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MRI differentiation between spinal tumor and spinal infection

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Background : *Although magnetic resonance imaging (MRI) has been the most sensitive and useful investigation in detecting and delineating spinal lesion, spinal tumor and spinal infection may be difficult to be distinguished.*

Objective : *To find reliable findings to differentiate spinal tumor from spinal infection.*

Methods : *Four hundred and seventy-nine cases of spinal MRI in 12 months were retrospectively reviewed. Sixty - one cases with MRI diagnosis of spinal tumor or spinal infection were included in the study. Sex, age, location, number of the level of spinal involvement and paravertebral/epidural extension were documented. White blood cell count and percentage of neutrophils were reviewed, if available. Vertebral marrow, disc, paravertebral soft tissue and spinal cord signal intensity (SI) on T1 - and T2 - weighted images, and post gadolinium enhancement were graded.*

Results : *There were 28 cases of spinal tumor and 24 cases of spinal infection. The significant MRI findings (p - value less than 0.05) between two groups are disc signal on T1 - and T2 - weighted images, disc enhancement, paravertebral soft tissue signal on T1 - weighted images and paravertebral soft tissue enhancement. Paravertebral/epidural abscesses are found only in the spinal infection group. Sacral location is seen only in the spinal tumor group. Age of more than 50 years, multiple levels of involvement and thoracic location are shown in the spinal tumor group more than the infection group.*

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Conclusion : *Decreased disc SI on T1 - weighted images, increased disc SI on T2 - weighted images, disc enhancement, decreased paravertebral soft tissue SI on T1 - weighted images, paravertebral soft tissue enhancement and paravertebral/epidural abscesses are significant findings in spinal infection which is useful in differentiation from spinal tumor. Sacral location is therefore considered spinal tumor. Age of more than 50 years, multiple levels of involvement and thoracic location increase possibility of spinal tumor.*

Keywords : *Spinal tumor, Spinal infection, MRI.*

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บทนำ : *การตรวจวินิจฉัยด้วยคลื่นสะท้อนในสนามแม่เหล็ก เป็นการตรวจวินิจฉัยที่แม่นยำและเชื่อถือได้มากที่สุดในการตรวจความผิดปกติของสันหลัง แต่บางครั้งการวินิจฉัยแยกโรคทั้งสองโรคระหว่างเนื้องอกกับการติดเชื้อก็ยังไม่สามารถทำได้อย่างชัดเจน*

วัตถุประสงค์ : *ศึกษาสัญญาณภาพจากผู้ป่วย 479 รายใน 12 เดือน ที่มารับการตรวจสันหลังด้วยคลื่นสะท้อนในสนามแม่เหล็ก เพื่อหาความแตกต่างของสัญญาณภาพระหว่างเนื้องอกกับการติดเชื้อของสันหลัง*

สถานที่ที่ทำการศึกษา : *โรงพยาบาลกลาง สำนักการแพทย์ กรุงเทพมหานคร*

รูปแบบการวิจัย : *การศึกษาย้อนหลัง*

ผู้ป่วยที่ได้ทำการศึกษา : *ผู้ป่วยที่มารับการตรวจสันหลังด้วยคลื่นสะท้อนในสนามแม่เหล็ก*

วิธีการศึกษา : *ผู้วิจัยเก็บข้อมูลเพศ อายุ จำนวนเม็ดเลือดขาว ตำแหน่งของโรค และสัญญาณภาพของกระดูกสันหลัง หมอนรองกระดูกสันหลัง เนื้อเยื่อรอบกระดูกสันหลัง และไขสันหลังของผู้ป่วยที่ได้รับการวินิจฉัยจากภาพคลื่นสะท้อนในสนามแม่เหล็กว่าเป็นเนื้องอกของสันหลังหรือเป็นการติดเชื้อของสันหลัง*

ผลการศึกษา : *เนื้องอกของสันหลัง 28 ราย การติดเชื้อของสันหลัง 24 ราย พบว่าสัญญาณภาพของหมอนรองกระดูกสันหลังในภาพ T1, T2, หลังจากฉีดสารแกดโดลีเนียม และสัญญาณภาพของเนื้อเยื่อรอบกระดูกสันหลังในภาพ T1 และหลังจากฉีดสารแกดโดลีเนียม มีความแตกต่างกันอย่างมีนัยสำคัญระหว่างผู้ป่วยสองกลุ่ม การเกิดผีรอบกระดูกสันหลังพบเฉพาะในกลุ่มการติดเชื้อ ตำแหน่งกระดูกสันหลังช่วงก้นพบเฉพาะในกลุ่มเนื้องอก ผู้ป่วยในกลุ่มเนื้องอกมีอายุมากกว่า มีรอยโรคหลายตำแหน่งมากกว่า และพบตำแหน่งกระดูกสันหลังช่วงอกมากกว่า*

วิจารณ์ และสรุป : *สัญญาณภาพที่ลดลงในภาพ T1 เพิ่มขึ้นในภาพ T2 และหลังจากฉีดสารแกดโดลีเนียมของหมอนรองกระดูกสันหลัง สัญญาณภาพที่ลดลงในภาพ T1 และเพิ่มขึ้นหลังจากฉีดสารแกดโดลีเนียมของเนื้อเยื่อรอบกระดูกสันหลัง และการเกิดฝีรอบกระดูกสันหลัง เป็นสัญญาณภาพที่ใช้ในการวินิจฉัยการติดเชื้อของสันหลังได้อย่างแม่นยำ ตำแหน่งรอยโรคที่กระดูกสันหลังช่วงก้นบอกถึงเนื้องอก ผู้ป่วยที่อายุมากกว่า 50 ปี มีโรคหลาย ๆ ตำแหน่ง และพบรอยโรคที่กระดูกสันหลังช่วงอก น่าจะเป็นเนื้องอกมากกว่าการติดเชื้อ*

คำสำคัญ : *เนื้องอกของสันหลัง, การติดเชื้อของสันหลัง, คลื่นสะท้อนใน สนามแม่เหล็ก.*

The diagnosis of spinal tumor and spinal infection is often difficult because of nonspecific symptoms, clinical and laboratory findings. Early diagnosis and prompt treatment are essential to prevent permanent neurologic deficit and/or spinal deformity.[1 - 4] Confirmation and localization of the infection and tumor is usually dependent on imaging. Although magnetic resonance imaging (MRI) has been the most sensitive and useful investigation in detecting and delineating spinal infection,[1 – 7] differential diagnosis with spinal tumor may be indistinguishable.[3, 7 – 13] The purpose of this study was, therefore, to determine the reliable findings to differentiate between spinal tumor and spinal infection.

Materials and Methods

Four hundred and seventy-nine cases of spinal MRI examined over a 12 - month period were retrospectively reviewed. Sixty - one cases of MRI diagnoses of spinal tumor and spinal infection were included in the study. Three cases were excluded due to no gadolinium administration. White blood cell count (WBCs) and percentage of neurtrophils were reviewed, if available.

Final diagnoses were based on clinical and/or laboratory findings including microbiological and histological data, and/or correlation with other diagnostic images (bone scan).

One radiologist reviewed the MR images. Sagittal and axial T1 - and T2 - weighted images, and post gadolinium sagittal and axial T1 - weighted images with fat saturation were obtained in all cases. Location, number of level of involvement and paravertebral/epidural extension were documented. The vertebral marrow, discs, paravertebral soft tissue and spinal cords signal intensity (SI) on T1 - and T2 - weighted images were graded as no significant change, increased or decreased. Post gadolinium enhancement, the vertebral marrow, discs, paravertebral soft tissue and spinal cords were evaluated as enhancement or not. Other vertebral bodies and discs, other levels of paravertebral soft tissue and spinal cords in the field of view served as sources of comparison. The review process was done with blindly outcome.

The variables were tabulated. T - test was used to compare spinal tumor patients and spinal infection patients.

Results

Final diagnoses revealed 28 cases of spinal tumor and 24 cases of spinal infection. One case was diagnosed as inflammatory/demyelinating disease, and another case as degenerative change. Four cases had no definite diagnosis.

MRI diagnoses were correct in 50 out of 52 cases of spinal tumor and spinal infection (96.2%). Twenty-six of 28 cases (92.8%) of spinal tumor were correctly diagnosed while other two cases were misdiagnosed as tuberculous spondylitis (Figure 1). Twenty-four of 24 cases (100%) of spinal infection were correctly diagnosed but one case with MRI diagnosis of spinal infection was a degenerative change.

Table 1 summarizes the patient population, diagnoses, selected laboratory information, location, number of level of involvement, and paravertebral/epidural extension. There were 17 men and 11 women ranging in age from 24 to 79 years old, with a mean age of 55.1 years and 95% confidence interval at

50.4 - 59.0 years in the spinal tumor group. Eleven men and 13 women ranging in age from 5 to 71 years old, with a mean age of 45.3 years and 95% confidence interval at 36.6 – 52.7 years were in the spinal infection group.

Of the 28 cases of spinal tumor, 24 cases were metastases (4 cases from colon cancer; 2 cases from lung cancer; 1 from ovarian cancer; 1 from breast cancer; 1 from hepatocellular carcinoma; 1 from cervical cancer; 1 from prostate cancer, and 13 cases from unknown primary). The other 4 cases were lymphoma, astrocytoma, meningioma and chondrosarcoma.

Twenty-four cases of spinal infection were from tuberculosis in 14, bacterial infection in 9, and HIV myelopathy in 1.

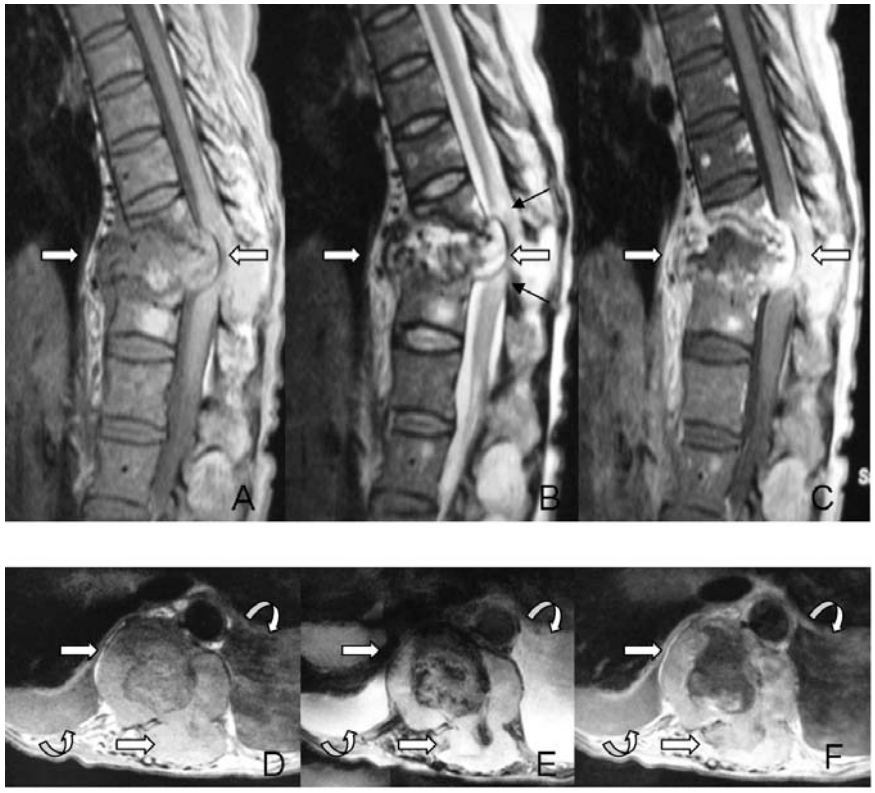

Figure 1. Spinal tumor (metastasis) was misdiagnosed as tuberculous spondylitis on MRI.
A: Sagittal T1-weighted image, B: Sagittal T2-weighted image, C: Post gadolinium sagittal T1-weighted image with fat saturation, D: Axial T1-weighted image, E: Axial T2-weighted image, F: Post gadolinium axial T1-weighted image with fat saturation. Tumor involving T10-12 vertebrae shows mixed signal intensity (SI) involving vertebrae and intervening discs on both T1- and T2-weighted images with enhancement on post gadolinium images. Paravertebral/epidural extension (white arrows) is noted showing slightly increased SI on T1-weigheted images, increased SI on T2-weighted images and heterogeneous enhancement on post gadolinium images without abscess formation. Compression to the spinal cord is seen with high SI on T2-weighted images (arrows). Bilateral pleural effusion is also observed (curve arrows).

Table 1. Patient population, laboratory data and location of the disease.

Number of Patients		**Spinal Tumor** 28	**Spinal Infection** 24
Sex	Male	17 (60.7%)	11 (45.8%)
	Female	11 (39.2%)	13 (54.2%)
Age (years)	Mean	55.1	45.3
	Range	24-79	5-71
	95% confidence interval	50.4 – 59.0	36.6 – 52.7
WBC	Increased	5 (17.9%)	8 (33.3%)
	Normal	9 (32.1%)	6 (25%)
	Decreased	1 (3.6%)	1 (4.2%)
	Not available	13 (46.4%)	9 (37.5%)
Neutrophil	Increased	10 (35.7%)	10 (41.7%)
	Normal	5 (17.9%)	5 (20.8%)
	Decreased	0 (0%)	0 (0%)
	Not available	13 (46.4%)	9 (37.5%)
Location	Cervical	3 (10.7%)	3 (12.5%)
	Thoracic	17 (60.7%)	7 (29.2%)
	Lumbar	19 (67.9%)	17 (70.8%)
	Sacral	9 (32.1%)	0 (0%)
Number of level of	Mean	5.1	2.6
involvement	Range	1-24	1-13
Paravertebral/	Soft tissue/mass	18 (64.3%)	6 (25%)
Epidural Extension	Abscess formation	0 (0%)	15 (62.5%)

WBC = white blood cell count (cells/ml), normal 4,500 - 10,000 cells/ml
Neutrophil (%), normal 40-69%

White blood cell count (WBC) and percentage of neutrophils are available in 15 cases in each group showing no significant difference between the two groups. Five cases in the spinal tumor group and 8 cases in the spinal infection group show increased WBC. Neutrophil predominant (equal or more than 70%) were found 10 cases in each group. Decreased WBC was also shown, 1 case in each group.

The location of involvement in most of the cases was the lumbar vertebrae, 19 cases in the spinal tumor group and 17 cases in the spinal infection group. All 9 cases of sacral locations are spinal tumors. Thoracic locations were found in 17 cases of the spinal tumor group and 7 cases in the spinal infection group, while cervical locations were found 3 cases in each group. The average number of the level of involvements were 5.1 vertebrae in the spinal tumor group and 2.6 vertebrae in the spinal infection group.

Paravertebral and epidural extensions were delineated in both groups, 18 cases in the spinal tumor

group and 21 cases in the spinal infection group. But abscess formation (fluid collection with smooth thin rim enhancement) was seen in 15 cases of spinal infection group only.

Overall summary of the MRI variables are tabulated. Tables by diagnosis and T-test are shown for the variables in Table 2.

The significant findings (p - value less than 0.05) are disc SI on T1 -, T2 - weighted images, and post enhancement, paravertebral soft tissue SI on T1-weighted image and post enhancement showing decreased T1 disc SI, increased T2 disc SI, disc enhancement, decreased T1 paravertebral soft tissue SI and paravertebral enhancement in most cases of spinal infection group (Figure 2).

Table 2. MRI variables in two groups, spinal tumor and spinal infection.

Number of Patients		**Spinal Tumor** 28	**Spinal Infection** 24	**p-value**
T1 vertebral marrow SI	Decreased	18 (64.3%)	21 (87.5%)	0.07
	Increased	2 (7.1%)	0 (0%)	
T2 vertebral marrow SI	Decreased	6 (21.4%)	4 (16.7%)	0.49
	Increased	7 (25%)	17 (70.8%)	
Vertebral marrow enhancement	Enhancement	22 (78.6%)	20 (83.3%)	0.33
	No enhancement	6 (21.4%)	4 (16.7%)	
T1 disc SI	Decreased	0 (0%)	12 (50%)	< 0.05
	Increased	0 (0%)	1 (4.2%)	
T2 disc SI	Decreased	1 (3.6%)	2 (8.3%)	< 0.05
	Increased	1 (3.6%)	16 (66.7%)	
Disc enhancement	Enhancement	0 (0%)	11 (45.8%)	< 0.05
	No enhancement	28 (100%)	13 (54.2%)	
T1 paravertebral soft tissue SI	Decreased	9 (32.1%)	17 (70.8%)	< 0.05
	Increased	5 (17.9%)	2 (8.3%)	
T2 paravertebral soft tissue SI	Decreased	3 (10.7%)	1 (4.2%)	0.09
	Increased	13 (46.4%)	20 (83.3%)	
Paravertebral soft tissue enhancement	Enhancement	18 (64.3%)	21 (87.5%)	< 0.05
	No enhancement	10 (35.7%)	3 (12.5%)	
T1 cord SI	Decreased	1 (3.6%)	0 (0%)	0.09
	Increased	1 (3.6%)	0 (0%)	
T2 cord SI	Decreased	0 (0%)	0 (0%)	0.18
	Increased	9 (32.1%)	5 (20.8%)	
Cord enhancement	Enhancement	17 (60.7%)	11 (45.8%)	0.14
	No enhancement	11 (39.3%)	13 (54.2%)	

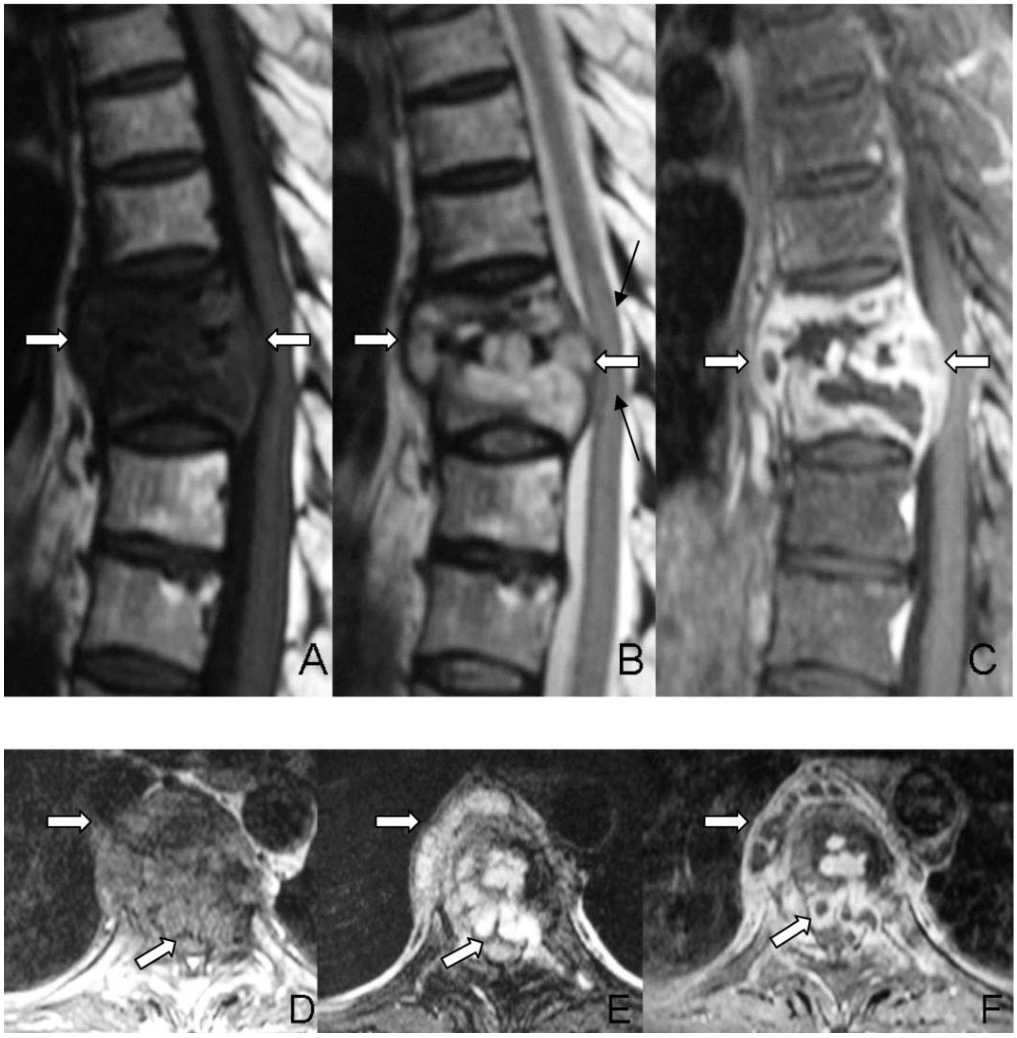

Figure 2. Spinal infection (TB spondylitis) involving T9-10 vertebrae shows decreased signal intensity (SI) on T1-weighted images, increased SI on T2-weighted images and enhancement of the vertebrae and intervening disc. A: Sagittal T1-weighted image, B: Sagittal T2-weighted image, C: Post gadolinium sagittal T1-weighted image with fat saturation. D: Axial T1-weighted image, E: Axial T2-weighted image, F: Post gadolinium axial T1-weighted image with fat saturation

Paravertebral/epidural extension (white arrows) is noted showing decreased SI on T1-weighted images, increased SI on T2-weighted images and multilocalated rim enhancement consistent with abscess formation. Compression to the spinal cord is seen with slightly high SI of the cord on T2-weighted images (arrows).

T1 vertebral marrow SI, T2 vertebral marrow SI, T1 spinal cord SI, T2 spinal cord SI either increased or decreased, and vertebral marrow enhancement and spinal cord enhancement either enhance or not, show no significance between the two groups of patients.

Discussion

Metastasis is the most common tumor of the spine. Approximately, 60 - 70% of patients with systemic cancer have spinal metastasis. Fortunately, only 10% of these patients are symptomatic. About 94 - 98% of these patients present with epidural and/or vertebral involvement. Intradural extramedullary and intramedullary seeding of systemic cancer is unusual accounting for 5 - 6% and 0.5 - 1% of spinal metastases, respectively. [9] Spinal metastases are slightly more common in men than in women, and adults aged 40 - 65 years than in other age groups. About 70% of symptomatic lesions are found in the thoracic spinal region. [9] More than 50% of patients with spinal metastasis have multiple lesions (Figure 3). [8, 9, 12] Spinal metastasis is associated with tumor embolic spread to the spine by hematogenous route.

Spinal infection is also associated with hematogenous spread and can be thought of as a spectrum of diseases comprising spondylitis, discitis, spondylodisicitis, pyogenic facet arthropathy, epidural abscess, meningitis, and intramedullary infection including cord abscess. Their most common causes are bacteria and tuberculosis.

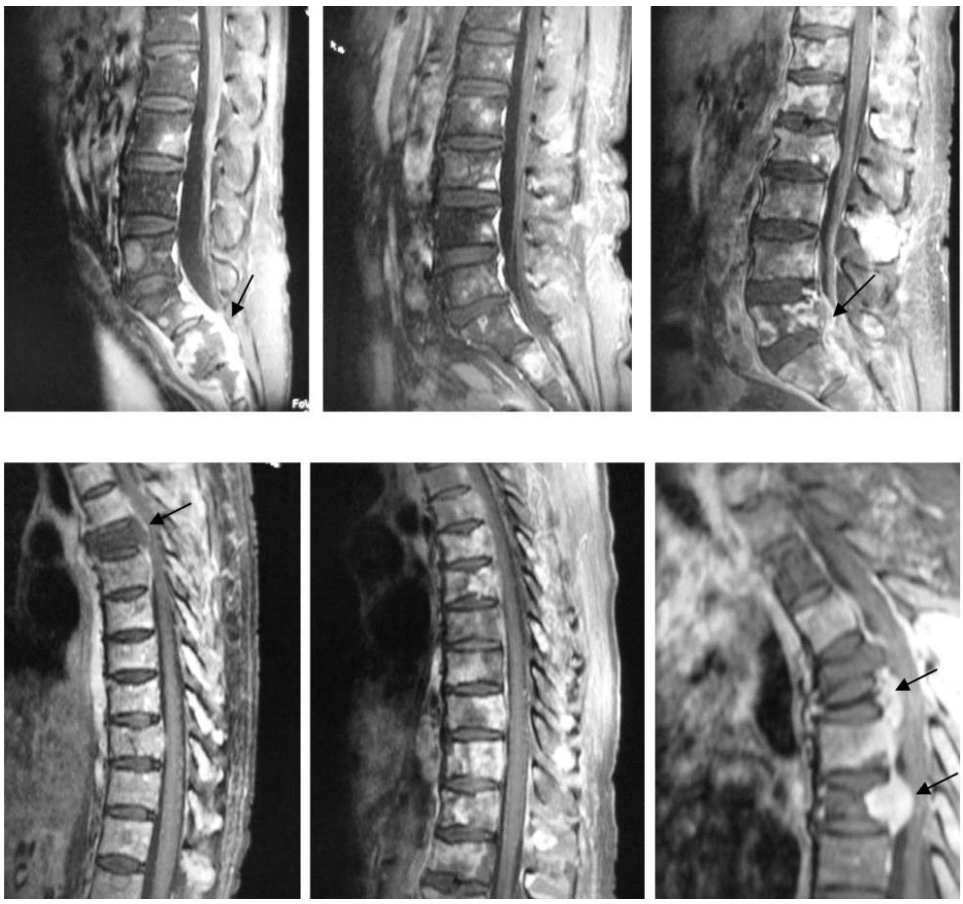

Figure 3. Various cases of spinal tumors (metastases) are well delineated on post gadolinium sagittal T1-weighted images with fat saturation showing enhancement of the vertebrae and spinal cord/nerve roots, without enhancement of intervertebral discs. Multiple levels of involvement are observed. Epidural extension (arrows) are seen compressing the cord or nerve roots, without abscess formation.

T2 - weighted image is the key to the diagnosis of intervertebral disc disease. Most of disc space infections show increased SI on T2 - weighted images, while degenerative change show decreased SI. [1, 3 - 7] Sixteen of twenty-four cases (66.7%) of spinal infection in this study revealed increased SI on T2 - weighted images.

Isosignal intensity and hypointensity of the infected discs on T2 - weighted images have been reported. [2, 5, 6] Two cases of spinal infection in this study (8.3%) showed hypointense disc on T2 - weighted images. It is important to realize that disc of iso - or hypointensity on T2 - weighted images does not exclude disc infection but may represent early infection [7] or healing and degeneration. On the other hand, increased disc SI on T2 - weighted images is not specific to spinal infection but can also be seen in highly vascularized degenerative disc, in erosive intervertebral osteochondritis. [7] Two cases of spinal tumor that were misdiagnosed as tuberculous spondylitis showed normal disc SI on T1 - weighted images in both cases but increased T2 disc SI in 1 case (Figure 1).

Enhancement of the disc on post-gadolinium injection made the detection of infected disc easier than a plain MRI, and this has been described as a reliable finding. [2 - 7] In follow up study, decrease in degree of enhancement is also an indicative of healing [2, 4] however gadolinium enhancement pattern by itself is not reliable for monitoring treatment response. [4] Eleven cases of the spinal infection patients (45.8%) showed disc enhancement while no case in the spinal tumor group showed disc enhancement. Thirteen cases of spinal infection patients (54.2%) showed no disc enhancement on post-gadolinium images. This can occur in a patient with infection that is not yet involving disc, and partially treated or resolving spondylodiscitis. [2, 3]

The findings of decreased disc SI on T1 - weighted image, increased disc SI on T2 - weighted image and disc enhancement are probably secondary to the exudative process and vascular ischemia. [1, 3, 4]

Spinal cord compression is a common neurological emergency. The causes may include primary or (more frequently) metastatic tumor, infections, trauma, and vertebral or intervertebral disc disease. Most of paravertebral soft tissue in both groups showed increased SI on T2 - weighted images. Post-gadolinium enhancement is helpful in delineating epidural and paraspinal lesions (Figure 3). [2 - 4] In this report, twenty-one of twenty-four patients (87.5%) of spinal infection had paravertebral and epidural extension; fifteen cases (71.4%) revealed abscess formation. Eighteen cases (64.3%) of spinal tumor also had paravertebral and epidural extension with enhancement, but no abscess formation. Two cases of spinal tumor that were misdiagnosed as tuberculous spondylitis also showed paravertebral and epidural extension but no abscess formation.

The findings of decreased paravertebral soft tissue SI on T1 - weighted image (17 cases) and paravertebral soft tissue enhancement (21 cases) in spinal infection group are probably representing fluid collection with abscess formation. However, decreased paravertebral soft tissue SI on T1 - weighted image was also seen in 9 cases (32.1%) and paravertebral soft tissue enhancement was seen in 18 cases (64.3%) of spinal tumor group showing homogeneous/heterogeneous enhancement, unlike rim enhancement in abscess.

Decreased SI of vertebral body on T1 - weighted image, increased SI of vertebral body on T2 - weighted image, and marrow enhancement are probably resulted from replacement of the normal marrow by an increased water content of inflammatory exudate and development of necrotic areas in spinal infection. [1, 3, 4] Spinal tumor shows variable vertebral marrow SI on both T1- and T2 - weighted images, mostly also decreased SI on T1 - weighted images, increased SI on T2 - weighted images and enhancement on post gadolinium images (Figure 3). [8]

Two cases in the study, with SI change of the spinal cord on T1 - weighted images, are cases of tumors within the spinal cord (intramedullary masses). Fourteen cases show increased SI of the cord on T2 - weighted images, 9 cases (32.1%) in the spinal tumor group and 5 cases (20.8%) in the spinal infection group. High SI within the cord on T2 - weighted images may representing cord ischemia due to cord compression from epidural extension in most cases which can occur in both spinal tumor and spinal infection patients.

Leptomeningeal enhancement along the cord and enhancement within the cord can be seen in both spinal tumor and spinal infection,[3.13] which are seen in 17 cases (60.7%) of the spinal tumor group and 11 cases (45.8%) of the spinal infection group in this study.

Findings of decreased disc SI on T1 - weighted image, increased disc SI on T2 - weighted image and disc enhancement that are significant findings in spinal infection group in this study, show no difference from other studies. [1-7] Presence of inflammatory paraspinal soft tissue is often described in spinal infection, [1-7] but decreased paravertebral soft tissue SI on T1 - weighted image and paravertebral soft tissue enhancement have not been documented as a reliable signs for MRI diagnosis of spinal infection.

Although MRI is accurate in diagnosis 50 out of 52 cases (96.2%) of spinal tumors and spinal infections (26 of the 28 cases of the spinal tumor group and all cases in the spinal infection group), the significant findings between two groups may increase the rate of correct diagnosis and raise confidence of radiologists in differential diagnosis.

Conclusion

In this study, the reliable signs of MRI for differentiation between spinal tumor and spinal infection are: decreased T1 disc SI, increased T2 disc SI, disc enhancement, decreased T1 paravertebral soft tissue SI and paravertebral soft tissue enhancement in the spinal infection group. Paravertebral/epidural extension can be found in both groups but all cases of abscess formation are in the spinal infection group. Sacral location is considered spinal tumor. Age of more than 50 years, multiple levels of involvement and thoracic location increase possibility of spinal tumor. The vertebral marrow and spinal cord SI on T1 -, T2 - weighted and post-gadolinium images including laboratory data of WBCs and percentage of neutrophils are not helpful for differentiation of the two conditions.

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