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ARTICLE

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Vacuum disc: frequency of high signal intensity on T2-weighted MR images

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Abstract *Objective.* To determine the frequency of lumbar intervertebral disc vacuum clefts demonstrating high signal intensity on T2-weighted magnetic resonance (MR) images.
Design and patients. MR images of the lumbosacral spine of 100 patients with radiographic evidence of the lumbar intervertebral disc vacuum phenomenon were retrospectively studied for the signal pattern of the intervertebral disc vacuum clefts.
Results and conclusion. Twelve of the reviewed MR studies demonstrated high signal intensity of the vacuum clefts on long TR and TE sequences while the remaining 88 cases demonstrated the vacuum as signal void on both T1- and T2-weighted images. It is concluded that vacuum clefts not infrequently show high T2 signal intensity.

Key words Vacuum phenomenon · Spine, intervertebral disc · Spine, MR · Spine, degeneration

Introduction

The vacuum phenomenon refers to the radiographic appearance of gas in an intervertebral disc space, usually in the lumbar spine [1]. Previous studies have demonstrated that on magnetic resonance imaging the vacuum phenomenon appears as a region of signal void on T1- and T2-weighted images [2]. However, intravertebral vacuum (Kummel's phenomenon) may show high signal intensity on T2-weighted images related to patient positioning and elapsed time [3, 4].

The aim of this retrospective study was to demonstrate the frequency with which the lumbar intervertebral vacuum phenomenon behaves similarly to the intravertebral vacuum clefts and shows high signal intensity on T2-weighted magnetic resonance (MR) images. This MR appearance might mimic a normal disc, an unstable segment or possible disc space infection.

Materials and methods

We reviewed the MR studies of the lumbosacral spine of 100 consecutive patients presenting with lumbar spine symptoms and radiologically proved to have the lumbar intervertebral disc vacuum phenomenon. There was no clinical suspicion of discitis in any of the patients. Vacuum was demonstrated by either plain radiography (62 patients) or computed tomography (CT) (38 patients) of the lumbosacral spine. Only patients in whom MR imaging was performed within a maximum of 1 week either before or after the radiographic study were included, to minimize the possibility of further pathological evolution. The age of the patients ranged from 37 to 87 years with a mean of 62.5 years. There were 53 men and 47 women.

The retrospectively studied MR images were performed on a superconducting MR unit (Signa; GE Medical Systems, Milwaukee, Wis.) operating at 1.5 T. All patients were examined in the sagittal and axial planes. The spin-echo (SE) technique was used with short repetition time (TR; 400–500 ms and short echo time (TE; 10–18 ms), while a long TR (2500–4000 ms) and long TE (80–120 ms) sequence was obtained with conventional spine-echo in 43 patients and fast spin-echo (FSE) in 57 patients. Axial cuts at the pathological disc level were also available. The matrix size was 256×256, with a field of view of 30 cm. The section thickness was 4 mm with an intersection gap of 1 mm.

The sagittal T1- and T2-weighted images were examined for the signal behavior of the intervertebral vacuum clefts. This was classified as being isointense, hypointense or hyperintense in comparison with the visualized distal cord as a standard of reference. The morphology of the high signal intensity involving the vacuum clefts was also noted.

Results

On MR images the intervertebral vacuum clefts demonstrated signal void on both T1- and T2-weighted images in 88 patients (88%). In 12 patients (12%), the vacuum clefts were hypointense on the T1-weighted images and hyperintense on the T2-weighted images. The high T2 signal intensity was uniform, involving the whole vacuum cleft, in six of these cases (50%) (Figs. 1, 2); four cases (33.3%) demonstrated a patchy change in signal intensity on the T2-weighted images, being partly hyperintense and partly hypointense. Two cases (16.7%) demonstrated a peripheral increase in signal intensity around the vacuum cleft on the T2-weighted images with the bulk of the vacuum continuing to have a hypointense signal (Fig. 3). Of the 12 cases demonstrating high T2 signal of the vacuum clefts, a FSE sequence was used in nine while the conventional spin-echo sequence was used in three cases. Follow-up of the 12 patients with hyperintense vacuum cleft did not reveal development of discitis or segmental instability.

Discussion

The vacuum phenomenon in intervertebral discs was first described 60 years ago by Magnusson [5]. In 1942, Knutsson [6] observed an association between the vacuum phenomenon and degenerative disc disease. Several reports have demonstrated that the vacuum phenomenon is best seen in extension views because of tensile stress [7].

Degenerative desiccation of the nucleus pulposus, primary intervertebral osteochondrosis, results in enlarging clefts [1, 8]. According to Griffiths [9], there is no synovial fluid within the disc to fill the degenerative potential space; consequently, gas in the surrounding extracellular fluid comes out of solution to occupy the cleft. Ford et al. [10] reported that the vacuum consists of 90%–92% nitrogen.

In our review of 100 patients with the lumbar intervertebral disc vacuum phenomenon on MR imaging, 88 (88%) demonstrated hypointense signal of the vacuum clefts relative to the spinal cord on both T1- and T2-weighted images. This agrees with the results of Granier et al. [2] who reviewed 150 MR studies of the lumbosacral spine and concluded that the vacuum phenomenon is recognized as an area of signal void, such that its signal intensity will be less than that of cortical bone on all pulse sequences; they attributed this to the negligible proton density of gas. However, in 12 of our patients (12%) the intervertebral vacuum clefts were hypointense on the T1-weighted sequence and hyperintense on the T2-weighted sequence – a pattern not previously recognized. The T2 pattern in these cases varies from hyperintensity of the whole vacuum cleft to focal hyperintensity, or a hyperintense rim surrounding the persistently hypointense vacuum cleft.

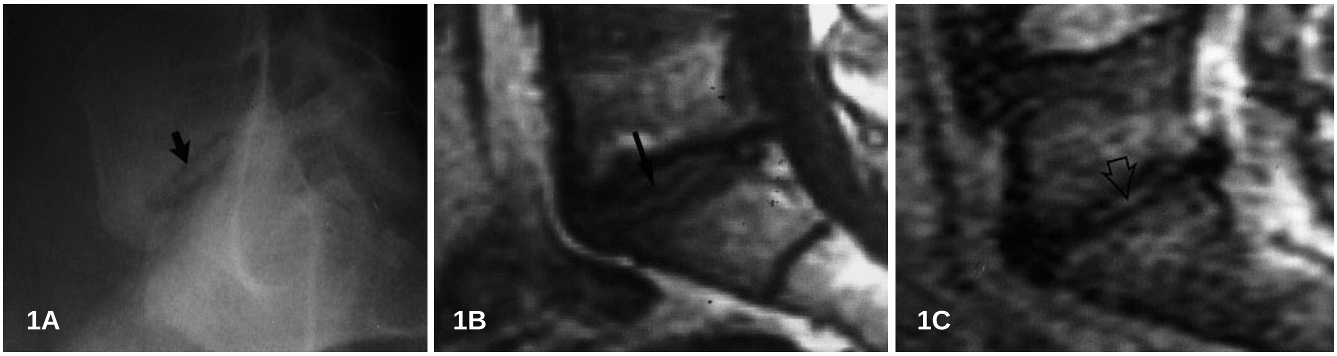
This discal MR pattern is similar to previous descriptions of the MR appearance of the intravertebral vacuum clefts, which was attributed to prolongation of the T2 relaxation time of the fluid and inflammatory exudate during the early phases of avascular necrosis [3]. Malghem et al. [4], however, proposed that the initial gas-like content of the intravertebral cleft can be replaced progressively by fluid during MR imaging as patients lie supine for a longer time than that needed for conventional radiography. They correlated this with several factors, such as the duration of recumbency before examination, variable intensity of the distraction applied on the spine by extension resulting from the supine position, and variable permeability of the cleft walls. We think that a similar mechanism could explain why the intervertebral disc vacuum clefts demonstrate high signal intensity on T2-weighted images. The difference in high T2 signal pattern, ranging from homogeneous to focal to marginal, could be explained by the same factors previously postulated by Malghem et al. [4].

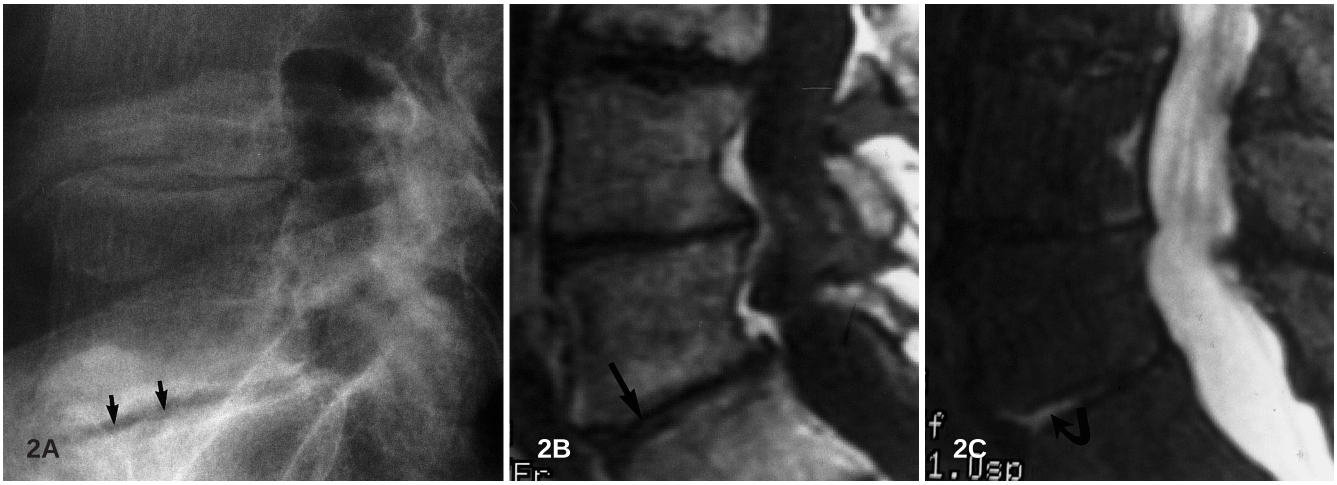
Another possible explanation for this phenomenon, given that in nine of the 12 cases demonstrating high T2 signal of the vacuum clefts MR imaging was performed utilizing the FSE sequence, is that with this sequence there is decreased sensitivity to the magnetic susceptibility phenomena that occur near the junction of gas and soft tissue structures.

A confounding factor is the potential for chemical shift artifact, since fat suppression was not routinely used; this may have either altered the size and perceptibility of the vacuum signal or affected the pattern of this signal.

We accept a number of limitations of our study. First, the number of cases is not large. Second, population bias has occurred since only a fraction of the patients with the vacuum phenomenon had an MR study performed within one week of their radiographic study. Lastly the reviewed studies were not performed using identical imaging parameters; however, in our protocol the difference in imaging time between conventional spin-echo and FSE T2 sequences is trivial and neither is done prior to the T1 sequence.

Accepting these limitations, we concluded that the vacuum phenomenon can infrequently demonstrate fluid-like behavior on MR imaging that might potentially render confusion in a minority of cases with disc space infection or segmental instability or may even mimic a “normal disc”. Awareness of this imaging appearance emphasizes the importance of the availability of plain radiographic or CT studies during the interpretation of MR images.





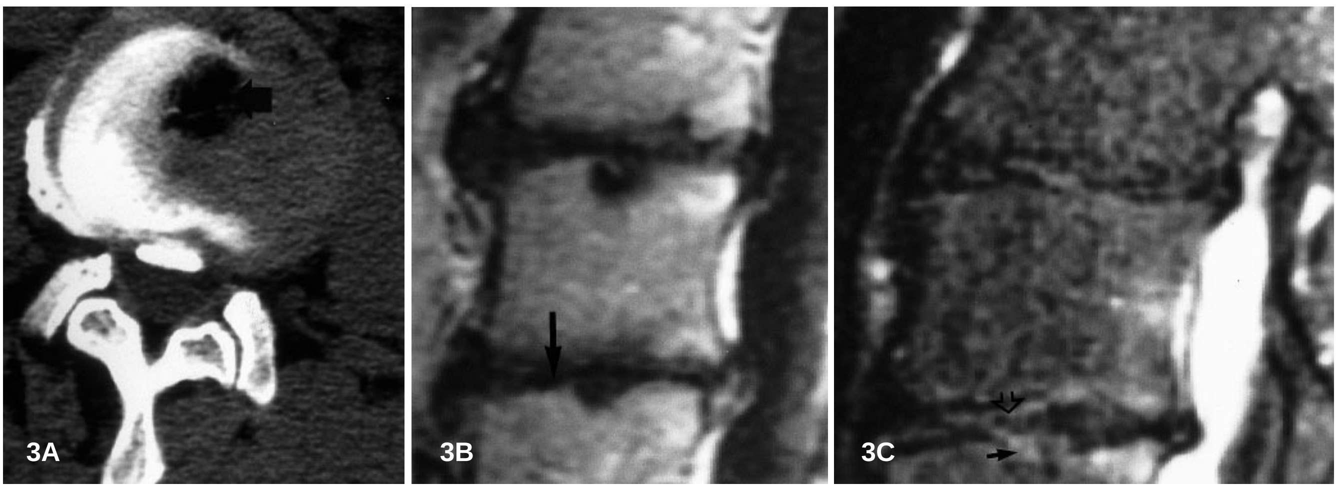


Fig. 1A–C A 39-year-old man. **A** Routine lateral radiograph of the lumbosacral junction shows a horizontally oriented vacuum cleft at the L5–S1 disc (*arrow*). **B** T1-weighted (567/10) MR image reveals a horizontal hypointense cleft at the L5–S1 disc (*arrow*) corresponding to the site of the vacuum cleft. **C** T2-weighted (1800/80) MR image demonstrates homogeneous hyperintensity of the vacuum cleft (*arrow*)

Fig. 2A–C A 63-year-old man. **A** Routine lateral radiograph of the lumbosacral junction region demonstrates a vacuum cleft at the L5–S1 disc level (*arrows*) associated with advanced spondylitic changes with disc space narrowing and end-plate sclerosis. **B** T1-weighted (400/12) MR image shows the vacuum cleft as a signal void (*arrow*) that is hardly separable from the lower vertebral end-plate of L5. **C** The vacuum cleft becomes homogeneously hyperintense (*arrow*) on the fat-suppressed T2-weighted (2616/95Ef) MR image

Fig. 3A–C A 41-year-old woman. **A** CT scan at the L2–3 disc level shows an intradiscal vacuum cleft (*arrow*). Associated apophyseal osteoarthritic changes are noted also. **B** T1-weighted (500/12) MR image demonstrates a hypointense vacuum cleft at the L2–3 disc (*arrow*). **C** T2-weighted (2633/76Ef) MR image reveals a marginal rim of hyperintensity surrounding the vacuum cleft (*open arrow*). A portion of the marginal T2 hyperintensity appears to be within a Schmorl's node at the upper end-plate of L3 (*small arrow*)

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