
T1 TSE sag	0.55	320 × 320	288 × 216	602	16	299	03:54
T2 TSE tra	0.55	200 × 200	192 × 144	4830	94	299	04:25
T2 TSE sag	0.55	320 × 320	320 × 240	3500	96	120	03:23
T1 TSE sag	0.55	320 × 320	320 × 224	454	13	130	02:28
T2 TSE Dixon cor	1.5	300 × 300	256 × 205	5200	92	455	04:04
T2 TSE sag	1.5	320 × 320	448 × 358	4400	102	505	04:10
T1 TSE sag	1.5	320 × 320	448 × 358	470	7.7	505	04:02
T2 TSE Dixon sag	3	340 × 340	448 × 314	5000	88	250	03:05
FLAIR sag	3	340 × 340	448 × 403	2000	29	260	03:20
T2 TSE tra	3	190 × 190	256 × 179	3000	100	500	03:06

Table 1: Sequences and associated parameters at 0.55T, 1.5T, and 3T. FOV = field of view



2 Sagittal T2-weighted metal artifact reduction sequences at 3T, 1.5T, and 0.55T. Note the decrease in susceptibility artifacts and substantially improved visibility of the spinal canal at 0.55T, with demarcation of a high-grade spinal stenosis at the T4/5 level caused by a compressive postoperative spinal hematoma (red arrow).



3 Axial T2-weighted metal artifact reduction sequences at 3T and 0.55T. High-grade spinal canal stenosis at the T4 level is clearly depicted at 0.55T, while the assessment of the spinal canal is not possible at 3T.

Diagnosis

With the substantially improved ability to assess the spinal canal on sagittal and axial T2-weighted images acquired using the low-field 0.55T MRI system, a postoperative compressive subdural hematoma extending from T4 to T5, and resulting in high-grade spinal canal stenosis without myelopathy, could be identified (Fig. 2). Even though a potential spinal hematoma might have been suspected on the sagittal T2-weighted images acquired at 1.5T, diagnostic confidence would have been low as spinal canal assessment was limited at this location. In particular, the craniocaudal extent of the subdural hematoma along two thoracic vertebrae was not visible on either 1.5T or 3T images, due to extensive susceptibility artifacts from the posterior instrumentation. Also, the degree of narrowing in the spinal canal and spinal cord deformation could only be determined on the axial T2-weighted images acquired at 0.55T (Fig. 3). The additional low-field MRI of the spine therefore provided crucial information to the referring spine surgeons with regards to their surgical approach for this patient.

Discussion

The correlation between field strength and metal artifact severity in MR imaging is well known and has been demonstrated both in phantom experiments and clinical studies [6, 7]. In addition to numerous existing and continually refined metal artifact reduction techniques, the introduction of a novel generation of low-field MRI systems operating at 0.55T may be considered as providing a new approach for improving image quality and diagnostic opportunities in patients with metal implants, especially following spinal instrumentation [5, 8, 9]. Particularly in an era of aging populations with accompanying increases in the prevalence of metal implants in multiple countries worldwide, these new approaches may overcome the current challenges of imaging this patient clientele on traditional 1.5T or 3T MRI systems. To the best of our knowledge, however, no studies have been performed to establish whether the reduction in metal artifact severity automatically translates into improved diagnostic performance or systematically affects patient management. This requires systematic investigation of large patient collectives.

This case report from our daily routine may provide a basis for future investigations, as the findings further underline the potential of modern low-field MRI systems in cases where diagnostic limits are reached when using well-established 1.5T and 3T MRI systems.

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