**Purpose**

Intradiscal vacuum phenomenon is a common finding in computed tomography (CT) of degenerative lumbar disc disease. Intradiscal fluid in MRI is rare in osteochondrosis and always raises the suspicion of spondylodiscitis.

Our aim was to correlate:

1) the presence of intradiscal vacuum phenomenon on CT to intradiscal fluid on MRI

2) the presence of end-plate changes with the presence of intradiscal fluid.

**Methods and Materials**

**Patients:**

19 patients (14 female, 5 male, mean age 71, age range 27-85 years) from our orthopaedic department, who had obtained a CT scan of the lumbar spine at our institution during their in-patient stay between November 2008 and July 2010 were enrolled in this study. Inclusion criteria were the presence of an intervertebral vacuum phenomenon on CT in one or more vertebral motion segments.

Patients with acute vertebral fractures, known or suspected spondylodiscitis, recent spinal surgery (<4 months), patients with a history of malignant tumours as well as patients who were clinically unstable or with any contraindication to MRI were excluded.

**CT and MRI:**

CT scans were performed on a 64-multidetector-row CT scanner (Somatom Sensation 64; Siemens Healthcare, Erlangen, Germany). The following parameters were employed: effective mAs: 300; kV: 120; Pitch: 0.9; collimation: 16 x 0.75 mm, and 64 x 0.6 mm. Axial and sagittal multiplanar images were reconstructed with a slice thickness of 2 mm.

The CT data sets were assessed by two experienced radiologists in a consensus reading (GS, ABM) for the presence and location of osteochondrosis and intervertebral vacuum phenomenon. Each vertebral motion segment was also assessed for the presence of erosive changes of the end-plates and their location.
The subjects then prospectively underwent two separate identical MRI exams, on a SIEMENS Avanto 1.5 Tesla system. One exam was performed after a period of mobilisation, and the other exam was performed after at least 6 hrs of overnight bed rest in the early morning. See Table 1- Study Protocol.

The MR images were assessed by the same readers (GS, ABM) for the presence of intradiscal fluid or intradiscal hyperintense signal and their respective locations were recorded. Intradiscal fluid was diagnosed as such if its signal intensity on T2-w images was equivalent to that of cerebrospinal fluid (CSF). An intradiscal hyperintense signal was described where the signal intensity of the disc on T2-w images was higher than that of other normal discs, but not equivalent to the signal intensity of CSF. This was correlated to the location of intervertebral vacuum phenomenon on CT. The two MRI exams were read in the same way and compared to assess any differences in the presence and amount of intradiscal fluid/hyperintense signal after mobilisation and after bed rest. Each vertebral motion segment was assessed for the presence and amount of bone marrow oedema along the end-plates (Modic Type I changes). If bone marrow oedema was present, the maximum vertical height of bone marrow hyperintense signal on STIR for each of two vertebrae adjacent to a discal segment was measured and calculated as a percentage of the total vertebral height. The percentage values for the two vertebrae were added, the resulting value (out of a maximum of 200) being an indicator of the amount of bone marrow oedema in the vertebrae adjacent to a discal segment. A total of 90 vertebral motion segments were evaluated.

Statistical analysis:

All patient and image interpretation data were collected in a database and analyzed with statistical data collection software (Excel, Microsoft, Redmond). A score representing the amount of bone marrow oedema for each vertebral motion segment was calculated as described above. The presence and the amount of bone marrow oedema and the presence of erosive changes of the end-plates in CT were correlated to the presence of intradiscal fluid/hyperintense signal and assessed for statistical significance by means of logistical regression models with random intercepts using SAS-Procedure PROC GLIMMIX (SAS Version 9.2 for Windows, SAS Institute, Cary, NC, USA).

Images for this section:
### Table 1 - MRI Study Protocol

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Fig. 1: Table 1 - MRI Study Protocol
Results

Out of the 90 evaluated discal segments, 64 (71.1%) showed an intradiscal vacuum phenomenon. 47 segments (52.2%) showed erosive changes of the adjacent endplates.

**After mobilisation** 15/64 segments showed a fluid-isointense signal (n=11) or hyperintense signal (n=4).

**After bed rest** the presence of fluid and hyperintense signal increased significantly (P-value <.0001). 40 segments (62.5%) out of 64 segments with vacuum phenomenon in CT showed intradiscal fluid (28/40) or hyperintense signal (12/40) (Fig. 2,3). There was no fluid signal in a disc level without intervertebral vacuum in CT. The remaining discal segments (without fluid signal or hyperintense signal) showed normal disc SI (n= 15) or dehydrated degenerative disc disease (n= 35).

17 discal segments showed exclusively fluid after bed rest. 9 segments showed more fluid after bed rest when compared to the exam after mobilisation. 2 segments had an unchanged amount of fluid in both exams.

Out of the 12 segments with hyperintense signal after bed rest, 9 segments (75%) showed a hyperintense signal exclusively after bed rest, while 3 segments showed a stronger hyperintense signal after bed rest than after mobilisation.

**Within the time course of the MR exam after mobilisation** there were 5 discal segments in 3 patients which showed a very discrete amount of fluid in the first T2-w sequence but then exhibited a significant increase in the second T2-w sequence 12 minutes after commencement of the exam. This was in turn followed by a slow progressive increase in fluid signal till the last T-2w weighted sequence (Fig. 4).

There were 2 discal segments in 2 patients which showed no fluid signal in the first T2-w sequence, but showed a fluid signal in the second T2-w sequence 12 minutes after commencement of the exam, followed by a slow progressive increase in discal fluid till the last sequence.

In contrast, when the same patients underwent the MR exam after bed rest (without prior mobilisation) there was no difference in fluid signal or hyperintense signal during the time course of the exam.

The presence of bone marrow oedema, the amount of bone marrow oedema and the presence of erosive changes of the end-plates in CT were correlated to the presence of...
intradiscal fluid/hyperintense signal and assessed for statistical significance as described above.

26/90 segments showed type Modic I changes (oedema) along the end-plates. All of the segments with type Modic I changes along the end-plates showed a vacuum phenomenon on CT (26 out of 64 segments with vacuum phenomenon). The mean score of oedema along the adjacent endplates was 22.78/200.

The presence of fluid or hyperintense signal was significantly correlated to the presence (P-value <.0001), and amount of oedema along the end-plates (P-value <.0004).

46/90 segments showed erosive changes of the end-plates in CT. 40/64 segments with intradiscal vacuum showed erosive changes in CT. The presence of erosive changes in CT was significantly correlated to the presence of fluid or hyperintense signal (P-value <.0001). Finally oedema in MRI (type Modic I changes) was significantly correlated to erosive end-plate changes in CT (P-value <.0001).

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Fig. 1: Table 1 - MRI Study Protocol
Fig. 2: 71 year-old female with osteochondrosis and vacuum phenomenon in multiple discal segments. CT and MRI of the lumbar spine after mobilisation (a) sagittal CT image
showing intervertebral vacuum phenomena as well as erosive changes of the endplates at several levels (b) sagittal T1-w image (c) sagittal STIR image showing vertebral bone marrow oedema at several levels, particularly T12/L1, L2/L3 and L3/L4 (d) sagittal T2-w image showing a discrete hyperintense signal at T12/L1 (arrow). (e,f) STIR and T2-w images after 6 hours of bed rest, now showing a fluid-isointense signal at the T12/L1 and L2/3 disc levels (arrowheads).

Fig. 3: 77 year-old female patient with osteochondrosis and vacuum phenomenon of the lumbar spine. CT and MRI of the lumbar spine after mobilisation (a) sagittal CT image
showing vacuum phenomena in the L2/3, L3/4, mildly in L4/5 and L5/S1 discs as well as erosive changes of the vertebral endplates at L2/3 and L3/4 levels (b-d) T1-w, STIR and T2-w images showing Modic Type II changes of the L2/3 and L3/4 endplates. T2-w image shows no hyperintense signal or fluid in the discal segments of L2/3 and L3/4 level (arrowheads). (e,f) MRI after 6 hours of bed rest. Sagittal STIR and T2-w images show now a marked hyperintense signal in the discal spaces L2/3 and L3/4 (arrowheads).

Fig. 4: MRI after mobilisation of the same patient as in Fig.2. At the level of T12/L1 there is initially no fluid in the first T2-w image (a). Fluid first appears in the second T2-w sequence (b) 9 minutes after commencement of the scan and shows a minimal progressive increase in the remaining T2-w sequences (c-e).
Conclusion

The replacement of intradiscal vacuum by intradiscal fluid in degenerative discs is a dynamic process, which is time- and position-dependent. Other factors, such as the individual anatomic and physiologic situation may also play a role. Fluid or hyperintense signal is seen more commonly in patients after prolonged bed rest. The presence of fluid/hyperintense signal is correlated to the presence and amount of bone marrow oedema and erosive endplate changes. Mobilisation of patients before MR examination can reduce the appearance of fluid/hyperintense signal, which can be a diagnostic dilemma to the diagnosis of spondylodiscitis, especially when band-like bone marrow oedema is present. Our findings also underline the important role of dynamic imaging in the study of functional phenomena in pathological spinal conditions.

References


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