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Case Report

Primary sacral non-germinal center type diffuse large B-cell lymphoma with MYC translocation: a case report and a review of the literature

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Abstract: An 85-year-old man presented with pain and numbness in the left buttock, and physical examination revealed an approximately 7 cm mass extending from the first to the third sacral vertebrae; biopsy of the mass led to the diagnosis of CD10-negative, BCL6-weakly positive, MUM1-positive, non-germinal center (non-GC) type diffuse large B-cell lymphoma (DLBCL). Furthermore, serological testing showed negative results for Epstein-Barr virus (EBV) infection, and fluorescence in situ hybridization (FISH) revealed a MYC translocation. Radiographs showed no remarkable osteolytic bone destruction, and the patient was staged with Stage IAE. After 8 cycles of rituximab therapy and 6 cycles of CHOP therapy, complete remission has been maintained until now, approximately 1 year after the treatment. Primary sacral lymphoma is very rare, with only 6 reported cases, including the present one. A review of the reported cases revealed that the disease predominantly affects elderly men, is usually non-GC-type DLBCL and stage IAE, measures approximately 2-7 cm in diameter in general, and does not show early recurrence after chemotherapy or chemoradiotherapy. There is no report in the literature yet of primary sacral DLBCL with MYC translocation, and this is the first case report. On the other hand, 35 cases of CD10-negative DLBCL with MYC translocation, including the present one, have been reported, and a review of the reported cases showed that the disease predominantly affects Asians, middle-aged or elderly men, shows positivity for either BCL6 or MUM1 and negativity for EBV, and has a high international prognostic index and poor prognosis.

Keywords: Primary sacral lymphoma, non-germinal center DLBCL, CD10-negative, MYC, paraffin-embedded tissue section-fluorescence in-situ hybridization

Introduction

Primary bone lymphoma (PBL) is rare, accounting for less than 2% of all lymphomas in adults [1], and diffuse large B-cell lymphoma (DLBCL) accounts for most of these cases [2]. PBL is defined as 1) a single skeletal site, with or without regional lymph node involvement, and 2) multiple bones are involved, but there is no visceral or lymph node involvement [3]. The femur and other long bones of the extremities, pelvic bone, head and neck are predominantly affected, while the sacrum is a rare site of occurrence of this tumor [4]. Sacral tumors are relatively rare, accounting for 1-2% of all musculoskeletal tumors [5]. Chordoma is the most common primary sacral tumor, and primary sacral lymphoma is very rare [6].

Primary spinal malignant lymphoma is also rare. According to the count of primary spinal tumors by Kelley et al., 44 out of a total of 127 cases were hematologic malignancies (11 cases of lymphoma and 33 cases of plasmacytoma/myeloma). Of these, thoracic tumors were the most common (n = 32), while there were only 2 cases of sacral tumor (0 case of lymphoma and 2 cases of plasmacytoma/myeloma) [7]. The disease occurs predominantly in elderly men, and the clinical symptoms include low back pain with or without radiculopathy [8]. The imaging findings of sacral lymphoma are similar

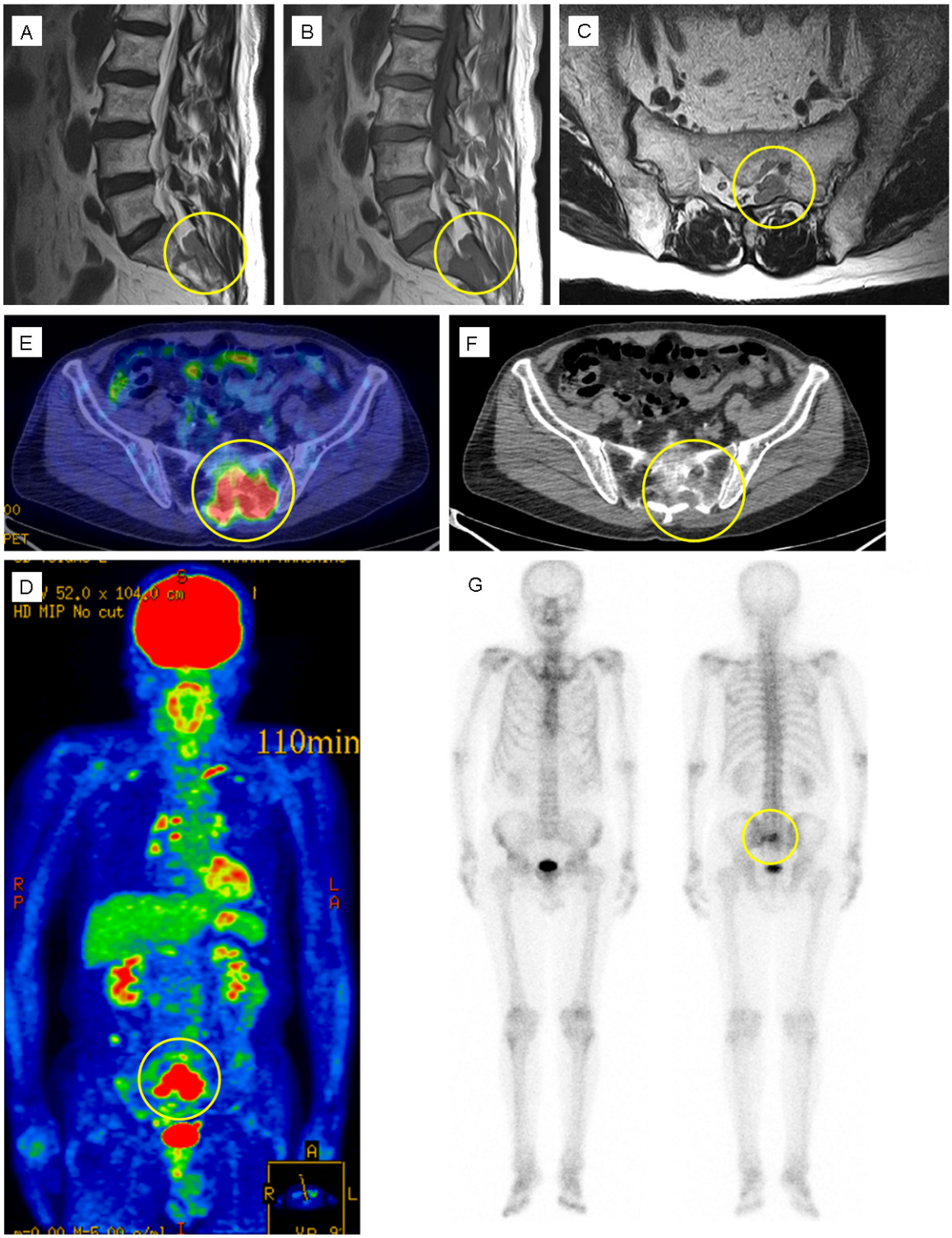

Figure 1. Imaging of sacral lymphoma. A: Sagittal section of T1 weighted MR image (WI). B: Sagittal section of T2WI. C: Coronal section of T1WI. The lesion is shown within the yellow circle. There is a soft tissue neoplastic lesion located in the epidural space and extending along the neuropore from the paramedian region to the left side within the spinal canal to the level of the second sacral vertebra. The lesion is visualized as a low-intensity signal on both T1WI and T2WI, and there are some water-rich areas exhibiting high signal intensity on the T2 star WI. The mass is found to infiltrate through the periosteum into the second sacral vertebral body. There is no obvious osteosclerosis or osteolytic lesion (no penetrating bone destruction). The mass is not seen to extend through the sacroiliac joint into the coxa. D-F: 18F-fluoro-2-deoxy-D-glucose-positron emission tomography/computed tomography (FDG-PET/

CT) images are shown. Malignant sacral tumor was suspected. Strong FDG accumulation (maximum standardized uptake value; SUVmax 17.3) is seen mainly in the midline and left side of the sacrum. FDG accumulation is limited to the sacrum and not observed in the surrounding pelvic bone or soft tissue. G: Bone scintigraphy. Irregularly-shaped, abnormal accumulation of radioactivity is observed in the sacrum.

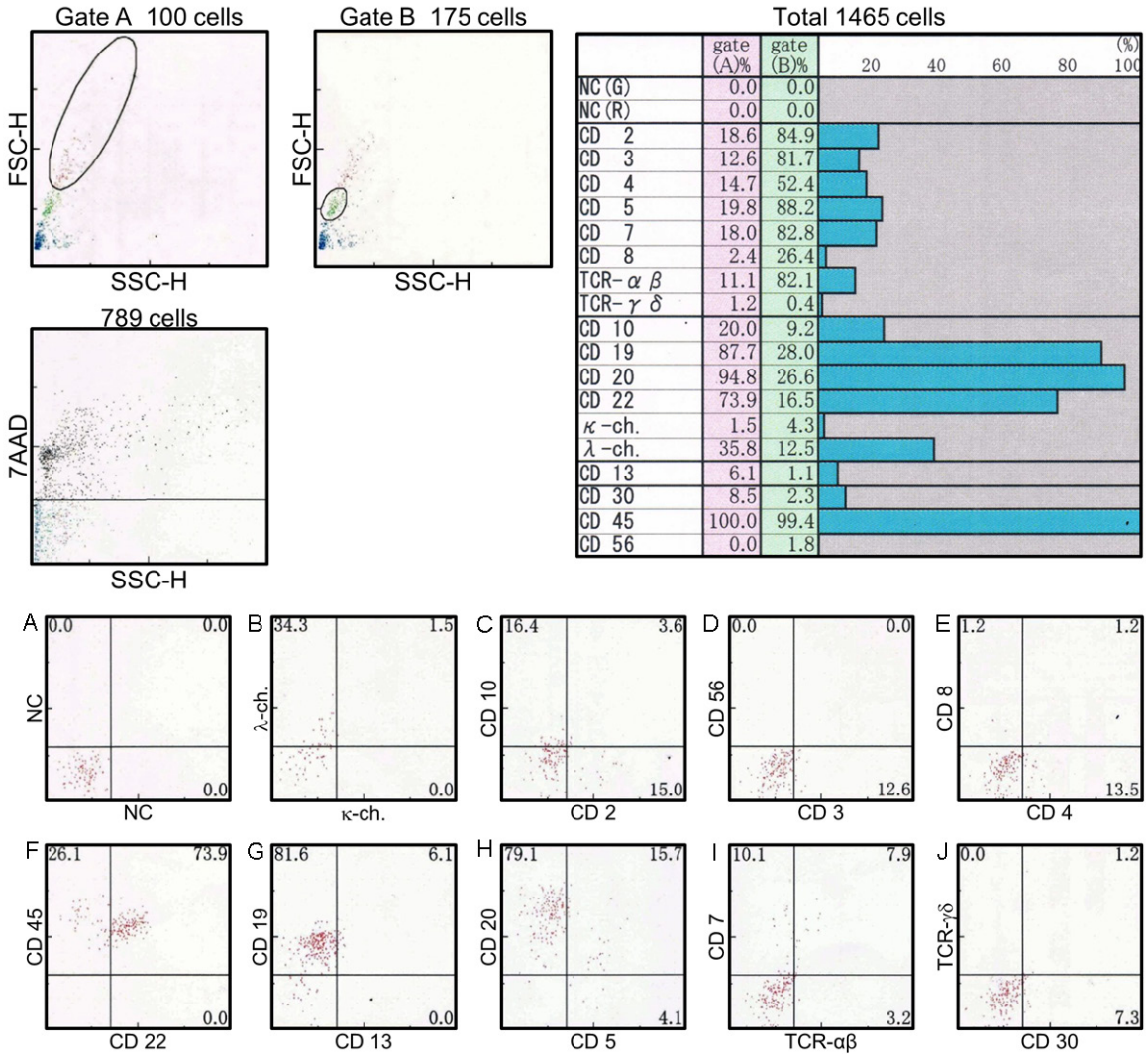

Figure 2. Flow cytometric analysis of the sacral lymphoma. DNA stain 7-aminoactinomycin D (7-AAD)-negative living lymphoma cells in gate A were analyzed by flow cytometry (FCM). Most of these cells were negative for CD10; furthermore, the cells were positive for CD19, positive for CD20, negative for kappa chains, positive for lambda chains, negative for CD30, positive for CD22, negative for CD13, negative for CD2, negative for CD3, negative for CD5, negative for CD7, negative for CD4, negative for CD8, positive for CD45, negative for CD56, negative for TCRαβ, and negative for TCRγδ.

to those of other neoplastic diseases, however, the prognosis of sacral lymphoma is relatively good and it is important to distinguish it from other neoplastic diseases [9].

We encountered a very rare case of primary sacral non-GC-type CD10-negative DLBCL with MYC translocation, and report the case herein.

Case report

An 85-year-old man presented to us with the complaints of pain and numbness in the left buttock. He had a history of treatment for pulmonary tuberculosis at age 20. In February 2012, he began to experience tenderness and numbness in the left buttock. There was a

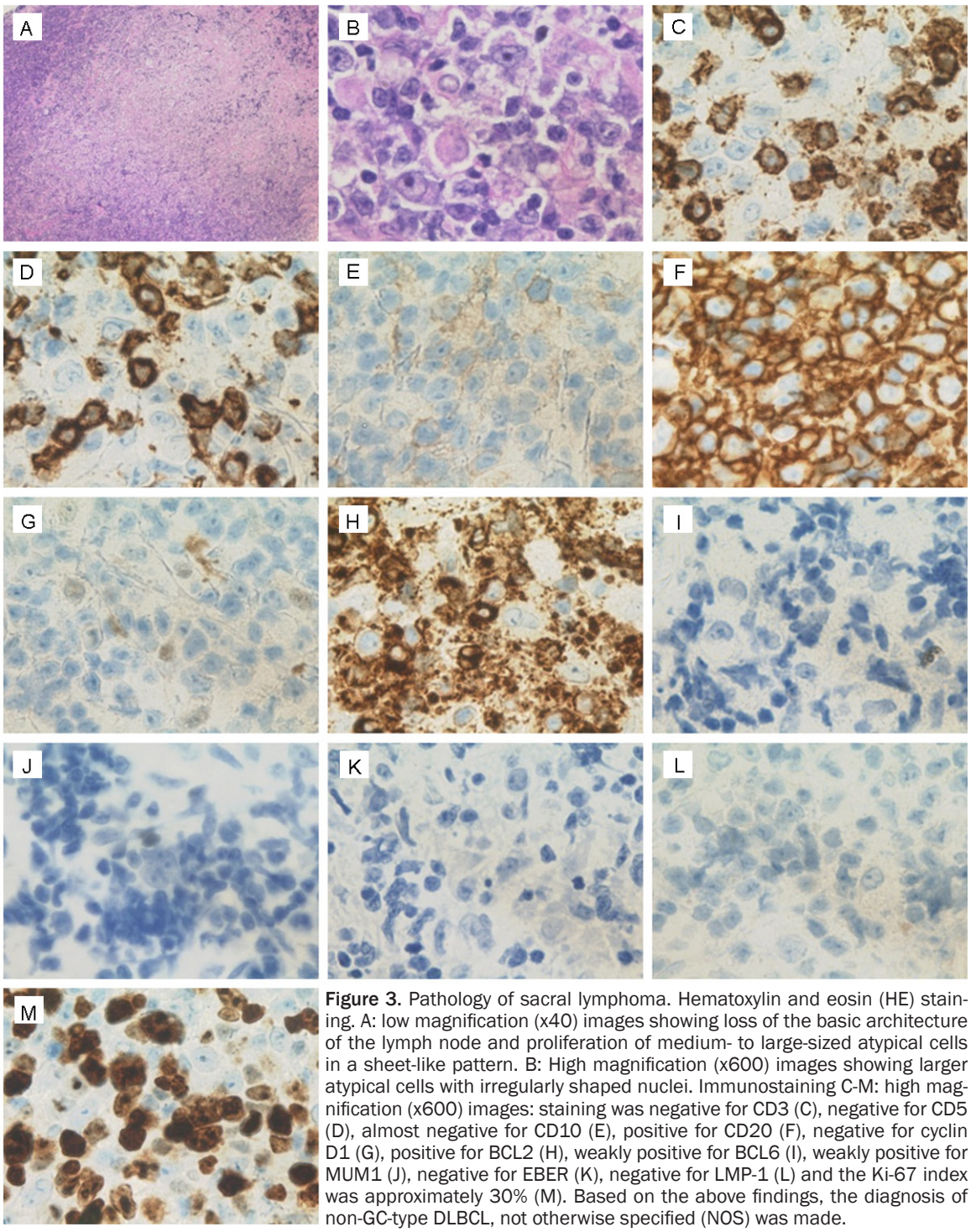

Figure 3. Pathology of sacral lymphoma. Hematoxylin and eosin (HE) staining. A: low magnification (x40) images showing loss of the basic architecture of the lymph node and proliferation of medium- to large-sized atypical cells in a sheet-like pattern. B: High magnification (x600) images showing larger atypical cells with irregularly shaped nuclei. Immunostaining C-M: high magnification (x600) images: staining was negative for CD3 (C), negative for CD5 (D), almost negative for CD10 (E), positive for CD20 (F), negative for cyclin D1 (G), positive for BCL2 (H), weakly positive for BCL6 (I), weakly positive for MUM1 (J), negative for EBER (K), negative for LMP-1 (L) and the Ki-67 index was approximately 30% (M). Based on the above findings, the diagnosis of non-GC-type DLBCL, not otherwise specified (NOS) was made.

2-day history of transient dysuria. In the same month, lumbosacral magnetic resonance imaging (MRI) revealed an epidural mass in the sacrum S1-3 region which was visualized as an isodensity on both T1- and T2-weighted MR images (T1WI and T2WI); the tumor was clearly demarcated, but was not associated with remarkable osteolytic bone destruction (**Figure 1A-C**).

However, 18F-fluoro-2-deoxy-D-glucose-positron emission tomography/computed tomography (FDG-PET/CT) showed FDG accumulation with a maximum standardized uptake value

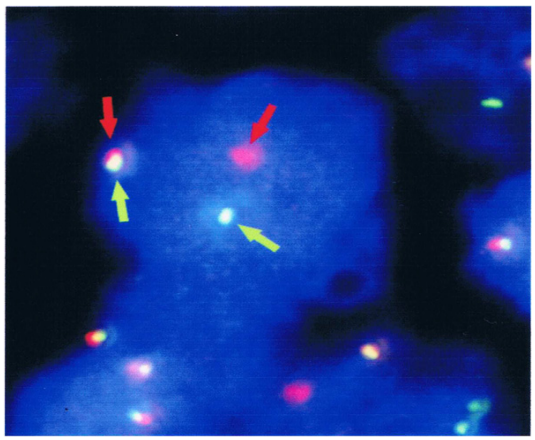

Figure 4. Paraffin-embedded tissue section-fluorescence in-situ hybridization (PS-FISH). FISH was performed on paraffin-embedded sections of the tumor tissue. Probes for the centromeric (red) and telomeric (green) sides of the MYC locus (8q24) were used. A MYC split signal suggesting breakage of the MYC gene was observed in approximately 60% of the cells.

(SUVmax) of 17.3 at the same site, raising the suspicion of malignancy (**Figure 1D-F**). The FDG accumulation was not limited to the epidural space, but was observed over a wide area including the sacrum. Bone scintigraphy also showed abnormal accumulation of radioactivity in the sacrum (**Figure 1G**). However, there was no significant osteolytic bone destruction and the lesion was more clearly visualized by FDG-PET/CT and bone scintigraphy than by MRI. Sacral tumor resection was performed at our hospital in April 2012. The patient was diagnosed histopathologically as having malignant lymphoma (DLBCL) and referred to the Department of Hematology.

At the initial examination, the patient was 168 cm tall, weighed 66 kg, had a body temperature of 36.2°C, and tenderness in the left buttock. There was no palpable superficial lymphadenopathy or hepatosplenomegaly. Laboratory examination revealed no abnormalities of the hematological parameters, blood biochemistry, serum lactate dehydrogenase (LDH), alkaline phosphatase (ALP), C-reactive protein (CRP), soluble interleukin-2 receptor (sIL-2R), immunoglobulin, etc. Serum human immunodeficiency virus (HIV) and M-protein were negative. Bone marrow examination revealed no infiltration by morphologically obvious lymphoma cells, and flow cytometry (FCM) and Southern blotting of immunoglobulin heavy chain joining segments (IgH-JH) showed no abnormalities. Chromosome G-banding analysis revealed 46, X, -Y, +8 in 11 out of 20 cells, but no dysplastic cells were observed in the bone marrow and there was no decrease of the peripheral blood cell counts. Therefore, the patient was unlikely to have myelodysplastic syndrome or bone marrow infiltration of DLBCL. No tumor cells were found in the cerebrospinal fluid.

FCM of the tumor cells showed that most of the cells were negative for CD10; furthermore, the cells were positive for CD19, positive for CD20, negative for kappa chains, positive for lambda chains, negative for CD30, positive for CD22, negative for CD13, negative for CD2, negative for CD3, negative for CD5, negative for CD7, negative for CD4, negative for CD8, positive for CD45, negative for CD56, negative for TCRαβ and negative for TCRγδ (**Figure 2**), suggesting the diagnosis of CD5-negative, CD10-negative mature B-cell lymphoma.

On histopathology, examination of hematoxylin-eosin (HE)-stained sections of the tumor tissue at low magnification showed loss of the basic architecture of the lymph node and proliferation of medium to large atypical cells in a sheet-like pattern, and at higher magnification, larger centroblasts with irregularly shaped nuclei were observed. Immunostaining showed negative staining results for CD5, negative staining of most cells for CD10, positive staining for CD20, positive staining for BCL2, weakly positive staining for BCL6, weakly positive staining for MUM1, negative staining for EBER and a MIB-1 (Ki-67) index of approximately 30% (**Figure 3**), which led to the diagnosis of CD5-negative, EBV-negative DLBCL, not otherwise specified (NOS). Furthermore, negativity for CD10, weak positivity for BCL6 and positivity for MUM1 suggested the non-GCB type of DLBCL.

Genetic analysis by Southern blotting and chromosome G-banding analysis could not be performed due to the lack of adequate specimens. In addition, paraffin-embedded tissue section-fluorescence in situ hybridization (PS-FISH) analysis showed a MYC split signal suggesting breakage of the MYC locus (**Figure 4**). Based on the above, the patient was diagnosed as having primary sacral DLBCL (non-GC type) with MYC translocation. The disease stage was IAE and the international prognostic index (IPI) was low

Table 1. Primary sacral lymphoma

Case	Race	Sex/Age	Pathology	Stage	Site	Size (cm)	C-MYC translocation	CD5	CD10	BCL2	BCL6	MUM1	EBV	Therapy	Outcome	Ref.
1	Caucasian	M/58	DLBCL	IAE	L5-S1	2.0	NA	NA	NA	NA	NA	NA	NA	CT + IT + RT + ASCT	ANED, 12 m	[19]
2	NA	M/52	DLBCL	IAE	S1-4	NA	NA	NA	NA	NA	+	NA	NA	R-CHOP x 6 + RT	ANED, 9 m	[9]
3	NA	M/64	DLBCL	IAE	S1	6.8 x 3.9	NA	NA	NA	NA	+	NA	NA	CHOP x 3 + RT	ANED, 13 m	[9]
4	Asian*	M/24	DLBCL	IAE	L5-S2	3.2 x 3.0 x 3.0	NA	NA	NA	NA	NA	NA	NA	CHOP x 6 + IT + RT	ANED, 3 m	[20]
5	Asian*	M/53	DLBCL	IAE	S1-2	NA	NA	-	NA	NA	NA	NA	NA	RT	ANED, 6 m	[8]
6	Asian	M/85	DLBCL	IAE	S1-3	6.7 x 3.7 x 2.4	+	-	-/+	+	+/-	+	-	R-CHOP	ANED, 12 m	present

Abbreviations: + positive; - negative; +/- weak positive; -/+ very weak positive; *suspicious; ANED alive with no evidence of disease; ASCT autologous stem cell transplantation; CHOP cyclophosphamide + doxorubicin + vincristine + prednisone; CT chemotherapy; DLBCL diffuse large B-cell lymphoma; IT intrathecal methotrexate; L lumbar spine; M male; m months; NA not available; R rituximab; RT radiation therapy; S sacrum.

Table 2. CD10-negative DLBCL with MYC translocation

Case	Race	Sex/Age	Site	IPI/AIPI	BCL6	MUM1	EBV	Outcome	References
1	Asian	M/58	LN	NA	+	NA	-	NA	[21]
2	Asian	F/74	LN	NA	NA	NA	-	D, 31 m	[21]
3	Asian	M/66	LN	NA	+	NA	-	D, 45 m	[21]
4	Caucasian	NA/NA	NA	NA	NA	NA	-	NA	[22]
5	Caucasian	NA/NA	NA	NA	NA	NA	-	NA	[22]
6	Asian	F/75	Stomach	NA	+	-	-	ANED, 16 m	[23]
7	Asian	M/58	LN	NA	+	-	-	NA	[23]
8	Asian	M/74	LN	NA	+	-	-	DOD, 31 m	[23]
9	Asian	F/70	LN	NA	+	-	-	A, 56 m	[23]
10	Asian	M/66	LN	NA	+	-	-	DOD, 5 m	[23]
11	Asian	M/66	LN	NA	+	+	-	DOD, 45 m	[23]
12	Asian	M/82	LN	NA	-	+	-	DOD, 2 m	[23]
13	Asian	M/87	LN	NA	-	+	-	DOD, 1 m	[23]
14	Asian	NA/NA	NA	NA	NA	NA	NA	NA	[24]
15	Asian	NA/NA	NA	NA	NA	NA	NA	NA	[24]
16	Asian	NA/NA	NA	NA	NA	NA	NA	NA	[24]
17	NA	F/67	NA	NA	+	NA	NA	ANED, 22 m	[25]
18	NA	F/64	NA	NA	+	+	NA	ANED, 12 m	[25]
19	NA	M/10	LN	L*	+	-	NA	NA	[26]
20	NA	M/15	LN	LI*	+	-	NA	NA	[26]
21	NA	F/12	LN	HI*	+	+	NA	NA	[26]
22	Asian	M/62	LN	H	NA	NA	NA	D, 2 m	[17]

23	Asian	M/81	LN	LI	NA	NA	NA	D 21.3 m	[17]
24	Asian	M/63	LN	H	NA	NA	NA	D, 3 m	[17]
25	Asian	M/57	LN	HI	NA	NA	NA	D 10 m	[17]
26	Asian	M/69	Bone	HI	NA	NA	NA	D, 0.5 m	[17]
27	Asian	F/69	LN	H	NA	NA	NA	D, 4.4 m	[17]
28	Asian	M/84	Tyroid gland	H	NA	NA	NA	D, 2.6 m	[17]
29	Asian	M/52	Eye	H	NA	NA	NA	D, 4 m	[17]
30	Asian	F/60	LN	H	NA	NA	NA	D, 4.8 m	[17]
31	Asian	F/53	LN	H	NA	NA	NA	D, 7.5 m	[17]
32	Asian	F/63	Breast	H	NA	NA	NA	D, 17 m	[17]
33	Asian	M/70	LN	H	NA	NA	NA	D, 6 m	[17]
34	Asian	F/56	LN	H	NA	NA	NA	D, 4.7 m	[17]
35	Asian	M/85	Sacral	L	+/-	+	-	ANED, 12 m	present

Abbreviations: + positive; - negative; +/- weakly positive; *suspicious; A alive; AIPI age-adjusted international prognostic index; ANED alive with no evidence of disease; D dead; DOD dead of disease; EBV epstein-barr virus; F female; H high risk; HI high intermediate risk; IPI international prognostic index; L low risk; LI low intermediate risk; LN lymph node; M male; m month (s); NA not available.

risk. Eight courses of rituximab and 6 courses of CHOP therapy, as well as a single intrathecal injection of methotrexate to prevent central nervous system infiltration, were administered between April and July 2012, and complete remission has been maintained for approximately one year as on date.

Discussion

Primary spinal lymphoma is rare, accounting for only approximately 0.4% of all primary bone tumors [7]. Malignant lymphoma is associated with a low incidence of B symptoms such as fever and weight loss. The present patient also showed no B symptoms. Laboratory findings are often non-specific; including increased serum CRP, LDH and ALP, with low frequencies of abnormal values, and their diagnostic usefulness is low.

The most common imaging finding is osteolytic bone destruction, which is observed in approximately 70% of all patients [10]. However, no remarkable osteolytic bone destruction was seen in the present patient. The MRI findings are also not specific, but the lesion is often visualized as a low signal intensity on T1WI and high signal intensity on T2WI, although, in the present case, the lesion was visualized as a low signal intensity on both T1WI and T2WI.

FDG-PET/CT is very useful for detecting lesions in cases without significant osteolytic destruction and atypical MRI images, like the present case. Furthermore, FDG-PET/CT is also useful for determining the disease stage at the time of diagnosis and for assessing the treatment effects after completion of treatment [11]. In the present case, sacral spinal nerve epidural lymphoma was considered in the differential diagnosis; however, FDG-PET/CT showed that the mass lesion was in the sacrum, making this condition unlikely.

Primary benign and malignant tumors of the sacrum are rare, accounting for less than 7% of all primary spinal tumors [12]. Approximately 40% of all primary sacral tumors are chordomas, and primary sacral lymphoma is extremely rare, with only 6 cases reported previously, including the present one (**Table 1**). They characteristically 1) occur in middle-aged to elderly men, 2) are non-GC-type DLBCL, 3) are stage IEA, 4) have a tumor diameter of approximately 2-7 cm, and 5) do not show early recurrence after combination chemotherapy or chemoradiotherapy. The features in our patient reported herein were consistent with these characteristics, while the surface markers and MYC translocation have not been examined in the previously reported cases. In the present patient, complete remission has been maintained for approximately 1 year as of the time of writing, and his prognosis is speculated to be relatively good. Until date, there are only few reports of primary sacral lymphoma; therefore, the incidence and prognosis have not yet been clearly elucidated.

Most lymphomas, including Burkitt's lymphoma and DLBCL with MYC translocation, are of the GCB type. Many reports have shown that MYC translocation is often encountered in GCB-type cases and is associated with a poor prognosis [13-16]. However, according to Zhang HW et al., 13 (12.3%) out of 106 DLBCL patients in their series showed MYC translocation, and the lymphoma in all the patients was CD10-negative and the non-GCB type [17]. In addition, one report suggests that GCB-type lymphoma is less common than non-GCB type lymphoma in Asian people [18]. The present patient showed an MYC split signal, but the tumor was almost entirely negative for CD10, and it can be said that he had the non-GCB type (CD10-/+, BCL6+/-, MUM1+) lymphoma rather than GCB-type lymphoma. Thirty cases of CD10-negative, non-GCB type DLBCL with MYC translocation have been reported until now, including the present case (**Table 2**). This condition is characterized by its predominant occurrence in Asian people including Japanese, in middle-aged to elderly men, association with lymph node lesions in many cases, positivity for BCL6 and/or MUM1, negativity for EBV, and a poor prognosis. The present patient had all of these features, except for the lymph node lesions and the poor prognosis. However, bone lesions are rare, with only 2 cases reported so far, including the present case.

We encountered a case of primary sacral DLBCL (non-GC type), and report the case herein, as this condition is considered to be extremely rare. This patient was unlikely to have Burkitt lymphoma, because he was negative for HIV and the tumor was CD10-negative and CD20- and BCL2-positive. Based on the negativity for CD10 and positivity for BCL6 and

MUM1, the lymphoma was categorized as MYC translocation-positive non-GCB-type DLBCL, NOS.

Disclosure of conflict of interest

The author(s) indicated no potential conflicts of interest.

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References

[1] Ramadan KM, Shenkier T, Sehn LH, Gascoyne RD and Connors JM. A clinicopathological retrospective study of 131 patients with primary bone lymphoma: a population-based study of successively treated cohorts from the British Columbia Cancer Agency. Ann Oncol 2007; 18: 129-135.

[2] Heyning FH, Hogendoorn PC, Kramer MH, Hermans J, Kluin-Nelemans JC, Noordijk EM and Kluin PM. Primary non-Hodgkin's lymphoma of bone: a clinicopathological investigation of 60 cases. Leukemia 1999; 13: 2094-2098.

[3] Unni KK and Hogendoorn PCW. Pathology and Genetics of Tumours of Soft Tissue and Bone. World Health Organization Classification of Tumours. Lyon, France: International Agency for Research on Cancer (IARC), 2002.

[4] Salter M, Sollaccio RJ, Bernreuter WK and Weppelmann B. Primary lymphoma of bone: the use of MRI in pretreatment evaluation. Am J Clin Oncol 1989; 12: 101-105.

[5] Capanna R, Benign and malignant tumors of the sacrum. The Adult Spine: Principles and Practice. ed 2. Philadelphia, PA: Lippincott-Raven Publishers, 1997.

[6] Epelbaum R, Haim N, Ben-Shahar M, Ben-Arie Y, Feinsod M and Cohen Y. Non-Hodgkin's lymphoma presenting with spinal epidural involvement. Cancer 1986; 58: 2120-2124.

[7] Kelley SP, Ashford RU, Rao AS and Dickson RA. Primary bone tumours of the spine: a 42-year survey from the Leeds Regional Bone Tumour Registry. Eur Spine J 2007; 16: 405-409.

[8] Nayil K, Makhdoomi R, Ramzan A, Malik R, Alam S, Wani A and Chhiber S. Primary sacral lymphoma: a case report and review of the literature. Turk Neurosurg 2011; 21: 659-662.

[9] Liu JK, Kan P and Schmidt MH. Diffuse large B-cell lymphoma presenting as a sacral tumor. Report of two cases. Neurosurg Focus 2003; 15: E10.

[10] Dürr HR, Müller PE, Hiller E, Maier M, Baur A, Jansson V and Refior HJ. Malignant lymphoma of bone. Arch Orthop Trauma Surg 2002; 122: 10-16.

[11] Yamamoto Y, Taoka T and Nakamine H. Superior clinical impact of FDG-PET compared to MRI for the follow-up of a patient with sacral lymphoma. J Clin Exp Hematop 2009; 49: 109-115.

[12] Llauger J, Palmer J, Amores S, Bagué S and Camins A. Primary tumors of the sacrum: diagnostic imaging. AJR Am J Roentgenol 2000; 174: 417-424.

[13] Niitsu N, Okamoto M, Miura I and Hirano M. Clinical features and prognosis of de novo diffuse large B-cell lymphoma with t(14;18) and 8q24/c-MYC translocations. Leukemia 2009; 23: 777-783.

[14] van Imhoff GW, Boerma EJ, van der Holt B, Schuuring E, Verdonck LF, Kluin-Nelemans HC and Kluin PM. Prognostic impact of germinal center-associated proteins and chromosomal breakpoints in poor-risk diffuse large B-cell lymphoma. J Clin Oncol 2006; 24: 4135-4142.

[15] Hummel M, Bentink S, Berger H, Klapper W, Wessendorf S, Barth TF, Bernd HW, Cogliatti SB, Dierlamm J, Feller AC, Hansmann ML, Haralambieva E, Harder L, Hasenclever D, Kühn M, Lenze D, Lichter P, Martin-Subero JI, Möller P, Müller-Hermelink HK, Ott G, Parwaresch RM, Pott C, Rosenwald A, Rosolowski M, Schwaenen C, Stürzenhofecker B, Szczepanowski M, Trautmann H, Wacker HH, Spang R, Loeffler M, Trümper L, Stein H, SSiebert R; Molecular Mechanisms in Malignant Lymphomas Network Project of the Deutsche Krebshilfe. A biologic definition of Burkitt's lymphoma from transcriptional and genomic profiling. N Engl J Med 2006; 354: 2419-2430.

[16] Savage KJ, Johnson NA, Ben-Neriah S, Connors JM, Sehn LH, Farinha P, Horsman DE and Gascoyne RD. MYC gene rearrangements are associated with a poor prognosis in diffuse large B-cell lymphoma patients treated with R-CHOP chemotherapy. Blood 2009; 114: 3533-3537.

[17] Zhang HW, Chen ZW, Li SH, Bai W, Cheng NL and Wang JF. Clinical significance and prognosis of MYC translocation in diffuse large B-cell lymphoma. Hematol Oncol 2011; 29: 185-189.

[18] Shiozawa E, Yamochi-Onizuka T, Takimoto M and Ota H. The GCB subtype of diffuse large B-cell lymphoma is less frequent in Asian countries. Leuk Res 2007; 31: 1579-1583.

[19] Theodorou DJ, Theodorou SJ, Sartoris DJ, Haghighi P and Resnick D. Delayed diagnosis of primary non-Hodgkin's lymphoma of the sacrum. Clin Imaging 2000; 24: 169-173.

[20] Mally R, Sharma M, Khan S and Velho V. Primary Lumbo-sacral Spinal Epidural Non-Hodgkin's Lymphoma: A Case Report and Review of Literature. Asian Spine J 2011; 5: 192-195.
[21] Nakamura N, Nakamine H, Tamaru J, Nakamura S, Yoshino T, Ohshima K and Abe M. The distinction between Burkitt lymphoma and diffuse large B-Cell lymphoma with c-myc rearrangement. Mod Pathol 2002; 15: 771-776.
[22] Barth TF, Müller S, Pawlita M, Siebert R, Rother JU, Mechtersheimer G, Kitinya J, Bentz M and Möller P. Homogeneous immunophenotype and paucity of secondary genomic aberrations are distinctive features of endemic but not of sporadic Burkitt's lymphoma and diffuse large B-cell lymphoma with MYC rearrangement. J Pathol 2004; 203: 940-945.
[23] Kikuchi A, Nakamura N, Kuze T, Sasaki Y, Abe M, Ohno H, Akasaka T, Nakamura S, Ohshima K and Ando K. Characterization of de novo diffuse large B-cell lymphoma with a translocation of c-myc and immunoglobulin genes. Leuk Res 2008; 32: 1176-1182.
[24] Nomura Y, Karube K, Suzuki R, Ying G, Takeshita M, Hirose S, Nakamura S, Yoshino T, Kikuchi M and Ohshima K. High-grade mature B-cell lymphoma with Burkitt-like morphology: results of a clinicopathological study of 72 Japanese patients. Cancer Sci 2008; 99: 246-252.
[25] Zhao XF, Hassan A, Perry A, Ning Y, Stass SA and Dehner LP. C-MYC rearrangements are frequent in aggressive mature B-Cell lymphoma with atypical morphology. Int J Clin Exp Pathol 2008; 1: 65-74.
[26] Gualco G, Weiss LM, Harrington WJ and Bacchi CE. Nodal diffuse large B-cell lymphomas in children and adolescents: immunohistochemical expression patterns and c-MYC translocation in relation to clinical outcome. Am J Surg Pathol 2009; 33: 1815-1822.