Differential diagnosis between vertebral fractures caused by metastasis and osteoporosis using sagittal T1-weighted magnetic resonance imaging

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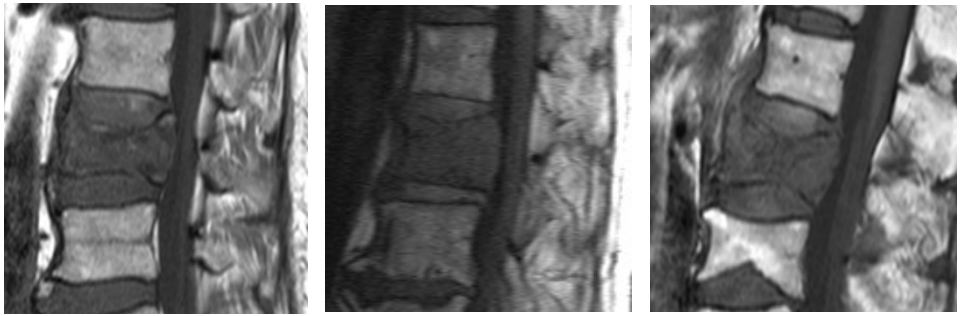
COI disclosure:None

Background

Metastatic and Osteoporotic compression fractures

Common clinical problem, in elderly patients.



Aging society like Japan

In Japan, the ratio of the population aged 65 and older to the total population has exceeded 20%, ahead of any other country in the world.

Which is metastatic and which is osteoporotic?

Differential diagnosis with MRI

- MRI is the **most helpful** (Baker LL et al. Radiology 1990)
- Metastatic lesions **usually** demonstrated **hypointense signal on T1-weighted images** (Carroll KW et al. J Magn Reson Imaging 1990)
- Whole-body MRI is an efficacious method of detecting osseous metastases and is more reliable than bone scintigraphy.
  (Barcelo J. et al. Radiologia 2007) (Ketelsen D et al. Rofo 2008)

Background

Whole-body MRI

It is much time-consuming to make axial imaging about all the metastatic vertebra

Total examination time of only the sagittal and coronal plane for T1WI and STIR was within 40 minutes

(Nakanishi K et al. Magn Reson Med Sci 2005)

there is no report to investigate whether the findings in only sagittal T1WI MRI is effective in differentiating between metastatic spinal tumor and osteoporotic compression fractures

Purpose

To investigate the usefulness of sagittal T1-weighted MRI findings in differentiating between metastatic spinal tumor and osteoporotic compression fractures.

Material

In the period from 2009 to 2016

Metastasis group

- Pathological examination in needle biopsy and operation materials

Excluded criteria

- Not pathological examination
- Direct tumor invasion

Total

43 patients 45 vertebrae

osteoporosis group

- Medical history, Physical examination
- Radiographs, CT, and MRI
- Radiographs didn't change significantly

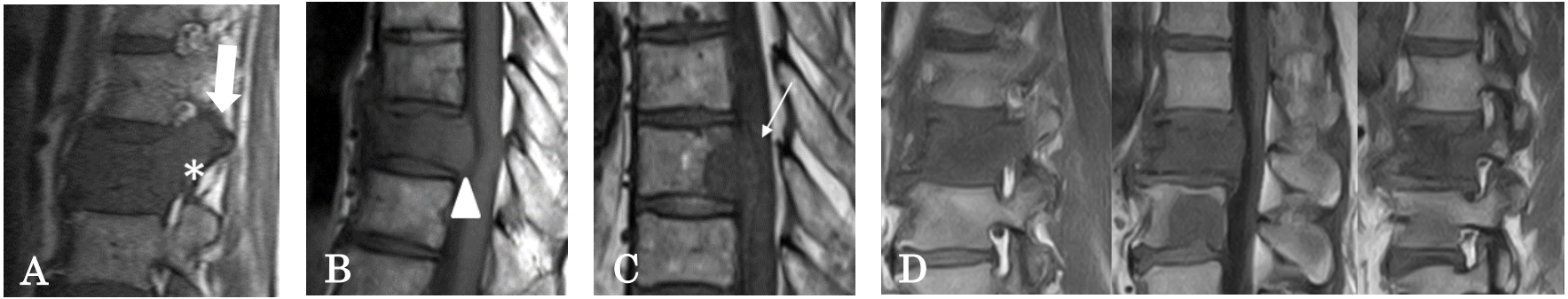
Excluded criteria

- Old fracture, MRI after 4 weeks or more from the onset of back pain
- High energy trauma

Total

118 patients 156 vertebrae

MRI findings of metastatic vertebral fractures



A: L2 vertebra of a 64-year-old female with lung carcinoma. B: Th10 vertebra of a 71-year-old male with lung carcinoma.
C: Th9 vertebra of a 64-year-old male with plasmacytoma. D: L2 vertebra of a 60-year-old male with breast carcinoma.

A: Pedicle element (asterisk) or Posterior element involvement (arrow)

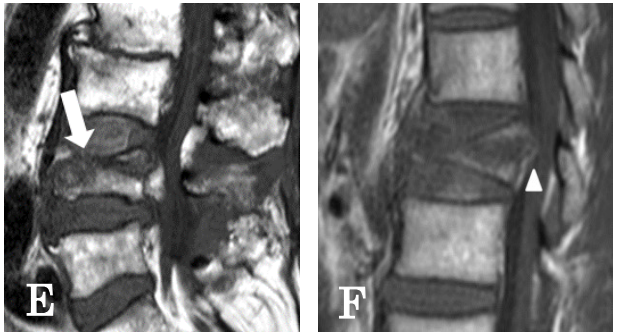
B: Convex posterior border of the vertebral body

C: Epidural infiltration

D: Diffuse homogeneous low signal intensity

(Jung HS et al. Radiographics 2003)
(Rupp RE et al. Spine 1995)
(Pongpornsup S et al. J Med Assoc Thai 2009)
(Yuh WT et al. Radiology 1989)

MRI findings of osteoporotic vertebral fractures



E: L4 vertebra of a 72-year-old male with minor trauma.
F: L1 vertebra of a 86-year-old female with minor trauma.

E: Low-signal-intensity band

F: Posterior retropulsion

（Cuenod CA et al. Radiology 1996）
（Yuzawa Y et al. J Orthop Sci 2005）

Statistical analysis

- Calculating the sensitivity and specificity of each MRI finding relative to metastatic or osteoporotic fracture.
- Calculating Intra-observer and inter-observer reliability of each MRI finding

Result

Demographic data

Parameters	metastatic group 45 vertebrae (n=43)	osteoporotic group 156 vertebrae (n=118)	P
Age, years (median [range])	62.9 [21-92]	77.8 [32-98]	< 0.01
Sex	male 27, female 16	male 35, female 83	< 0.01
Cervical vertebra	5/45	0/156	< 0.01
Thoracic vertebra	26/45	43/156	< 0.01
Lumbar vertebra	12/45	113/156	< 0.01
Sacral vertebrae	2/45	0/156	< 0.01
Below thoracolumbar transition (Th11 or less)	20/45	140/156	< 0.01

Age were analyzed using Student's t-test.
Sex and level of diseased vertebrae were analyzed using chi-square tests.

Result

List of the number of patients with tumor entities

Tumour type	No. of case	Tumour type	No. of case
Lung carcinoma	10	Colon carcinoma	1
Renal carcinoma	7	Parotid adenocarcinoma	1
Breast carcinoma	4	MPNST	1
Thyroid carcinoma	4	Chondrosarcoma	1
Prostate carcinoma	3	Rhabdomyosarcoma	1
Hepatocellular carcinoma	2	Osteosarcoma	1
Malignant lymphoma	2	Plasmacytoma	7

MPNST Malignant peripheral nerve Sheath tumor

Result

MR Imaging Findings

MR Imaging Findings of Metastatic Vertebra

MR Imaging Finding	sensitivity	Specificity	PPV	NPV	Accuracy	P
(a) pedicle or posterior element involvement	**88.9**	78.8	54.8	96.1	81.1	< 0.01*
(b) convex posterior border of the vertebral body	53.3	**96.8**	82.8	87.8	87.1	< 0.01*
(c) epidural infiltration	51.1	**98.7**	92	87.5	88.1	< 0.01*
(d) diffuse homogeneous low signal intensity	57.8	**90.4**	63.4	88.1	83.1	< 0.01*

MR Imaging Findings of Osteoporotic Vertebral fracture

MR Imaging Finding	sensitivity	Specificity	PPV	NPV	Accuracy	P
(f) low-signal-intensity band	48.7	**100**	100	36	60.2	< 0.01*
(g) posterior retropulsion	14.1	**97.8**	95.7	24.7	32.8	0.03*

Result

Reliability

	Kappa	
MR Imaging Finding	Intra observer	Inter observer
(a) pedicle or posterior element involvement	0.80	0.80
(b) convex posterior border of the vertebral body	1.00	0.89
(c) epidural infiltration	0.46	0.24
(d) diffuse homogeneous low signal intensity	0.89	0.89
(f) low-signal-intensity band	0.90	0.66
(g) posterior retropulsion	1.00	0.77

Kappa value was classified as follows

poor, 0-0.20; fair, 0.21-0.40; moderate, 0.41-0.60; good, 0.61-0.80; and excellent, 0.81-1.00.

（Fleiss JL et al. Statistical Methods for Rates and Proportions, 3rd Edition, 2013）

Discussion

Summary of Sagittal T1-weighted MRI findings

MR Imaging Finding	sensitivity	Specificity	Intra observer	Inter observer
(a) pedicle or posterior element involvement	88.9	78.8	0.80	0.80
(b) convex posterior border of the vertebral body	53.3	96.8	1.00	0.89
(c) epidural infiltration	51.1	98.7	0.46	0.24
(d) diffuse homogeneous low signal intensity	57.8	90.4	0.89	0.89
(f) low-signal-intensity band	48.7	100	0.90	0.66
(g) posterior retropulsion	14.1	97.8	1.00	0.77

Each findings of **only sagittal plane** were **consistent** with previous studies **using axial plane**.

(Pongpornsup S et al. J Med Assoc Thai 2009)
(Cicala D et al. Musculoskelet Surg 2013)
(Abdel-Wanis ME et al. J Orthop Surg (Hong Kong) 2011)

Discussion

In this study

Pedicle or posterior element involvement was the most **useful** for the screening of differentiating

Why

Tumoral involvement already spreads to pedicles and neural arch before collapse in most cases of malignant compression fractures （Jung HS et al. Radiographics 2003）

Epidural infiltration was **less reliable** than other findings

Why

The other reports were often used in the axial plane. （Cicala D et al. Musculoskelet Surg 2013）

Epidural infiltration may be difficult to judge with only a sagittal image as with whole spine MRI.

Conclusion

- **Sagittal T1-weighted** MRI findings are **useful** for differentiation of metastatic from osteoporotic compression fractures.
- To prevent overlooking, we should pay attention the **involvement of the pedicles or posterior elements** at first.