# Diagnostic Yield of Multidetector Computed Tomography in Patients with Acute Spondylodiscitis

## Diagnostischer Wert der Multidetektor-Computertomografie bei der akuten Spondylodiszitis

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## ZUSAMMENFASSUNG

**Ziel** Evaluation der diagnostischen Genauigkeit der Multidetektor-Computertomografie (MDCT) bei der akuten Spondylodiszitis.

**Material und Methoden** Die radiologische Datenbank unserer Klinik wurde nach Patienten durchsucht, bei denen zwischen 2007 und 2015 eine Magnetresonanztomografie (MRT) zum Ausschluss einer Spondylodiszitis durchgeführt wurde (n = 325). In die weiteren Analysen wurden die Patienten eingeschlossen, die zuvor eine MDCT erhalten hatten (n = 67). Statistische Genauigkeit, Sensitivität und Spezifität sowie positiver und negativer prädiktiver Wert wurden insgesamt für die MDCT und getrennt für native (NECT, n = 31) und kontrastmittelgestützte (CECT, n = 36) MDCT berechnet. Die Ergebnisse der MRT und der klinische Verlauf wurden als Referenz herangezogen.

**Ergebnisse** Bei 34 von 43 Patienten mit einer mittels MRT diagnostizierten akuten Spondylodiszitis konnte der Befund bereits in der MDCT nachgewiesen werden. Die Spezifität und der positive prädiktive Wert der MDCT waren 100 %. Die Sensitivität betrug 79 % und der negative prädiktive Wert 72 %. Die Gesamtgenauigkeit wurde mit 87 % berechnet. Die Genauigkeit der CECT (89 %) war höher als die der NECT (84 %), der Unterschied war jedoch statistisch nicht signifikant (p = 0,55). Mittels der MDCT konnten 90 % der paravertrebralen Abszesse (34/38), aber nur 6 % der epiduralen Abszesse (2/36) erkannt werden.

**Schlussfolgerung** Die MDCT weist eine nur moderate Sensitivität, jedoch eine exzellente Spezifität und einen hohen positiven prädiktiven Wert bei der Diagnostik der akuten Spondylodiszitis auf. Bei einem positiven Befund in der MDCT können insofern formal umgehend weitere Therapiemaßnahmen eingeleitet werden. Trotzdem muss bei jeder akuten Spondylodiszitis eine MRT erfolgen, um Komplikationen wie einen epiduralen Abszess auszuschließen, welcher mit der MDCT nicht zuverlässig nachgewiesen werden kann.

**Kernaussagen:**

- Aufgrund der oft unspezifischen klinischen Symptomatik der Patienten mit einer Spondylodiszitis wird häufig die Computertomografie als initiales bildgebendes Verfahren eingesetzt (in ca. 20 % der Fälle).
- Die MDCT weist im Vergleich zur MRT eine nur moderate Sensitivität, jedoch eine exzellente Spezifität und einen hohen prädiktiven Wert hinsichtlich der Diagnose der akuten Spondylodiszitis auf.
- Der Nachweis eines paravertebralen Abszesses erweist sich als sicherster Indikator für die Diagnosestellung der akuten Spondylodiszitis in der MDCT.
- Trotz hoher Spezifität und hohem prädiktiven Wert der MDCT für die akute Spondylodiszitis ist die Durchführung der MRT zum Ausschluss von Komplikationen wie dem epiduralen Abszess unabdingbar.

## ABSTRACT

**Purpose** To determine the value of multidetector computed tomography (MDCT) in patients with acute spondylodiscitis.

**Methods and Materials** For data acquisition, we searched our radiological database for all patients who had undergone magnetic resonance imaging (MRI) for suspected spondylodiscitis between 2007 and 2015 (n = 325). For further analyses, we included all patients (n = 67) who initially underwent MDCT prior to MRI. Overall accuracy, sensitivity, specificity and positive and negative predictive values were calculated for MDCT and, separately, for contrast-enhanced CT (CECT, n = 36) and for non-enhanced CT (NECT, n = 31). MRI together with clinical evaluation served as the standard of reference.

Results: In 34 of 43 patients with acute spondylodiscitis on MRI, correct diagnosis was already made by the initial MDCT scan. The specificity and positive predictive value were 100 % for MDCT. The sensitivity was 79 % and the negative predictive value was 72 %. The overall accuracy was 87 %. Accuracy was higher for CECT (89 %) than for NECT (84 %), however without statistical significance (p = 0.55). MDCT detected 90 % of paravertebral abscesses (34/38), but only 6 % of epidural abscesses (2/36).

**Conclusion** MDCT has moderate sensitivity, but high specificity for acute spondylodiscitis. Thus, if MDCT is positive for spondylodiscitis, treatment can be started without further delay. However, MRI should be added to both MDCT negative and positive cases to rule out complications such as epidural abscesses that cannot reliably be detected by MDCT.

**Key Points:**

- Patients with acute spondylodiscitis are often initially suspected of having other differential diagnosis because of nonspecific symptoms.
- Therefore, MDCT is frequently performed prior to MRI in patients with acute spondylodiscitis.
- MDCT proved moderate sensitivity but high specificity for the diagnosis of acute spondylodiscitis.
- Paravertebral abscess is a strong indicator for the presence of spondylodiscitis on MDCT.
- However, MRI is crucial to rule out epidural abscesses, an important complication.

**Citation Format**

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# Introduction

Spondylodiscitis – the osteomyelitis of the spine and inflammation of the adjacent disc – has a low but increasing incidence of about 2.4/100 000 [1, 2] and high risk of sequelae [3]. It can result from hematogenous spread of pathogens following a distant infection, in continuity from neighboring tissues or after spinal surgery [4]. Elderly patients and those with immunosuppressive diseases, renal failure, or intravenous drug abuse are at particular risk [5]. Diagnosis can be challenging as patients may present with nonspecific symptoms such as back or abdominal pain [6], fever, malaise and/or elevated inflammatory blood values while blood cultures often return negative [5]. Moreover, symptoms can be masked by previous (self-) medication, resulting in a delay of correct diagnosis of up to several months [4].

Magnetic resonance imaging (MRI) is the recommended reference standard for diagnostic evaluation of suspected spondylodiscitis [5, 7]. MRI is highly accurate in the diagnosis of spondylodiscitis with a sensitivity and specificity of above 95 % [7 – 9]. The inherent high soft-tissue contrast of MRI allows for reliable detection of the inflammation of vertebrae and discs as well as paravertebral and epidural abscesses and bone erosions [9].

However, due to the nonspecific symptoms in patients suffering from acute spondylodiscitis, computed tomography (CT) is frequently performed prior to MRI to rule out other differential diagnoses in the course of the diagnostic work-up. Likewise, patients with an infectious state of unknown origin undergo CT as the first-line imaging procedure [10]. Besides that, MRI is contraindicated in patients with metallic or cochlear implants as well as non-MRI-compatible cardiac pacemakers. Moreover, it may not be performed in patients suffering from claustrophobia without sedation.

With its high availability in the acute setting, CT enables rapid assessment of other alternative diagnoses such as vertebral and sacral fractures [11 – 13] or infectious pathologies outside the spine [10]. Therefore, CT may serve as the primary imaging method in emergency situations.

Yet, there is a gap in the current literature about the accuracy of CT in the diagnosis of suspected spondylodiscitis. Previous studies used outdated single-slice scanners with a relatively high slice thickness, or investigated a rather small patient collective [14, 15]. Technical advances such as the introduction of the thin-sliced multidetector CT (MDCT) technique and multiplanar reconstruction have significantly improved the diagnostic yield of CT, e. g. in traumatic injury of the spine [16 – 18].

So far, there is no current study that evaluates the diagnostic accuracy of MDCT in the clinical setting of acute spondylodiscitis. Furthermore, there is a lack of data providing information about the additional value of MRI in the diagnosis of spondylodiscitis, e. g. the detection of complications, such as abscess formation.

Therefore, the purpose of the study was to determine the value of MDCT in patients with acute spondylodiscitis.

# Materials and Methods

## Patients

This retrospective study was HIPAA-compliant and IRB-approved. The need for informed consent was waived.

In the clinical routine of our institution, all patients with suspected spondylodiscitis undergo MRI if appropriate – even if diagnosis of spondylodiscitis has previously been made on MDCT – to confirm the diagnosis and rule out affection of further vertebral segments or complications, e. g. epidural abscess. Therefore, we searched our radiologic information system for MRI of the spine for clinically suspected spondylodiscitis between January 2007 and December 2015 and identified 325 patients (median 66 years, interquartile range [IQR] 55 to 75 years; 157 females).

In 67 of the 325 patients (21 %), MDCT was performed prior to MRI as the primary imaging modality because diagnoses other than spondylodiscitis were initially suspected. Clinical indications for MDCT were the ruling out of fracture (n = 15), radiological alignment check after spine surgery (n = 6), detection or exclusion of thoracoabdominal infectious foci (n = 40), suspected oncological disease (n = 5) or suspected vascular disorder (n = 1). The median time interval between MDCT and MRI was one day (IQR 0 to 4 days). All 67 patients (median age 65 years, IQR 56 to 75 years; 27 females) were included for further analyses.

## MR Imaging

Magnetic resonance examinations were performed using either a 1.5-T (Philips Achieva, Philips Healthcare, Best, the Netherlands or Avanto, Siemens Medical Solutions, Erlangen, Germany) or a 3.0-T system (Philips Intera, Philips Healthcare, Best, the Netherlands) with a multichannel receive-only surface coil. The imaging protocol comprised T1-weighted and fat-saturated T2-weighted turbo spin-echo (TSE) pulse sequences in sagittal and axial planes (TR/TE, 400 – 465/9 and 2000 – 3500/100 ms), respectively. A slice thickness of 4 mm and a field of view of 340 × 340 mm were used for all sequences. In 62/67 patients (93 %), intravenous injection of 0.2 ml gadopentetate dimeglumine per kilogram body weight (Gd-DTPA, Magnograf, 0.5 mmol/ml, Jenapharm, Jena, Germany) followed by axial and sagittal T1-weighted TSE sequences with fat saturation (TR/TE, 500 – 767/9 – 13 ms) was performed. Due to impaired renal function (glomerular filtration rate < 30 mg/dl), no contrast agent was injected in the remaining 5 patients.

## MDCT Imaging

MDCT was performed using either a 64-detector (Brilliance 64, Philips Healthcare, Best, the Netherlands) or a 256-detector MDCT scanner (iCT 256, Philips Healthcare, Best, the Netherlands) with a collimation of 64 × 0.625 mm and 128 × 0.625 mm, respectively.

In 31 of the 67 patients (46 %), a non-contrast-enhanced CT (NECT) scan and in 36 of the 67 patients (54 %) a contrast-enhanced abdominal, thoracicoabdominal or cervico-thoracic-abdominal CT (CECT) was performed prior to MRI. For the 36 CECT scans we used non-ionic iodinated contrast material (100 – 120 ml) with an iodine concentration of 300 mg/ml (Imeron, Bracco s.p. a. Milan, Italy or Iohexol, GE Healthcare, London, UK). Contrast enhancement was waived in the case of clinically suspected fracture or radiologic alignment check after surgery of the spine (n = 21). Moreover, no contrast agent was injected in 10 patients with impaired renal function (glomerular filtration rate < 30 mg/dl).

The latter 10 NECT and all 36 CECT data sets were reconstructed in axial, coronal, and sagittal orientation with a 5-mm slice thickness using a bone and soft-tissue kernel, a 512 × 512 matrix and a FOV of 40 × 40 cm. The remaining 21 NECT scans of the spine were reconstructed in axial, coronal, and sagittal orientation with a 3-mm slice thickness using a bone and soft-tissue kernel, a 512 × 512 matrix and a FOV of 20 × 20 cm. All MDCT scans were performed with 120 kV and a tube current–time product ranging from 90 to 170 mAs using automated exposure control.

## Image Analyses

The original interpretations of MRI and MDCT examinations of the on-duty board-certified staff radiologists (range of experience from 5 to 30 years) were used for analysis. We did not alter the original interpretations of the staff radiologists through retrospective image review to preserve the actual clinical impact of the image evaluation.

The following well-established criteria for acute spondylodiscitis are routinely used for image interpretation in our clinic:

- For MRI: Edema of the vertebrae and disc, paravertebral/epidural inflammation or abscess, bone erosion and enhancement of vertebrae and disc after injection of gadolinium on MRI [19].
- For MDCT: Erosion/destruction of the endplates and vertebral bodies as well as paravertebral/epidural inflammation or abscess formation on MDCT [14, 19].

Correct MRI diagnosis was further confirmed either by positive blood cultures and clinical follow-up or positive histopathological or microbiological samples gathered by open surgery or core needle biopsy.

## Statistical Analysis

The overall sensitivity, specificity and positive and negative predictive values (PPV and NPV) were calculated for MDCT (and separately for CECT and NECT) using MRI as the standard of reference. Pearson's Chi-squared test was used to test for significant differences in the accuracy of CECT and NECT. A P-value of less than 0.05 indicated a significant difference. The dedicated software R (version 3.2.3; R Development Core Team, Vienna, Austria 2015) was used for all statistical analyses.

# Results

## Reference standard

MRI revealed spondylodiscitis in 43 of the 67 patients (64 %) and ruled out spondylodiscitis in the remaining 24 patients (36 %). Correct MRI diagnosis was further confirmed by histopathological or microbiological samples in 39 patients (58 %), and by blood cultures and/or clinical follow-up in 28 patients (42 %). As causative pathogens, pyogenic spondylodiscitis was diagnosed in 41 of 43 patients (96 %), tuberculous spondylodiscitis was diagnosed in one patient (2 %) and brucellous spondylodiscitis in another patient (2 %).

A total of 45 vertebral segments were affected: 8 cervical (18 %), 18 thoracic (40 %) and 19 lumbar (42 %) segments. In 41 of the 43 patients (95 %) with spondylodiscitis, only 1 segment of the vertebral spine was involved, whereas 2 segments were affected in 2 of 43 patients (5 %). In both patients with two-segmental spondylodiscitis, one segment of the lumbar spine was affected and, additionally, one segment of the cervical spine and thoracic spine, respectively. For the calculation of the distribution of segmental affections and the frequency of findings on MRI and MDCT, all segments were included (45 segments in 43 patients).

The frequency of diagnostic findings of spondylodiscitis on MRI was as follows: edema of the vertebral body and/or intervertebral disc in 45/45 (100 %), bone erosion of the vertebral body in 19/45 (42 %), paravertebral and/or epidural inflammation in 43/45 (96 %), and contrast enhancement in vertebral bodies and/or intervertebral disc in 40/40 (100 %) of cases (▶ **Table 1**).

## MDCT results

In the case of MDCT, spondylodiscitis was diagnosed in 34 of the 67 patients (51 %; CECT: n = 19; NECT: n = 15) (▶ **Fig. 1, 2**). Both two-segmental cases of spondylodiscitis were diagnosed by CECT, resulting in 36 spondylodiscitis-positive segments. The

▶ **Table 1** Diagnostic findings of spondylodiscitis on MRI in 43 patients.

▶ **Tab. 1** MRT-Befunde bei 43 Patienten mit Spondylodiszitis.

| finding | location | number |
|---|---|---|
| edema | | 45 (100 %) |
| | vertebral body | 41 (91 %) |
| | disc | 31 (69 %) |
| bony erosions/ destructions | vertebral body | 19 (42 %) |
| inflammatory fluid collection in adjacent tissue | | 43 (96 %) |
| | intradiscal | 4 (9 %) |
| | epidural | 36 (80 %) |
| | paravertebral | 38 (84 %) |
| contrast enhancement | | 40 (100 %) |
| | vertebral body | 39 (98 %) |
| | disc | 26 (65 %) |

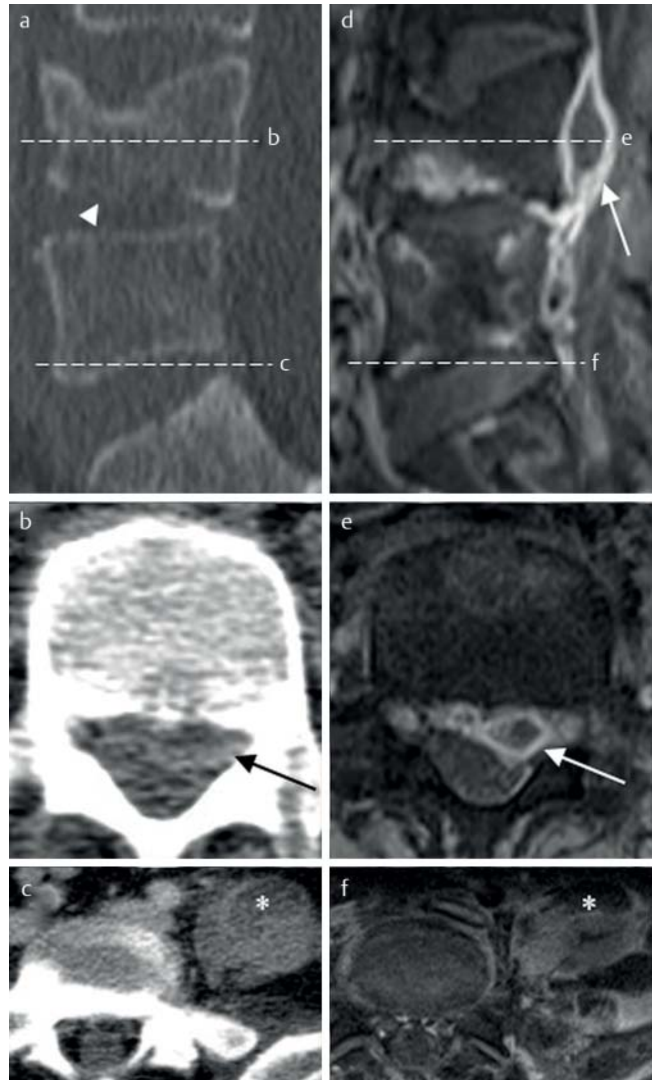
Note: In 43 patients with spondylodiscitis, all 45 affected segments were used for calculation. Numbers indicate involved number of segments. 38 of the 43 MRI examinations were contrast-enhanced (40 segments).
Beachte: Bei 43 Patienten wurden insgesamt 45 Segmente mit einer Spondylodiszitis im MRT nachgewiesen, welche alle für die weiteren Berechnungen herangezogen wurden. Es ist jeweils die Anzahl der betroffenen Segmente angegeben. 38 von 43 MRT-Untersuchungen waren kontrastmittelunterstützt (40 Segmente).

frequencies of diagnostic findings of spondylodiscitis on MDCT were bone erosions in 30/36 (83 %) and paravertebral/epidural inflammatory fluid collections or abscesses in 34/36 (94 %) (▶ **Table 2**).

## Diagnostic accuracy on a per-subject basis

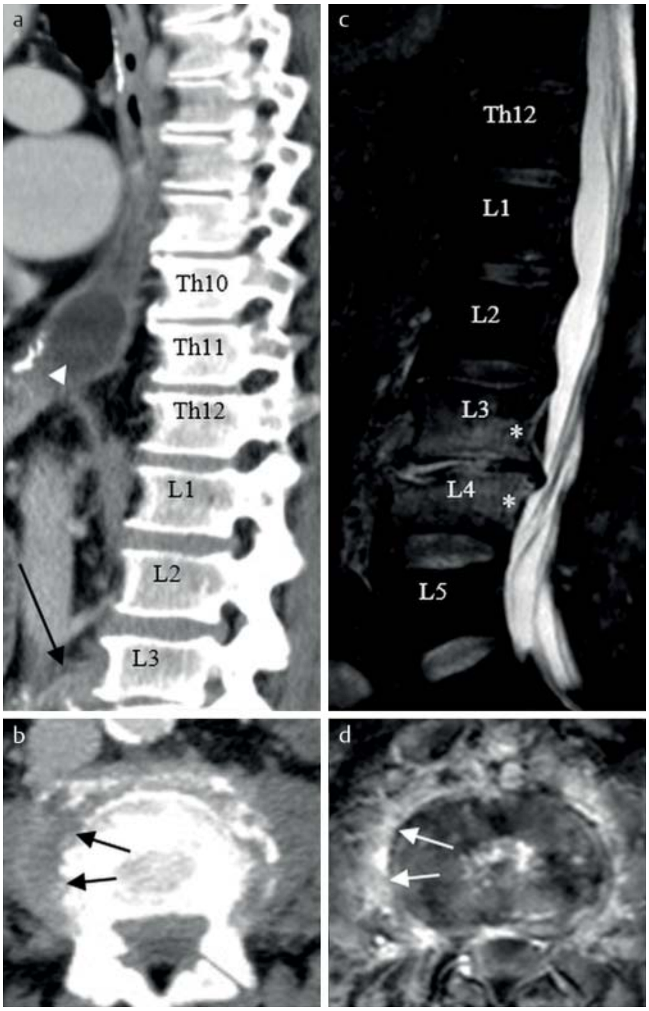
All 34 patients (including the two two-segmental cases) with diagnosis of spondylodiscitis on MDCT were classified as true positive according to the MRI standard of reference. Thus, MDCT had a specificity and PPV of 100 % using both CECT as well as NECT (▶ **Fig. 5**). MDCT yielded a false-negative result in 9 of 43 patients with confirmed spondylodiscitis (CECT: n = 4; NECT: n = 5). Thus, MDCT had an overall sensitivity of 79 % and NPV of 72 %. Overall, the accuracy of MDCT was 87 %. The sensitivity was higher for CECT (83 %) (19/23) compared to NECT (75 %) (15/20). The NPV was higher for CECT (77 %) compared to NECT (69 %). However, there was no statistically significant difference in the accuracy between CECT (89 %) and NECT (84 %; p = 0.55).

In the 9 false-negative cases of spondylodiscitis on MDCT, the staff radiologists prospectively misinterpreted findings as spinal osteochondrosis (CECT: n = 2; NECT: n = 3), osteoporotic fractures (CECT: n = 1; NECT: n = 1) or postinterventional alterations following vertebroplasty (CECT: n = 1) (▶ **Fig. 3**). On one CECT scan the finding of the spine was regarded as unremarkable. MRI showed that in 5/9 false-negative cases the extraosseous inflammatory




▶ **Fig. 1** Comparison of true-positive CECT **a**–**c** and MRI **d**–**f** of spondylodiscitis in segment L4/5 in a 50-year-old man. **a** Sagittal reconstruction in bone window of CECT with axial planes in soft-tissue window at indicated levels **b**, **c**. **d**–**f** Sagittal **d** and axial **e**, **f** fat-saturated T1-weighted contrast-enhanced MRI. Sagittal reconstruction of CT demonstrates the erosion of the endplate of L4 (arrowhead) with excellent image quality. Note the epidural (arrow) and paravertebral abscess in the left psoas muscle (asterisk) that can be detected by both CECT and MRI. Spondylodiscitis was confirmed by microbiological samples gathered during open surgery.

▶ **Abb. 1** Vergleich der richtig positiven kontrastmittelunterstützten CT und der MRT eines 50-jährigen Patienten mit akuter Spondylodiszitis im Segment L4/5. **a** Sagittale Rekonstruktion der MDCT im Knochenfenster mit den korrespondierenden transversalen Schichten im Weichteilfenster **b**, **c**. **d**–**f** Sagittale **d** und transversale **e**, **f** fettsaturierte T1-gewichtete MRT mit Kontrastmittel. Die sagittale Rekonstruktion der MDCT zeigt eine Erosion der Grundplatte LWK4 (Pfeilspitze). Beachte den epiduralen Abszess (Pfeil) und den paravertebralen Abszess im linken Musculus psoas (Stern), beide Befunde sind sowohl in der MDCT als auch im MRT abzugrenzen. Die Diagnose Spondylodiszitis wurde durch mikrobiologische Proben im Rahmen einer offenen Operation bestätigt.




▶ **Fig. 2** True-positive CECT for spondylodiscitis of L3/4 detected in thoracicoepigastral CECT in a 70-year-old man. Sagittal **a** and axial **b** CECT in soft-tissue window. Sagittal fat-saturated T2-weighted MRI **c** with axial fat-saturated T1-weighted contrast-enhanced sequences **d**. Diagnosis of spondylodiscitis on MDCT was challenging because findings were located at the border areas of the FOV. However, the paravertebral fluid collection adjacent to the intervertebral space (arrows) was suspicious for spondylodiscitis. Furthermore, the MRI shows edema of the disc and adjacent vertebral bones (asterisks). Note the gastric pull-up after esophageal cancer with esophagectomy 17 years ago (arrowhead). Spondylodiscitis was confirmed by positive blood cultures.

▶ **Abb. 2** Richtig positives Beispiel einer mittels kontrastmittelunterstützten CT von Thorax und Oberbauch diagnostizierten akuten Spondylodiszitis im Segment L3/4 bei einem 70-jährigen Patienten. Sagittale Rekonstruktion **a** und korrespondierende transversale Schicht **b** der MDCT im Weichteilfenster. Sagittale fettsaturierte T2 gewichtete MRT **c** und transversale fettsaturierte T1-gewichtete MRT mit Kontrastmittel **d**. Der Nachweis der Spondylodiszitis im MDCT war erschwert, da sich der Befund am kaudalen Rand des Untersuchungsvolumens befand. Trotzdem wies die paravertebrale Flüssigkeitsformation angrenzend an den Zwischenwirbelraum (Pfeile) auf eine Spondylodiszitis hin. Die MRT bestätigte den Befund und wies darüber hinaus noch ein Ödem in der Bandscheibe sowie in den angrenzenden Wirbelkörpern (Sternchen) nach. Beachte den Magenhochzug bei Zustand nach Ösophaguskarzinom mit Ösophagektomie 17 Jahre zuvor (Pfeilspitze). Die Spondylodiszitis wurde durch positive Blutkulturen bestätigt.

▶ **Table 2** Diagnostic findings of spondylodiscitis on MDCT in 34 patients.

▶ **Tab. 2** CT-Befunde bei 34 Patienten mit Spondylodiszitis.

| finding | CT imaging technique | number |
|---|---|---|
| bony erosions/destructions of end plates and vertebral bodies | | 30 (83 %) |
| | CECT | 16 |
| | NECT | 14 |
| inflammatory fluid collection in adjacent tissue | | 34 (94 %) |
| epidural | | 2 (1 %) |
| | CECT | 1 |
| | NECT | 1 |
| paravertebral | | 34 (94 %) |
| | CECT | 21 |
| | NECT | 13 |

Note: 34 patients with 36 affected segments of spondylodiscitis on MDCT. Both two-segmental cases of spondylodiscitis underwent contrast-enhanced CECT examination. In both segments with epidural abscess, paravertebral infectious fluid collection was also found. Numbers indicate the number of involved segments. CECT = contrast-enhanced CT; NECT = non-contrast-enhanced CT.
Beachte: Im MDCT wurden bei 34 Patienten insgesamt 36 Segmente mit einer Spondylodiszitis detektiert. Beide Fälle, bei denen jeweils zwei Segmente von einer Spondylodiszitis betroffen waren, wurden mittels kontrastmittelunterstützten CT untersucht. In beiden Segmenten mit epiduralem Abszess wurde auch ein paravertebraler Abszess nachgewiesen. Es ist jeweils die Anzahl der betroffenen Segmente angegeben. CECT = kontrastmittelunterstütztes CT; NECT = natives CT.

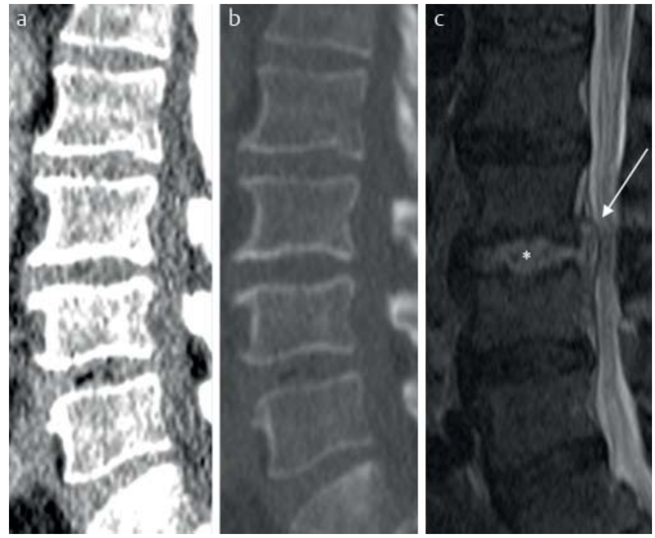
process (including phlegmonous inflammation and abscess) was limited to the epidural space, which was occult on MDCT (▶ **Fig. 4**). Overall MDCT was limited with respect to the evaluation of epidural inflammation, detecting only two of 34 epidural findings (6 %; CECT: n = 1, NECT: n = 1). However, MDCT was sensitive with respect to the detection of diffuse paravertebral inflammation or abscess formation: 34 of 38 segments (90 %) with paraspinal fluid collection or abscess (including abscess formation in the psoas muscle) were correctly identified by MDCT (▶ **Table 1, 2**).

## Discussion

In our patient population, MDCT was performed prior to MRI in the diagnostic work-up in approximately 20 % of patients undergoing MRI for suspected spondylodiscitis. In this setting, MDCT yields a moderate sensitivity (79 %) and excellent specificity (100 %) in the diagnosis of spondylodiscitis. The accuracy of MDCT was higher when using contrast agent (89 %) compared to non-enhanced studies (84 %). However, this was not significant in our study.


▶ **Fig. 3** False-negative NECT for spondylodiscitis of L2 – 4 after spinal intervention in a 50-year-old man. **a**, **b** Sagittal **a** and axial **b** NECT of the lumbar spine with positive findings of vertebral fractures of L3 and L4. NECT was not suspicious for spondylodiscitis. **c**, **d** Contrast-enhanced T1-weighted fat-saturated MRI demonstrates enhancement of vertebral bodies (asterisk) and paravertebral muscles (arrowhead) as well as an extensive abscess of the right psoas muscle (arrow). Spondylodiscitis was confirmed by microbiological samples gathered during open surgery.

▶ **Abb. 3** Falsch negative native CT einer Spondylodiszitis in den Segmenten L2 – 4 nach Wirbelsäulenoperation bei einem 50-jährigen Patienten. **a**, **b** Sagittale Rekonstruktion **a** und korrespondierende transversale Schicht **b** des CT der Lendenwirbelsäule mit Frakturzeichen in den Segmenten L3 und L4. Das CT lieferte keinen Anhalt für eine Spondylodiszitis. **c**, **d** In der fettsaturierten T1-gewichteten MRT mit Kontrastmittel zeigt sich eine Signalanhebung der Wirbelkörper (Sternchen) und paravertebralen Muskeln (Pfeilspitze) sowie einen ausgedehnten Abszess des rechten Psoasmuskels (Pfeil). Die Spondylodiszitis wurde durch mirkobiologische Proben im Rahmen einer offenen Operation bestätigt.




▶ **Fig. 4** False-negative CECT for spondylodiscitis of L3/4 in a 61-year-old man. **a**, **b** Sagittal CECT reconstruction in soft-tissue **a** and bone **b** window of the lumbar spine without findings of spondylodiscitis. **c** T2-weighted fat-saturated MRI with "hot disc" (asterisk) and epidural abscess (arrow). Spondylodiscitis was confirmed by microbiological samples gathered during open surgery.

▶ **Abb. 4** Falsch negatives kontrastmittelunterstütztes CT einer Spondylodiszitis des Segmentes L3/4 bei einem 61-jährigen Patienten. **a**, **b** Sagittale Rekonstruktionen im Weichteil- **a** und Knochenfenster **b** des CT der Lendenwirbelsäule ohne Zeichen der Spondylodiszitis. **c** Fettgesättigte T2-gewichtete MRT mit "Hot-disc-Zeichen" (Sternchen) und epiduralem Abszess (Pfeil). Die Spondylodiszitis wurde durch mirkobiologische Proben im Rahmen einer offenen Operation bestätigt.

Our retrospective study design demonstrates the major drawbacks of MDCT that were responsible for the rather low sensitivity for spondylodiscitis.

First, as reported by previous studies, in contrast to MRI, MDCT has deficits in the detection of early changes such as edema and contrast enhancement within the vertebral bones and the disc space [8, 19].

Second, MDCT has limitations with respect to the detection of epidural fluid even if intravenous contrast material is used, which is also in line with a previous study [20]. This is an important clinical concern because epidural abscess in spondylodiscitis – if not accurately treated – accounts for significant morbidity (e. g. persisting neurological deficits) and mortality rates [21]. The ongoing discussion about the early surgical treatment of epidural abscesses is an indication of its clinical impact [21 – 23].

The current literature about the accuracy of MDCT in the diagnosis of osteomyelitis, and especially of spondylodiscitis as a vertebral form of osteomyelitis, is sparse. In an animal study in rabbits directly comparing the diagnostic value of CT and MRI in osteomyelitis of the tibia, poor sensitivity of CT was demonstrated (66 % versus 94 % for osteomyelitis and 52 % versus 93 % for abscesses) [24]. Based on the literature, the sensitivity of CT in the diagnosis of spondylodiscitis is expected to be higher. In a retrospective study on humans from 1989 with 20 cases of vertebral osteomyelitis, the sensitivity of non-contrast-enhanced CT was found to be 94 % using histopathological results as the standard of reference [14]. In 2000, Wirtz et al. reported a sensitivity of contrast-enhanced CT of 93 % [15].

The previously reported sensitivities are higher than in the presented study (83 %). This is surprising, taking into consideration that prior studies date back to an era when single-slice scanners with poorer spatial resolution were used [14, 15]. It seems unlikely that modern MDCT has an inferior sensitivity regarding the detection of spondylodiscitis compared to older CT scanners [25]. More likely, the lower sensitivity in our study is explained by the retrospective study design with a collective of patients who underwent MDCT with suspicion of other differential

| | | MDCT for SD | | | | | |
|---|---|---|---|---|---|---|---|
| | | Positive | | Negative | | | |
| | | CECT | NECT | CECT | NECT | | |
| MRI for SD | Positive | 19 | 15 | 4 | 5 | | |
| | Total MDCT | 34 | | 9 | | 43 | Sensitivity 79% |
| | Negative | 0 | 0 | 13 | 11 | | |
| | Total MDCT | 0 | | 24 | | 24 | Specificity 100% |
| | | 19 | 15 | 17 | 16 | | |
| | Total MDCT | 34 | | 33 | | 67 | |
| | | PPV | | NPV | | | |
| | | 100% | 100% | 77% | 69% | | |
| | Total MDCT | 100% | | 72% | | | |

True positive (light grey): 19, 15, 34; False negative (dark grey): 4, 5, 9

Note: - MDCT = multidetector CT; MRI = magnetic resonance imaging; CECT = contrast-enhanced CT; NECT = non-contrast-enhanced CT; SD = spondylodiscitis; PPV/NPV = positive/negative predictive value.

Beachte: MDCT = Multidetektor-CT; MRI = Magnetresonanztomographie; CECT = kontrastmittelunterstütztes CT; NECT = natives CT; SD = Spondylodiszitis; PPV/NPV = positiver/negativer prädiktiver Wert.

▶ **Fig. 5** Contingency table presenting the diagnostic accuracy of MDCT for spondylodiscitis compared to MRI.

▶ **Abb. 5** Diagnostische Genauigkeit der MDCT im Vergleich zur MRT für die Spondylodizitis.

diagnosis. Another explanation might be the technical advances in MR imaging during the past two decades. The introduction of 3 Tesla scanners and modern spine coils with improved spatial resolution and dedicated fat saturation techniques allowing early detection of bone marrow edema nowadays enables the diagnosis of spondylodiscitis in earlier stages. Consequently, a higher sensitivity of MRI as the standard of reference accounts for a relatively lower sensitivity of MDCT compared to previous studies.

Our study demonstrates that the clinical value of MDCT is its high specificity for the diagnosis of spondylodiscitis. If spondylodiscitis was diagnosed with MDCT, the diagnosis was of high certainty. This observation might be explained by the high incidence of paravertebral abscesses in true-positive cases (94 %) with acute spondylodiscitis. 34/38 (90 %) of paravertebral abscess formations later proved by MRI were initially detected by MDCT. Therefore, the detection of paravertebral abscess proved to be a high predictor for the diagnosis of spondylodiscitis on MDCT. Hence, the finding of paravertebral abscess on MDCT, even without bone erosions, can be regarded as a strong indicator for spondylodiscitis, resulting in a high specificity of MDCT. We demonstrate that the sensitivity of MDCT for the detection of paravertebral abscess (90 %) outperforms the detection rates of 69 % reported in a previous study with a single-slice CT scanner [15], likely reflecting the ameliorated spatial resolution and availability of multiplanar reconstructions in current state-of-the-art MDCT protocols.

Another virtue of MDCT is the opportunity to gather minimally invasive core needle biopsies to ensure the microbiological diagnosis for specific antibiotic treatment [5] and to rule out traumatic or degenerative reasons for back pain in the same procedure. Moreover, other infectious foci of the abdomen can be assessed, which is an advantage over spinal MRI.

## Limitations

The major drawback of the presented study is the rather small patient population that resulted in two even smaller subgroups for the comparison of CECT and NECT. From other infectious diseases we know that contrast media improve the sensitivity of MDCT. Therefore, intravenous contrast media are routinely used in MDCT if an inflammatory focus is suspected and contraindications are excluded [26, 27]. However, our study failed to prove this advantage in the setting of spondylodiscitis, most likely due to the low number of patients in both groups.

A general limitation of our study is the retrospective design. Therefore, further prospective and blinded studies are needed to confirm our results.

## Summary

Compared to MRI, state-of-the-art MDCT lacks sensitivity for the diagnosis of spondylodiscitis due to its weakness in detecting edema of vertebrae and discs as well as epidural inflammation. However, MDCT has an excellent specificity regarding infectious spondylodiscitis. Thus, if MDCT is positive for spondylodiscitis, treatment can be initiated without further delay. Yet, MRI should be added to both MDCT negative and positive cases to rule out complications such as epidural abscess that cannot reliably be detected on MDCT.

## Conflict of Interest

On behalf of all authors, the corresponding author states that there is no conflict of interest.

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