Diagnostic Accuracy of MR Imaging in Tuberculous Spondylitis

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Objective: *To systemically evaluate MR imaging features of tuberculous spondylitis and to find features that may help differentiating tuberculosis from other spinal diseases.*
Material and Method: *Retrospective review of 65 MR imaging of two groups of patients between January 2002 and December 2005. Thirty-one patients were diagnosed as tuberculosis spondylitis and the rest were a randomly selected group of 34 patients with other spinal diseases. All images were reviewed by two neuroradiologists blinded to clinical data. Sensitivity and specificity of each MR imaging features were calculated.*
Results: *Three most useful MR imaging features with high sensitivity and specificity (> 80%) were endplate disruption (100%, 81.4%), paravertebral soft tissue (96.8%, 85.3%), and high signal intensity of intervertebral disc on T2W (80.6%, 82.4%). High sensitivity but low specificity signs in MRI included bone marrow edema (90.3%, 76.5%), bone marrow enhancement (100%, 42.5%), posterior element involvement (93.5%, 76.5%), canal stenosis (87.1%, 26.5%), and spinal cord or nerve root compression (80.6%, 38.2%). Low sensitivity but high specificity features in MRI were intervertebral disc enhancement (63.3%, 84.2%), vertebral collapse (58.1%, 85.3%), and kyphosis deformity (67.7%, 82.4%). Overall, the sensitivity and specificity of MRI for spinal tuberculosis were 100% and 88.2% respectively.*
Conclusion: *The authors presented three good to excellent sensitivity and specificity MR imaging features for spinal tuberculosis, end plate disruption, paravertebral soft tissue formation, and high signal of intervertebral disc on T2W. In contrast to a previous study, most of the presented cases still presented with classic radiological pictures of "two vertebral disease with the destruction of the intervertebral disc". Only a small portion of the patients revealed sparing intervening disc or isolated single vertebral body involvement, which possibly reflected the early stages of the disease process.*

Keywords: *Tuberculosis, Spondylitis, Magnetic resonance imaging*

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Spinal tuberculosis is the most common site of osseous involvement in tuberculosis. The disease prevalence will continue to rise as the number of immunocompromised patients increases. Neurological complications occur in about 10% of patients and can be devastating. Paraplegia may be a result of spinal cord compression from liquid or caseous pus, inflammatory granulation tissue of active disease or kyphosis deformity in the late state of disease[1]. Therefore, early diagnosis and establishment of treatment are necessary for avoiding this long-term disability.

Magnetic resonance imaging is currently a modality of choice for the evaluation of a potential spinal infection[2-6]. Advantages of MR imaging include the capacity of multiplanar imaging, direct evaluation of the bone marrow and contemporary visualization of the neural structures[7]. Typical radiolographic changes of two adjacent vertebral bodies with destruction of the intervertebral disc and a presence of paravertebral abscesses are easily appreciated and usually

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prompt antituberculous treatment[8]. However, atypical appearance on MR imaging such as involvement of a single vertebra or isolated involvement of posterior elements, although occur less frequently, is less recognized, but has been well documented[8-10]. Other common spinal diseases such as degenerative disc disease with associated endplate edema, spinal metastasis, inflammatory spondyloarthropathy, and erosive intervertebral osteochondrosis may occasionally mimic radiographic appearance of spinal tuberculosis. Hence, the authors conducted the present study to systematically evaluate MR imaging features of tuberculous spondylitis and to find features that may help differentiating tuberculosis from other spinal diseases.

Material and Method

The authors retrospectively reviewed spinal MR imaging and plain radiography of spines (when available) obtained during January 2002 to December 2005. A total of 65 MR imaging was included, in which 31 patients were diagnosed as tuberculous spondylitis and the rest was a randomly selected group of 34 patients with other spinal conditions (degenerative spondylitis 24 patients (70.6%), spinal metastasis 3 cases (8.8%), benign compression fracture 2 cases (5.8%), pyogenic spondylitis 2 cases (5.8%), multiple myeloma 2 cases (5.8%) and hemangioma 1 case (2.9%)). Of the 31 patients with tuberculous spondylitis, 18 patients (58.1%) were diagnosed based on the presence of histopathological or microbiological evidence and 13 patients (41.9%) were diagnosed based on typical radiological findings with good response to antituberculous treatment.

The present study was conducted after approval was obtained from Siriraj Hospital's review board to review patient images and medical chart record. The board determined that this retrospective study could be conducted without requiring a signed informed consent from the patients.

All MR Imaging was performed with 1.5 Tesla MRI scanner. Sagittal T1-Weighted spin echo and T2-Weighted spin echo and axial T2-Weighted spin echo were acquired in all cases. In addition, T1-Weighted with fat saturation in sagittal and axial planes were obtained after intravenous administration of gadopentetate (Gd-DTPA) where infection or tumor processes are suspected. All of the presented spinal tuberculosis cases were given gadolinium injection.

Two trained neuroragiologists reviewed all MR Imaging independently and were blinded to the clinical data. In case of disagreement, the final judgments were rendered by a consensus.

Plain radiography was evaluated for the present of bony destruction, bony sclerosis, end plate disruption, pedicle destruction, intervertebral disc space, and paravertebral soft tissue. On MR imaging various features of the imaging findings were evaluated, including signal intensity of the involved vertebral marrow and intervertebral disc on T1W, T2W and contrast-enhanced images, destruction of the vertebral bodies and vertebral end plate, extent of the vertebral body involvement, paraspinous soft tissue mass or abscess formation, degree of spinal canal compromise with or without cord or nerve root compression and alignment of the spine.

Data analysis

Sensitivity and specificity of each imaging signs described above were calculated. Interobserver agreements were calculated with Kappa statistic (poor agreement = 0; slight, agreement = 0.01-0.20; fair agreement = 0.21-0.40; moderate agreement = 0.41-0.60; good agreement = 0.61-0.80; and excellent agreement = 0.81-1.00)[11].

Results

The tuberculosis spondylosis group consisted of 19 males (61.2%) and 12 females (38.7%); age range, 16-83 years; mean age, 59 years. Whereas, the non-tuberculosis group consisted of 21 males (61.7%) and 13 females (38.2%); age range, 35-84 years; mean age, 61 years. There was no significant difference between sex and age between the two groups.

Most common presenting neurological symptoms were back or neck pain. Among these, tuberculosis patients also presented with paraplegia in 12 cases (38.7%), whereas non-tuberculosis patients only had associated radiculopathy without cord compression in 11 cases (32.4%). Thoracic spine was the most common site of spinal TB involvement followed by lumbar and cervical. Sacrum was not involved in any spinal TB cases (Table 1).

Table 1. Site of spinal involvement

Spinal regions	TB (91)	Non TB (94)
Cervical	8 (8.8%)	32 (34.0%)
Thoracic	49 (53.8%)	10 (10.6%)
Lumbar	34 (37.4%)	46 (48.9%)
Sacrum	0	6 (6.4%)

Radiographs of the spine were available in 57 cases. Endplate destruction and vertebral body destruction were the most two useful signs in plain radiograph for diagnosing tuberculous spondylitis with high sensitivity and specificity (> 79%). Presence of paravertebral soft tissue and pedicle destruction had high specificity but low sensitivity, whereas decreased height of intervertebral disc had high sensitivity but low specificity. Overall, the sensitivity and specificity of plain radiography were 82.8% and 89.3% respectively (Table 2).

MRI features with high sensitivity and specificity (> 80%) were endplate disruption (100%, 81.4%), paravertebral soft tissue (96.8%, 85.3%) and high signal intensity of intervertebral disc on T2W (80.6%, 82.4%).

High sensitivity but low specificity signs in MRI included bone marrow edema (90.3%, 76.5%), bone marrow enhancement (100%, 42.5%), posterior element involvement (93.5%, 76.5%), canal stenosis (87.1%, 26.5%), and spinal cord or nerve root compression (80.6%, 38.2%). Low sensitivity but high specificity features in MRI were intervertebral disc enhancement (63.3%, 84.2%), vertebral collapse (58.1%, 85.3%), and kyphosis deformity (67.7%, 82.4%). Details of sensitivity and specificity of each MRI feature were shown in Table 3.

Destruction of the posterior elements were found in spinal tuberculosis in 29 cases (93.6%), in which pedicles were the most frequently affected site (27 cases (93.1%)).

Overall, the sensitivity and specificity of MRI for spinal tuberculosis were 100% and 88.2% respectively. Interobserver agreement (k statistics) on MRI findings was 0.94.

Discussion

The symptoms and clinical findings in patients with spinal infection are often non-specific and may vary widely, depending on the site, extent, and severity of the pathological process[5,6,12]. Especially, tuberculosis infection is more indolent with a gradual onset of symptoms over months to years. Cases with spinal and radicular pain without fever often are diagnosed erroneously as disc protrusions.

In the present study, patients with tuberculosis spondylitis had more clinical severity and more often presented with paraplegic complication. This

Table 2. Plain radiography findings with sensitivity and specificity of each sign

Plain radiography Findings	TB	Non TB	Sensitivity	Specificity
Endplate disruption	25	5	86.2%	82.1%
Body destruction	23	4	79.3%	85.7%
Paravertebral soft tissue	18	0	62.1%	100.0%
Decreased disc height	24	18	82.8%	35.7%
Pedicle destruction	8	2	27.6%	92.9%
Sclerosis	18	8	62.1%	71.4%

Table 3. MR imaging findings with sensitivity and specificity of each feature

MRI Findings	TB	Non TB	Sensitivity	Specificity
Endplate disruption	31	6	100%	81.4%
High SI of disc, T2W	25	6	80.6%	82.4%
Disc enhancement	19	3	63.3%	84.2%
Paravertebral soft tissue/abscess	30	5	96.8%	85.3%
Bone marrow enhancement	30	11	100%	42.5%
Bone marrow edema	31	12	90.3%	76.5%
Posterior element involvement	29	8	93.5%	76.5%
Canal stenosis	27	25	87.1%	26.5%
Spinal cord compression	25	21	80.6%	38.2%
Vertebral collapse	18	5	58.1%	85.3%
Kyphosis	21	6	67.7%	82.4%

probably reflects rapid disease progression during the acceleration phase or a delay in detecting the disease. Spinal cord compression due to vertebral body collapse or epidural inflammatory tissue and vascular impairment can deteriorate spinal cord functions[13]. The onset of paraplegia depends on the rapidity of increase of cord compression mechanism and in spinal tuberculosis the spinal canal can tolerate 50 to 76% of canal stenosis before neural deficit appears[14]. This finding emphasized the importance of early disease detection and accuracy of imaging findings interpretation.

Thoracic spine is frequently reported as the most common site of involvement in spinal tuberculosis[15-19], followed by lumbar and cervical spines, respectively. The present results are consistent with other previous studies, in which thoracic and lumbar spines involvement together contributed at least 90% of the cases. Multifocal spinal TB was reported to account for 1-24% of the cases[15,16,20-22]. In the present study, the number of multiple vertebral body involvement (> 3 vertebral bodies) was significantly higher (36%).

On spinal plain radiography, the most common early findings were narrowing of the disc space and vertebral osteolysis. Then followed by paravertebral shadow, vertebral collapse, and angulation of the spine in advanced cases[23]. The present study showed that plain radiography could identify vertebral body destruction and disc involvement with overall fair sensitivity (82.8%) and specificity (89.3%) (Fig. 1). Other signs on plain films were reactive sclerosis, vertebral collapse, gibbus deformity, and vertebral fusion, which are findings of the advanced cases[24]. It is worth mentioning that these abnormalities may not be visible on plain radiography for up to 8 weeks[6,25-27].

Magnetic resonance imaging (MRI) is the investigation method of choice for the diagnosis of spondylodiscitis because it presents some advantages including high sensitivity in early stages, better definition of paravertebral and epidural extension, spinal cord involvement and the possibility of distinguishing tubercular infection from those of other origin[6,28]. MRI is also the best procedure for differentiating typical and atypical spinal TB. Previous literatures showed varying frequencies of these two distinct patterns across studies[6,25,29-31].

An increasing number of atypical forms characterized by spondylitis without disc involvement, were reported and even claimed to be the most common pattern of spinal TB type in foreign-born subjects in industrialized countries[32]. In the present series,

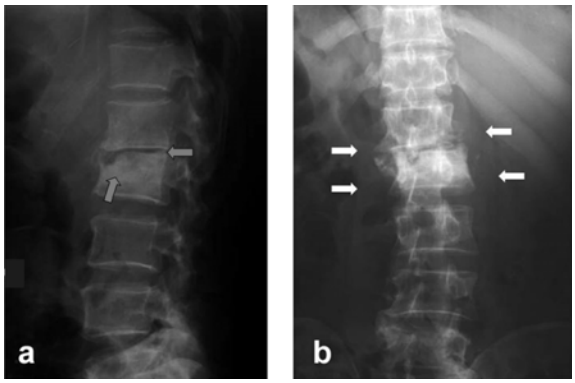

Fig. 1 (a, b) A 57-year-old man presented with low back pain with paraplegia, lateral view (a) and anterior-posterior view (b) of plain lumbar spine radiograph reveals anterior-superior end plate destruction of L2 vertebral body with markedly reduced L1-2 intervertebral disc height and surrounding sclerosis (grey arrows), minimal degree of lateral subluxation and scoliosis is present of AP view, surrounding bony sclerosis and small bony fragment adjacent to the involved area is noted, subtle paraspinal soft tissue shadows bilaterally are also noted (white arrows)

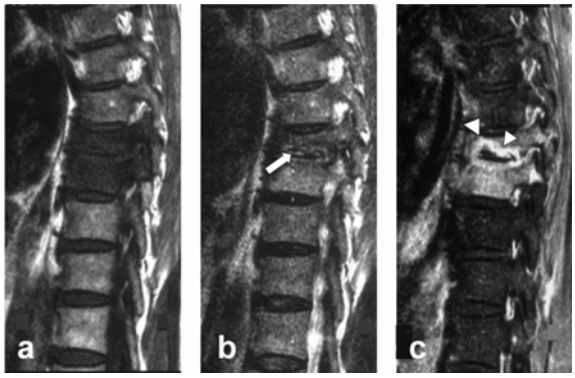

Fig. 2 Tuberculosis spondylitis of T8-9, (a, b, c) Magnetic resonance image of the thoracic spine in a 58-year-old woman presented with back pain, (a) Pre-Gadolinium T1-Weighted in sagittal plane (b) T2-weighted in sagittal plane (c) post-Gadolinium T1-Weighted in sagittal plane show typical pattern of two vertebral bodies destruction with intervening disc involvement, linear high signal intensity of disc on T2-weighted images is well appreciated (white arrow), after Gadolinium enhancement, there is enhancement of the involved vertebra including posterior element, irregular rim enhancing intervertebral disc is present (white arrow heads), collapse of T8 vertebra is noted

classic tuberculosis spondylitis features, which showed involvement of at least two adjacent vertebral bodies, abnormalities of the intervening disc and paraspinal soft tissue formation, are still the most common pattern of spinal TB found in 23/31 (74.2%) cases (Fig. 2). Atypical form which was characterized by spondylytis without disc involvement[32] were present in seven cases (22.6%) (Fig. 3). Among these, single vertebra involvement was found in only one case (3.2%). The explanation could be due to most patients having more severe disease or late diagnosis.

In the early state, infection usually originates at the anterior sub-chondral bone adjacent to the vertebral end plates. Then, it spreads underneath the longitudinal ligament, mostly anterior longitudinal ligament, followed by adjacent vertebra or multiple vertebral bodies and discs involvement. When both of the neighboring vertebral bodies are involved, the disc may lose its nutrition and involved secondarily[24]. Three most useful MRI features with high specificity in the present study were in keeping with the previous purposed disease process where endplate disruption is the most sensitive sign followed by paravertebral soft tissue formation and high signal of intervertebral disc on T2W. Other signs are less sensitive and less specific because other disease processes can produce the same appearance.

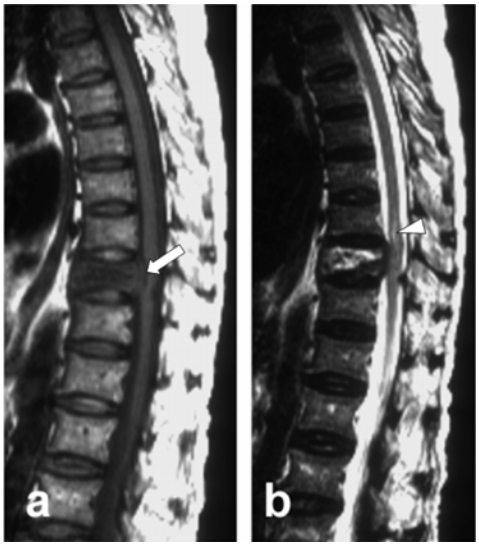

Fig. 3 Atypical findings of tuberculosis spondylitis of T7, (a, b) Magnetic resonance image of the thoracic spine in a 69-year-old woman presented with back pain and paraplegia (a) precontrast T1-weighted in sagittal plane (b) T2-weighted in sagittal plane show signal change of bone marrow edema of T7 vertebral body with minimal decrease vertebral body height, convex of posterior border of verebral body cause central canal stenosis and mild cord compression are noted (white arrow), high signal of the spinal cord, just superior to the infected vertebral is detected (white arrow head), note preservation of the adjacent intervertebral disc, these findings may difficult to differentiate with the neoplasm process

Destruction of the end plates is considered typical for disc infection[2,3,5,12]. However, some authors reported intact endplates on both sides of an infected disc and lack of endplates involvement can therefore not be use as a reliable sign to exclude spinal infection[33-35]. Pseudosparing of the endplate due to chemical shift artifact can be avoided by means of selection of the phase-encoding plane in the craniocaudal direction[36].

Presence of paravertebral soft tissue in previous spinal TB reports varied from 80 to 98%[37,38]. In the present series, most of the cases with paraspinal mass also had typical spondylitis features. Six cases had normal appearance of intervertebral discs and only one case with single vertebra was affected without disc involvement. This may indicate early state of infection and the fact that disease process has originate from the vertebral end plate and then spread into sub-ligamentous route and form a paravertebral soft tissue mass or abscess. In these cases, it is possible that the disease process had not yet spread into the intervening disc.

High signal in disc on T2W and disc enhancement are considered typical for spinal infection but not specific for TB[39, 40]. It also can be seen in other conditions such as highly vascularized degenerative discs in erosive intervertebral osteochondritis[7]. High signal disc on T2W were seen in all of the presented cases with disc involvement. Again, normal signal of disc was seen in seven cases. Six patients with disc involvement did not show disc enhancement. A lack of enhancement of infected discs was reported to occur rarely[33,40].

Differentiating spinal TB from pyogenic spondilitis is usually difficult, although there are many previous claims that there may be some features helpful. Clinically, TB infection generally affects adults in fourth and fifth decades whereas peak incidence of pyogenic spondyloitis is seen in the sixth or seventh decades[24]. The smooth margin of a cold abscess from TB, which is sub-ligamental spread without destruction of the paraspinal ligament, contrasts with the irregular

margin of pyogenic abscesses, which proteolytic enzyme can destroy the paraspinal ligament[28]. Posterior elements or multiple vertebral body involvement are less commonly encountered in pyogenic spondilitis[2,41-43]. In addition, size of the paraspinal mass is larger in tuberculosis than in pyogenic infections[43,44]. Collapse of the vertebral bodies is rarely seen in pyogenic spinal infection but common in spinal TB[4,45]. In the chronic stage, tubercular spondylitis shows a slightly hyperintense signal of vertebral body on T1-Weighted images, whereas the non-tuberculous spondylitis shows low-signal intensity[6,46]. Nonetheless, by using these signs in the present series, the authors were still unable to differentiate bacterial spondylitis from spinal TB (Fig. 4). However, the number of patients with pyogenic spongylitis in the present study is small. Further study is required to evaluate this topic in more detail.

Isolated involvement of the posterior elements with sparing of the vertebral body, a feature that are more typical of neoplasm than infection process, does occur in spinal TB especially in countries where TB is epidemic[24,47]. However, this finding was not found in the present study, where all of the presented cases that had posterior involvement also had vertebral body and intervertebral disc involvement and could be differentiated from neoplasm.

Some limitation applies to the present study. Since most of the control group in the present study is degenerative spinal disease, which sometimes is rather easy to differentiate from spinal TB. This may have led to overestimation of sensitivity and specificity of some signs. However, the most common condition to be encountered in real practice is degenerative disease, which is somewhat similar to the present study population. Therefore, the statistical values in the present study may still be applicable. Another limitation is that the gold standard of diagnosing TB (histology or microbiology) from clinical specimen is not available in every case. This may again have led to a contamination of non-TB diseases in the TB group. Nevertheless, a diagnosis of TB spine without histology or microbiology may still be valid since the acid-fast bacillus is not seen in over 50% of the histological section[1].

Conclusion

The authors presented three good to excellent sensitivity and specificity MR imaging features for spinal tuberculosis; end plate disruption, paravertebral soft tissue formation, and high signal of intervertebral disc on T2W. In contrast to a previous study[32], most of the presented cases still presented with classic radiological pictures of "two-vertebral disease with the destruction of the intervertebral disc". Only a small portion of the patients revealed sparing intervening disc or isolated single vertebral body involvement, which possibly reflected the early stages of the

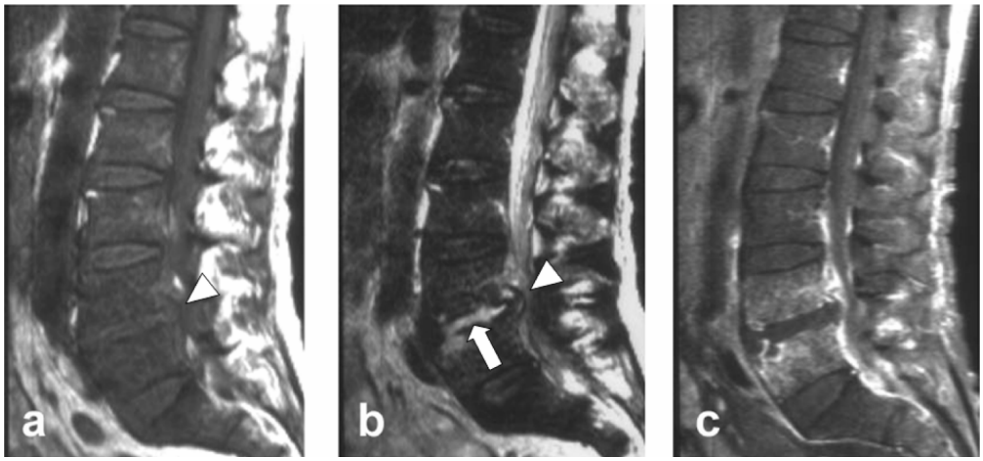

Fig. 4 Bacterial spondylitis of L4-5 (a, b, c) Magnetic resonance image of the lumbar spine in a 64-year-old man presented with back pain and leg weakness, (a) pre-Gadolinium T1-weighted in sagittal plane (b) T2-weighted in sagittal plane (c) Post-Gadolinium T1-weighted in sagittal plane show classical findings of spondylitis with involvement of intervening disc which can not be differentiated from tuberculous spondylitis (white arrow), linear dark line of the posterior longitudinal ligament on both T1-weighted and T2-weighted images is not well demonstrated and possible destroy by bacterial proteolytic enzyme (arrow heads)

disease process. Differentiating TB spondylitis from pyogenic spondylitis with radiological findings alone is usually difficult and not reliable.

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ความแม่นยำในการวินิจฉัยผู้ป่วยโรควัณโรคกระดูกสันหลังด้วยเครื่องสนามแม่เหล็กไฟฟ้า

ณสุดา ด่านชัยวิจิตร, ศิริวรรณ เต็มราน, พิพัฒน์ เชี่ยววิทย์, กุลธร เทพมงคล

วัตถุประสงค์: *เพื่อหาลักษณะผิดปกติทางภาพแม่เหล็กไฟฟ้าของกระดูกสันหลังที่มีลักษณะเฉพาะสำหรับผู้ป่วยวัณโรคกระดูกสันหลังเปรียบเทียบกับผู้ป่วยโรคกระดูกสันหลังอื่น ๆ*

วัสดุและวิธีการ: *การศึกษาย้อนหลังภาพแม่เหล็กไฟฟ้าของกระดูกสันหลังของผู้ป่วย 2 กลุ่มในช่วงปี พ.ศ. 2545 - พ.ศ. 2548 กลุ่มแรกเป็นผู้ป่วยวัณโรคกระดูกสันหลังจำนวน 31 คน ส่วนกลุ่มที่สองเป็นผู้ป่วยโรคกระดูกสันหลังอื่น ๆ ที่สุ่มเอาในช่วงเวลานั้นจำนวน 34 คน ภาพแม่เหล็กไฟฟ้าถูกแปลผลโดยรังสีแพทย์ผู้เชี่ยวชาญด้านระบบประสาท 2 ท่านซึ่งไม่ทราบถึงประวัติของผู้ป่วยมาก่อน*

ผลการศึกษา: *พบว่าภาพแม่เหล็กไฟฟ้าของกระดูกสันหลังที่มีลักษณะค่อนข้างไวและจำเพาะต่อโรควัณโรคกระดูกสันหลังได้แก่ การทำลายของแผ่นปลายประสาทเคลื่อนไหวของกระดูกสันหลัง (ความไว 100%, ความจำเพาะ 81.4%), การมีก้อนหรือฝีหนองที่บริเวณรอบกระดูกสันหลัง (ความไว 96.8%, ความจำเพาะ 85.3%), และสัญญาณที่เพิ่มขึ้นของหมอนรองกระดูกสันหลัง (ความไว 80.6%, ความจำเพาะ 82.4%), ส่วนลักษณะผิดปกติรูปแบบอื่น ๆ บางรูปแบบก็มีความไวแต่ไม่มีความจำเพาะ บางรูปแบบมีความจำเพาะแต่ไม่มีความไว*

สรุป: *การศึกษานี้พบว่าลักษณะเฉพาะบางอย่างของวัณโรคกระดูกสันหลังที่ตรวจพบด้วยเครื่องแม่เหล็กไฟฟ้ามีความไวและความจำเพาะสูง นอกจากนี้ผู้ป่วยวัณโรคกระดูกสันหลังในการศึกษานี้ส่วนใหญ่ยังมีความผิดปกติของกระดูกสันหลังแบบตรงต้นแบบ ซึ่งแตกต่างจากการศึกษาอื่นซึ่งพบว่าไม่มีการทำลายของหมอนรองกระดูกสันหลังเป็นส่วนใหญ่*