Magnetic Resonance Imaging in the Staging of Solitary Plasmacytoma of Bone

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Purpose: **To assess prospectively the role of magnetic resonance (MR) imaging in the staging of patients with a solitary bone plasmacytoma (SBP).**

Patients and Methods: **Twelve consecutive patients with an apparent SBP underwent MR imaging of both the primary tumor and the thoracic and lumbosacral spine to seek additional foci of marrow involvement that might have been undetected by standard skeletal survey. All patients received megavoltage irradiation (total dose, 40 Gy) to the primary lesion.**

Results: **MR imaging of the thoracic and lumbosacral spine showed additional foci of marrow replacement in four of 12 patients, with signal characteristics identical to those of the primary tumor. In all four patients, the abnormal protein persisted at greater than 50% of the pretreatment value following radiation treatment. In contrast, the myeloma protein disappeared or was reduced by greater than 50% in five of the six patients with secretory disease and without additional marrow abnormalities. One of four patients progressed to multiple myeloma 10 months after diagnosis with new lesions on conventional radiographs in the same areas as detected previously by MR imaging.**

Conclusion: **Four of 12 patients considered to have a SBP by standard criteria may have been understaged, because MR imaging showed additional marrow abnormalities consistent with myeloma. MR imaging of the spine may contribute to the initial staging of SBP, especially since some patients may be cured with radiotherapy.**

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SOLITARY BONE plasmacytoma (SBP) represents the only disease feature in approximately 5% of patients with plasma cell myeloma.[1] The diagnosis requires histologic evidence of a monoclonal plasma cell infiltrate in one bone lesion, absence of other bone lesions on skeletal survey, and lack of marrow plasmacytosis elsewhere. Virtually all patients show preserved levels of uninvolved immunoglobulins (Igs) in contrast to the marked depression in most patients with multiple myeloma.[2-4] Although local radiotherapy is usually effective for the primary tumor, most patients develop multiple myeloma within 3 years and less than one third remain stable for more than 10 years.[1-5] Early progression most likely results from occult generalized disease that was not recognized at diagnosis. In multiple myeloma, magnetic resonance (MR) imaging has detected foci of disease not observed on conventional radiographs.[6-9] Routine spin echo T1-weighted images of the spine may demonstrate well-defined areas of similar or low signal intensity relative to muscle; on T2-weighted MR images, myeloma lesions are hyperintense relative to muscle.[6-9] Based on these observations, we conducted MR imaging of the spine in patients with SBP in a search for additional foci of disease that were undetected by standard bone surveys.

PATIENTS AND METHODS

Between April 1990 and April 1992, 12 patients were referred with presumed SBP. Biopsy of the lesion showed monoclonal plasma cells. Aspiration and biopsy of the primary tumor, electrophoretic studies of serum and urine concentrates, immunofixation and serum Ig quantitation, and skeletal surveys met the diagnostic criteria for a SBP.[1-5]

Patient characteristics are listed in Table 1. Ten patients had a monoclonal protein of low level in serum (seven patients) or urine (three patients). Two patients did not show an abnormal protein on immunifixation studies. Uninvolved Igs were preserved in all patients (IgM > 50 mg/dL, IgA > 100 mg/dL, IgG > 700 mg/dL).

All patients underwent MR imaging of the primary lesion and of the thoracic and lumbosacral spine before initiation of treatment. All studies were performed on a 1.5T superconducting magnet (Signa, GE Medical Systems, Milwaukee, WI). Routine spin echo T1-weighted and gradient-recalled acquisition in the steady-state (GRASS) images were obtained in sagittal and axial planes.

All patients received megavoltage irradiation of the primary lesion. Treatment was administered at 2 Gy daily for 5 days per week to a total dose of at least 40 Gy. Serial electrophoretic studies were conducted every 2 months to monitor changes in abnormal protein level.

RESULTS

The SBP was located in the axial skeleton in 11 of 12 patients (Table 1). With conventional radiographs, 10 patients showed purely lytic bone destruction, one patient had a collapsed vertebra with coarsened trabeculae, and one showed sclerotic involvement of the first lumbar vertebra. On MR imaging, the signal intensity of the SBP was similar to muscle on T1-weighted images and hyperintense to muscle on T2-weighted images in 11 of 12 pa-

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Table 1. Characteristics of Patients With SBP

No. of Patients	Age (years)	Site	Myeloma Protein Type	Protein Levels (g/dL)		Months of Stability
				Pretreatment	Posttreatment	
Lesions on MR imaging						
1	44	Sacrum	Kappa only	0.3*	0.25*	31+
2	31	L-1	IgGK	2.3	1.7	28+
3	47	C-3	IgGk	1.5	2.8	10
4	39	T-12	IgGk	1.1	0.6	10+
No lesions on MR imaging						
1	53	Pelvis	IgGL	0.8	0	33+
2	44	Pelvis	None	0	0	24+
3	70	Sacrum	IgAK	1.3	0.3	16+
4	30	L-5	Kappa only	0.3*	0*	12+
5	47	Radius	IgGk	1.2	0.6	10+
6	45	T-6	None	0	0	9+
7	38	L-5	Lambda only	0.25*	0.01	6+
8	44	L-1	IgAL	0.3	0.2	6+

*Bence-Jones protein excretion in urine (g/d).

tients (Fig 1); in the patient with a sclerotic lesion on conventional radiographs, the involved vertebra was predominantly hypointense to muscle on both T1- and T2-weighted images. An extraosseous soft tissue component was identified in all patients, with extension into the spinal canal in six of nine patients with vertebral involvement.

MR imaging of the lumbosacral and thoracic spine showed additional foci of marrow-replacing signal abnormalities in four of 12 patients (Figs 2 through 4). Multiple additional sites of involvement were found in three patients and one additional focus of disease was detected in one patient. The lesions varied in size from 0.3 to 2 cm and the MR signal characteristics were identical to those of the primary tumor. In three patients, the lesions were of low signal intensity on T1-weighted images and high signal intensity on T2-weighted images. In the fourth patient with a sclerotic lesion, the additional foci depicted with MR imaging were hypointense to muscle on both T1- and T2-weighted sequences; computed tomographic (CT) examination of the spine in this patient confirmed the sclerotic nature of the abnormal foci. Biopsies of the additional foci were not performed due to the hazards of this procedure in patients with small vertebral lesions. Follow-up MR imaging in one patient (patient no. 1, Table 1) with unexpected lesions showed progression of the marrow involvement (Fig 3). This patient remains asymptomatic.

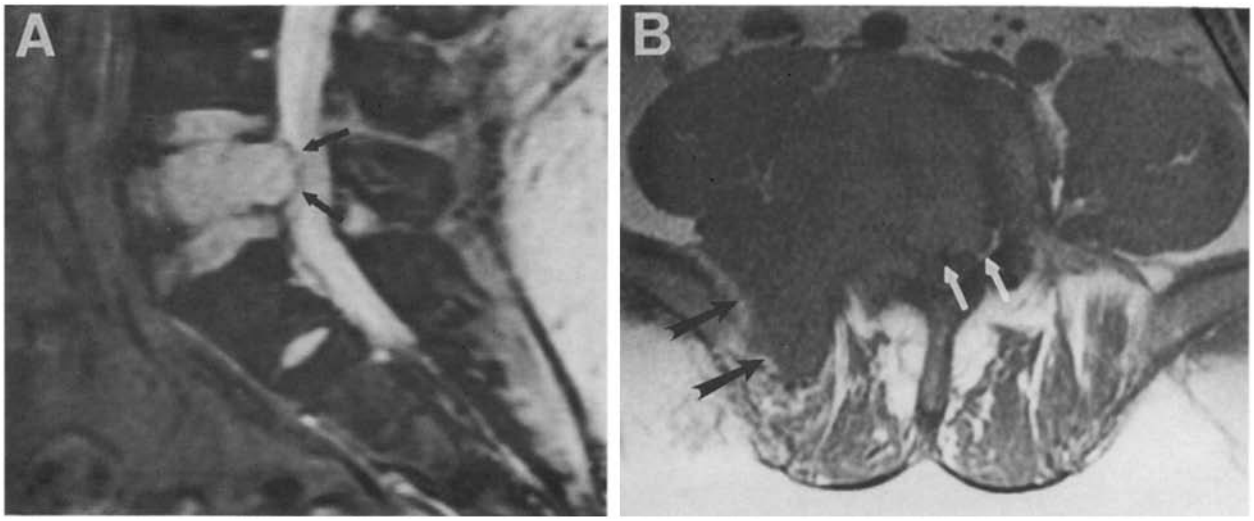

Fig 1. (A) GRASS sagittal MR image (250/20; 20-degree flip angle) shows hyperintense signal intensity in the L-5 vertebra, which is compressed. Note extension of tumor into the spinal canal (arrows). (B) Axial T1-weighted MR image (600/20) at the level of L-5 shows tumor in the spinal canal (white arrows) and in the right paraspinal region (black arrows).

With a median follow-up of 13 months (range, 6 to 33), no patient has developed a recurrence within the field of radiotherapy. All eight patients without other lesions have been monitored without additional treatment and have remained stable without evidence of myeloma. Among six patients with a myeloma protein, there was disappearance in two patients and a reduction of protein levels by at least 50% in three additional patients; in none of the four patients with abnormal foci on MR imaging was the myeloma protein reduced by 50% ($P < .01$) (Table 1).

All four patients with marrow abnormalities on MR imaging were treated with interferon alfa-2b at a dose of 2 MU/m^2 subcutaneously three times a week after completion of radiotherapy. Three patients have remained clinically stable for 10, 28, and 31 months. One patient (patient no. 3, Table 1) developed multiple symptomatic bone lesions at the site of the initial MR abnormalities with increasing levels of myeloma protein 10 months after radiotherapy; she has responded to combination chemotherapy for multiple myeloma and is currently in remission.

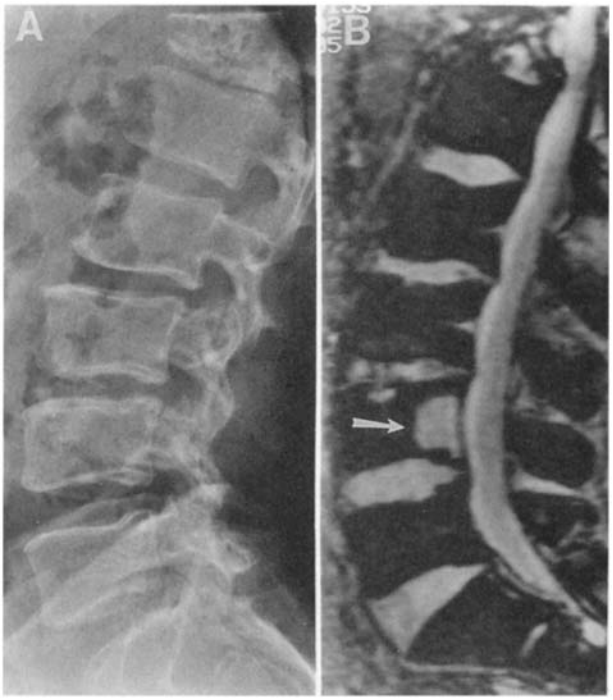

Fig 2. (A) Conventional radiograph of the lumbar spine shows pathologic compression fracture of the T-12 vertebra. (B) GRASS sagittal MR image (250/20; 20-degree flip angle) shows the involvement of the T-12 vertebra and an additional focus of disease at L-4 (arrow).

DISCUSSION

The diagnosis of SBP is based on specific criteria that require a solitary plasma cell tumor without evidence of other disease. Some investigators have postulated that multiple myeloma begins as a SBP that then becomes generalized after several years.[4] Because SBP is radiosensitive, there is a potential for cure with early diagnosis. Nevertheless, fewer than one third of patients with SBP have remained stable for more than 10 years, presumably because occult generalized disease is present in most patients at diagnosis.[3,4] This report indicates that additional foci of marrow disease are present by MR imaging in approximately one third of patients considered to have a SBP on standard studies.

Most patients with SBP have a lytic destructive lesion on conventional radiographs, but rare occurrences of a cystic, trabeculated lesion resembling a giant-cell tumor or an aneurysmal bone cyst have been described.[10] Among our patients, a lytic feature was dominant in 10, but one patient showed a compressed vertebra with coarsened trabeculae. Sclerotic lesions, as seen in another patient, occur in less than 3% of patients with multiple myeloma, some of whom have other clinical features such as polyneuropathy, organomegaly, endocrinopathy, and skin changes (POEMS syndrome).[11] Our patient with sclerotic SBP did not have any other clinical features of POEMS syndrome.

There is virtually no information regarding the MR appearance of SBP. In 11 of 12 patients, the MR appearance resembled that of other primary or secondary malignancies that produce lytic destruction of bone. In the sclerotic SBP, the lack of bright signal on T2-weighted images reflected the dense bone and was indistinguishable from blastic involvement of any etiology. In all patients, an extraosseous soft tissue component was present. MR imaging is of value and superior to CT scanning in depicting the extent of both the intraspinal tumor and the paraspinal soft tissue component so that portals of radiation treatment can be defined with maximum precision.

MR imaging showed unanticipated foci in the marrow of four of 12 patients with SBP. The MR imaging features of these abnormalities were identical to those of each patient's histologically confirmed primary SBP and to the appearance of marrow involvement by multiple myeloma in other patients.[6-9] The small size of the lesions and the known hazards of spinal biopsies prevented us from confirming unequivocally the histologic nature of these foci. None of these patients had or developed signs of any other disease that could account for the MR imaging findings. The later development of overt disease in the same area

as the MR lesions in one patient and the progression of the lesions on follow-up MR study in another patient support our view that the additional foci represented occult myeloma.

In contrast to multiple myeloma, where approximately 97% of patients have an abnormal protein in the serum or urine, an abnormal protein has been found in approximately one half of patients with SBP.[1-4] In those with a protein marker, serial electrophoreses help to define a response to treatment and to identify a residual clonal population after radiation treatment. Among our patients, there was a significant correlation between the persistence of myeloma protein and the presence of additional lesions on MR imaging.

The evolution of SBP to myeloma is not prevented, but may be slowed with adjuvant chemotherapy.[5] Because prolonged administration of alkylating agents may cause a treatment-related leukemia or the earlier evolution of resistant subclones, we administered in-

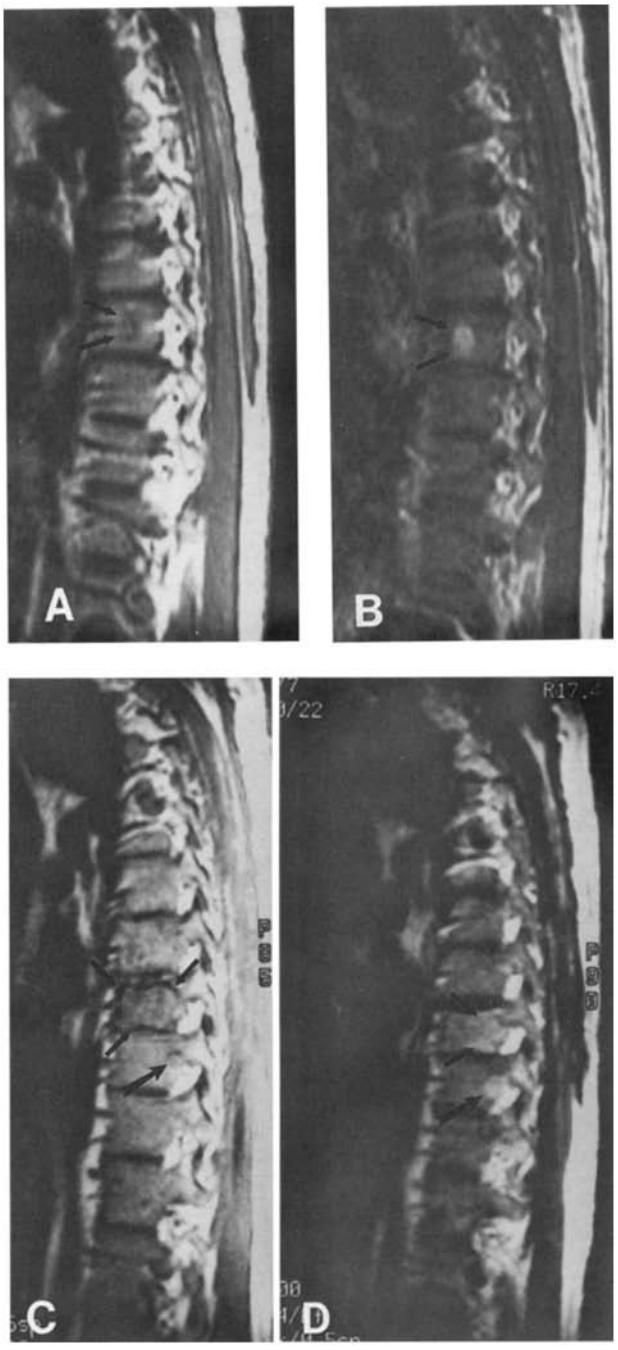

Fig 3. (A) T1-weighted sagittal MR image (600/20) of the thoracic spine shows small hypointense lesion in the T-8 vertebra (arrows). (B) On corresponding T2-weighted MR image (2,000/80), the lesion is hyperintense to muscle and marrow (arrows). (C) Twenty-four–month follow-up T1-weighted sagittal MR image of the thoracic spine shows almost complete involvement of the vertebral body of T-8 with sparing of the pedicle (arrows) and a new lesion in T-9 (long arrow). (D) On the corresponding T2-weighted image, mild increase in signal intensity can be seen in the involved vertebral body of T-8 (arrows). The lesion in T-7 is seen (long arrow).

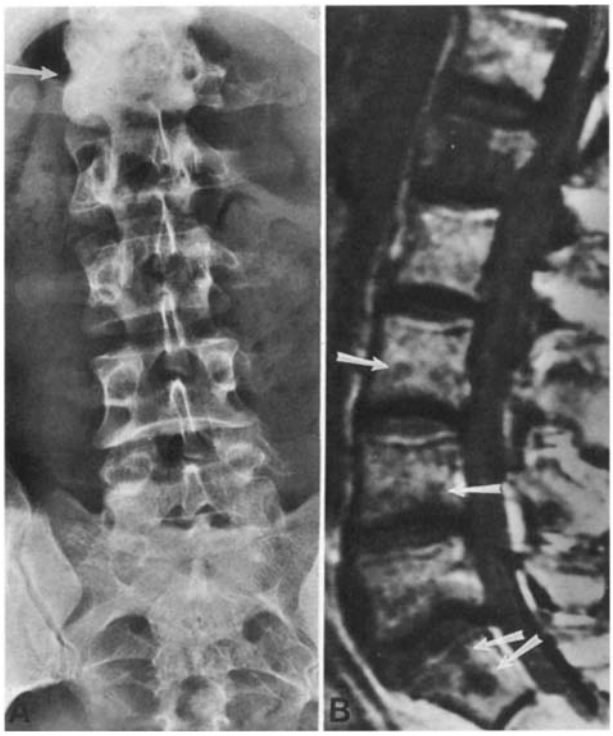

Fig 4. (A) Conventional radiograph of the lumbar spine shows sclerotic changes in the L-1 vertebra (arrow). (B) MR image (600/20) shows fatty marrow replacement in L-1, as well as multiple well-defined areas of disease throughout the spine (arrows).

terferon alfa to our four patients with additional MR signal abnormalities as part of a prospective study.[12] Interferon alfa has an established cytostatic effect against myeloma when given during remission maintenance and has not been associated with secondary leukemias.[13] Our study constitutes a preliminary report on the potential value of MR imaging in the initial assessment of patients with SBP.

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