Feasibility of Whole-body MRI for Detecting Metastatic Myxoid Liposarcoma: A Case Series

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abstract

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No feasible method currently exists to evaluate systemic metastasis in patients with myxoid liposarcoma. The purpose of this study was to determine the feasibility of performing whole-body magnetic resonance imaging (MRI) to detect metastatic myxoid liposarcoma. From June 2008 to May 2010, all patients who were newly diagnosed with myxoid liposarcomas at our institution underwent whole-body MRI along with other conventional imaging methods. We divided the whole body into 38 sections (7 soft tissue sections and 31 bone tissue sections). In total, there were 570 regions (105 soft tissue regions and 465 bony regions) in 15 patients (10 men and 5 women) who underwent whole-body MRI.

Of 105 soft tissue regions, there were 4 true positives, 3 false positives, 1 false negative, and 97 true positives. Of 465 bone tissue regions, there were 11 true positives, 5 false positives, 2 false negatives, and 447 true negatives. In soft tissue, whole-body MRI for the detection of metastatic lesion showed a sensitivity of 80%, a specificity of 97.0%, a positive predictive value of 57.1%, and a negative predictive value of 99.0%. In bone tissue, whole-body MRI had a sensitivity of 84.6%, a specificity of 98.9%, a positive predictive value of 68.8%, and a negative predictive value of 99.6%.

Whole-body MRI is feasible and effective for detecting bone and soft tissue metastasis in patients with myxoid liposarcoma.
liposarcoma is the second most common soft tissue sarcoma other than myxofibrosarcoma, previously known as malignant fibrous histiocytoma, and liposarcoma accounts for 10% to 35% of all types of soft tissue sarcoma. Well-differentiated liposarcoma is usually low grade and rarely metastasizes, yet myxoid liposarcoma has a higher prevalence of metastasis. Unlike other sarcomas, myxoid liposarcoma has a tendency to metastasize to unusual sites. Prior to pulmonary metastasis, it metastasizes to the musculoskeletal system (eg, the retroperitoneum, axilla, and contralateral lower limb and bone). Therefore, the surveillance and metastatic workup for myxoid liposarcoma should be different from other sarcoma, and it is important to develop a new reliable method for detecting metastasis of the musculoskeletal system, not only at the time of the initial diagnosis, but also during the follow-up period. A chest/abdominal/pelvis computed tomography (CT) scan has been used for staging and follow-up of these patients; however, CT is not feasible for detecting lesions in the musculoskeletal system.

Fluorodeoxy-D-glucose-positron emission tomography (FDG-PET), which detects tumors with high glucose metabolism, has been useful for the early detection of systemic metastasis by scanning the whole body. However, several reports have documented the limited use of FDG-PET in diagnosing myxoid liposarcoma due to its low sensitivity. Schwab et al reported that FDG-PET had an unacceptably low sensitivity of 14% for the detection of spinal metastasis in myxoid liposarcoma. Magnetic resonance imaging (MRI) has been recognized as a useful diagnostic test for assessing the primary lesion of myxoid liposarcoma. Although whole-body MRI has not yet been used for assessing patients with myxoid liposarcoma, it has been accepted as a feasible method for detecting metastasis of other tumors. We hypothesized that whole-body MRI is feasible for detecting metastasis of myxoid liposarcoma. We performed whole-body MRI for patients who were histologically diagnosed with myxoid liposarcoma and evaluated the diagnostic value of whole-body MRI for detecting metastasis in patients with myxoid liposarcoma.

**MATERIALS AND METHODS**

**Study Group**

Every patient diagnosed with myxoid liposarcoma of the extremities at our institution between June 2008 and May 2010 was enrolled in this study. Diagnosis was confirmed via a preoperative biopsy. Because there was no specific test available to detect metastasis of myxoid liposarcoma, all patients underwent whole-body MRI and chest CT to detect systemic and pulmonary metastasis. Wide excision was performed when there was no metastasis noted on the initial evaluation. When wide excision was not possible because the neurovascular system was close to the lesion, marginal excision was performed, followed by radiation therapy. Patients were enrolled when they fulfilled all inclusion criteria: (1) diagnosed with myxoid liposarcoma at our institution between June 2008 and May 2010, (2) provided informed consent to undergo whole-body MRI, and (3) had a lesion located in the extremities. Patients were excluded if they (1) did not give their consent, (2) were not able to undergo the MRI procedure for a long time due to claustrophobia, or (3) if the lesion was not located in the extremities such that it was difficult to follow up with the patient.

**Data Collection**

Institutional review board approval was obtained for the study. All MRIs were performed with a 3.0-T imager (Achieva; Philips Healthcare, Amsterdam, the Netherlands). A body coil with a 4-coil element (built in the bore) was used to obtain the whole-body images. For the whole-body reformatted images, 7 stacks of contiguous images were obtained using the fat-suppressed, T2-weighted coronal and sagittal sequences and the T1-weighted coronal sequence. To obtain the enhanced images, a paramagnetic contrast agent (Gadovist; Bayer Schering Pharma, Berlin, Germany) was administered intravenously via a bolus injection technique at a dose of 0.2 mmol per kg of body weight. After the administration of contrast material, the T1-weighted fast gradient-echo sequences with fat suppression were obtained in the coronal and sagittal planes. It took approximately 60 minutes to complete a whole-body MRI scan.

Every image was interpreted by an experienced musculoskeletal radiologist (J.W.K.). Core needle biopsy was performed for the highly probable lesions detected on whole-body MRI. The histopathology was confirmed by a specialized pathologist. For the less probable lesions detected on the whole-body MRI, a follow-up ultrasound was done every 3 months. Biopsy was performed when the ultrasonographic features indicated that the lesion was more likely to be a metastatic lesion. The follow-up ultrasound was not performed for bone tissue lesions. All patients underwent whole-body MRI again after 6 months, and biopsy was per-
formed on all highly probable lesions observed on the follow-up whole-body MRI.

Biopsy was not performed on multiple highly probable lesions if 1 of the lesions was histologically confirmed to be a metastatic myxoid liposarcoma. If those lesions appeared advanced on the next follow-up MRI, we confirmed them to be a true positive.

We divided the soft tissue of the whole body into 7 sections: (1) head and neck, (2) trunk (including internal organs of chest and abdomen), (3) pelvis, (4) right upper extremity, (5) left upper extremity, (6) right lower extremity, and (7) left lower extremity. We divided the bone of the whole body into 9 sections: (1) cranium, (2) seven cervical vertebrae, (3) twelve thoracic vertebrae and ribs, (4) five lumbar vertebrae, (5) sacrum and pelvis (6) right upper extremity, (7) left upper extremity, (8) right lower extremity, and (9) left lower extremity (Figure 1). Each spinal segment was evaluated as an independent factor. Thus, a total of 31 regions of bone were independently evaluated.

Pulmonary metastasis was assessed separately by chest CT. Routine evaluation with FDG-PET or a bone scan was not performed to detect metastasis because the reported diagnostic sensitivity is low, but we consulted with our radiologist in reading the results from these scans that were performed at another hospital.

**Data Interpretation**

**Definition of True Positive.** A true positive was defined as a suspicious lesion seen on initial whole-body MRI that was histologically confirmed as myxoid liposarcoma by pathologists. True positives were also confirmed if a highly probable lesion seen on initial whole-body MRI appeared to have advanced on the whole-body MRI performed 6 months later. An advanced lesion was defined as the observation of disease progression or cortical bone destruction on the 6-month follow-up whole-body MRI. A lesion was determined to be a false positive if myxoid liposarcoma was histologically excluded for a highly probable lesion on whole-body MRI. When a highly probable lesion seen on the previous whole-body MRI decreased or did not increase in size, it was determined to be a false positive.

**Definition of True and False Negatives.**

A true negative was defined as the absence of metastatic lesion in each body section on both the initial and 6-month follow-up whole-body MRIs (Figure 2). When a soft tissue lesion on the previous whole-body MRI turned out to be highly probable in ultrasonography or when those lesions ad-
advanced to become a highly probable lesion on the follow-up whole-body MRI, a core needle biopsy was performed. If that lesion was confirmed as being a myxoid liposarcoma, it was considered a false negative.

**Evaluation of Diagnostic Value.** We evaluated the sensitivity, specificity, and positive and negative predictive value for the bone and the soft tissue lesions, respectively.

**RESULTS**

**Demographic Data**

Fifteen patients (10 men and 5 women) were diagnosed during the study period (Table 1). Mean patient age was 45.2 years (range, 22-70 years), and mean duration of follow-up was 17 months (range, 12-30 months). Every patient underwent whole-body MRI for staging, and 11 patients underwent FDG-PET and chest/abdominal/pelvic CT scan at our hospital or an outside hospital. Four of the 15 patients had local recurrence in the primary lesion.

**Analysis of Whole-body MRI and FDG-PET Scans**

The whole body was divided into 38 sections (7 sections of soft tissue and 31 sections of bone tissue). In total, we had 570 regions (105 soft tissue regions and 465 bony regions) in 15 patients.

Highly probable lesions on whole-body MRI were found in 7 sections of soft tissue (3 sections in patient 1, one section in patient 8, and 3 sections in patient 13) and 16 sections of bone tissue (in patient 8) out of the 570 total sections.

**Validation of Initial Whole-body MRI**

Three regions of soft tissue in patient 13 (Figure 3) and 1 region of bone tissue in patient 8 were determined to be true positives.

**Figure 3:** A case of soft tissue metastasis. A 39-year-old man underwent FDG-PET at another hospital, but no lesion was found (A). He underwent whole-body MRI at our hospital. Suspicious lesions were found in the gluteus maximus (arrow) (B), the right inguinal area (arrow) (C), and the left proximal thigh (arrow) (D). Excisional biopsy was done for all lesions. Histology confirmed the lesions as myxoid liposarcoma, and 3 were determined to be true positives.

**Figure 4:** A case of bone metastasis. A 61-year-old man had diffuse involvement of multiple vertebrae, including T3, T4, T6, and T8, seen throughout the spine on T1-weighted imaging with high-signal intensity (A). Six months later, follow-up whole-body MRI showed disease progression of those lesions (B).

**Figure 5:** False positive case. One less probable lesion in the right upper arm was detected on the initial whole-body MRI of a 53-year-old man (A). Three months later, there was a hypoechoic lesion suggesting neurilemmoma on follow-up ultrasonography (B), and 6 months later, there was no increase in lesion size on follow-up whole-body MRI (C).
positives based on core needle biopsy at the initial evaluation. One region of soft tissue and 10 regions of bone tissue in patient 8 (Figure 4) were determined to be true positives because the lesions had increased in size significantly on the 6-month follow-up whole-body MRI.

Three regions of soft tissue in patient 1 and 5 regions of bone tissue in patient 8 were determined to be false positives by follow-up ultrasonography (soft tissue) (Figure 5) and 6-month follow-up whole-body MRI (bone tissue). One region of soft tissue and 2 regions of bone tissue in patient 8, which were undiagnostic or benign on the initial whole-body MRI, were found to be advanced metastatic lesions on the 6-month follow-up whole-body MRI, so these lesions were determined to be false negatives (Tables 2, 3).

**Statistical Analysis**

There were 4 true positives, 3 false positives, 1 false negative, and 97 true positives of 105 regions of soft tissue. There were 11 true positives, 5 false positives, 2 false negatives, and 447 true negatives of 465 regions of bone tissue. For detecting metastatic lesions in soft tissue, whole-body MRI showed a sensitivity of 80%, a specificity of 97.0%, a positive predictive value of 57.1%, and a negative predictive value of 99.0%. For the bone tissue, whole-body MRI showed a sensitivity of 84.6%, a specificity of 98.9%, a positive predictive value of 68.8%, and a negative predictive value of 99.6% (Tables 4, 5).

**DISCUSSION**

Whole-body MRI showed reliable outcomes not only for soft tissue lesions (sensitivity, 80%; specificity, 97.0%), but also for bone lesions (sensitivity, 84.6%; specificity, 98.9%). These results support our hypothesis that whole-body MRI is a feasible method for detecting metastasis of myxoid liposarcoma.

In general, FDG-PET has shown a reliable performance (sensitivity, 73%-93.3%; specificity, 88%-99.5%) for detecting

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**Table 2**

<table>
<thead>
<tr>
<th>Patient No.</th>
<th>Probable Lesion on First MRI</th>
<th>Follow-up Result (Modality)</th>
<th>Final Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Right upper arm</td>
<td>Neurogenic tumor (US)</td>
<td>False +</td>
</tr>
<tr>
<td></td>
<td>Left inguinal area</td>
<td>Postop change (US)</td>
<td>False +</td>
</tr>
<tr>
<td></td>
<td>Primary tumor site</td>
<td>Postop change (US)</td>
<td>False +</td>
</tr>
<tr>
<td>8</td>
<td>Left back muscle</td>
<td>Advanced lesion (MRI)</td>
<td>True +</td>
</tr>
<tr>
<td></td>
<td>Right lung; advanced lesion (MRI)</td>
<td>False −</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Right gluteus maximus</td>
<td>Myxoid liposarcoma (biopsy)</td>
<td>True +</td>
</tr>
<tr>
<td></td>
<td>Right inguinal area</td>
<td>Myxoid liposarcoma (biopsy)</td>
<td>True +</td>
</tr>
<tr>
<td></td>
<td>Left proximal thigh</td>
<td>Myxoid liposarcoma (biopsy)</td>
<td>True +</td>
</tr>
<tr>
<td>Total</td>
<td>7 lesions</td>
<td>8 lesions</td>
<td>4 true +</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3 false +</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1 false −</td>
</tr>
</tbody>
</table>

*Abbreviations: −, negative; +, positive; MRI, magnetic resonance imaging; postop, postoperative; US, ultrasonography.*

**Table 3**

<table>
<thead>
<tr>
<th>Patient No.</th>
<th>Probable Lesion on First MRI</th>
<th>Follow-up Result (Modality)</th>
<th>Final Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>T1</td>
<td>Advanced lesion (MRI)</td>
<td>True +</td>
</tr>
<tr>
<td></td>
<td>T2</td>
<td>Advanced lesion (MRI)</td>
<td>True +</td>
</tr>
<tr>
<td></td>
<td>T3</td>
<td>Advanced lesion (MRI)</td>
<td>True +</td>
</tr>
<tr>
<td></td>
<td>T4</td>
<td>Advanced lesion (MRI)</td>
<td>True +</td>
</tr>
<tr>
<td></td>
<td>T6</td>
<td>Advanced lesion (MRI)</td>
<td>True +</td>
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<tr>
<td></td>
<td>T8</td>
<td>Advanced lesion (MRI)</td>
<td>True +</td>
</tr>
<tr>
<td></td>
<td>T12</td>
<td>No change (MRI)</td>
<td>False +</td>
</tr>
<tr>
<td></td>
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<td>L5</td>
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<tr>
<td></td>
<td>Pelvis</td>
<td>Advanced lesion (MRI)</td>
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</tr>
<tr>
<td></td>
<td>Left femur shaft</td>
<td>Myxoid liposarcoma (biopsy)</td>
<td>True +</td>
</tr>
<tr>
<td></td>
<td>Both proximal femurs</td>
<td>Advanced lesion (MRI)</td>
<td>True +</td>
</tr>
<tr>
<td></td>
<td>Right humeral shaft</td>
<td>Advanced lesion (MRI)</td>
<td>True +</td>
</tr>
<tr>
<td></td>
<td>Scapula &amp; rib: advanced lesion (MRI)</td>
<td>False −</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Left humerus: advanced lesion (MRI)</td>
<td>False −</td>
<td></td>
</tr>
<tr>
<td>Total</td>
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<td>18 lesions</td>
<td>11 true +</td>
</tr>
<tr>
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<td>5 false +</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2 false −</td>
</tr>
</tbody>
</table>

*Abbreviations: −, negative; +, positive; MRI, magnetic resonance imaging.*
bone metastasis of various tumors such as uterine cervix, breast, head and neck, and lung. In contrast to its performance with other tumors, FDG-PET has shown a limited diagnostic performance in detecting metastasis of myxoid liposarcoma.

According to recent reports, whole-body MRI has shown good performance for detecting metastatic disease (sensitivity, 67%-89%; specificity, 88%-98%) from various tumors. Our results, with a sensitivity of 80% to 84.6% and a specificity of 97.0% to 98.9%, showed a comparable diagnostic value for detecting metastasis from myxoid liposarcoma. Our results are significant because ours is the first study to demonstrate the use of a feasible method for the evaluation of metastasis in patients with myxoid liposarcoma.

According to our results, the advantage of whole-body MRI is its high diagnostic accuracy for the detection of metastasis to both bone and soft tissue. Dividing the whole body into several regions seems to contribute to the improved diagnostic accuracy.

In the case of soft tissue metastasis, the diagnostic accuracy seems high because the signal intensity of the metastatic lesion is identical to that of the primary lesion on MRI. However, in the case of bone metastasis, we encountered some difficulties in diagnosing metastasis because the signal intensity of the metastatic lesion, even when detected on whole-body MRI, was not identical to that of the primary lesion. It seems that the tumor does not sufficiently produce myxoid matrix at a bone metastasis site, and this factor should be considered during the diagnostic process.

Within the current study sample, metastasis was not evenly distributed in each case; rather, it was concentrated in only a few patients, so a detection bias might have been present because there is a tendency to overdiagnose the patients who already have metastasis. To minimize this bias, we consulted radiology specialists to re-examine each image that was segmented according to body regions using our criteria, and the cases were randomly assigned to these radiology specialists.

Another limitation of our study is the absence of pathologic confirmation of the sites where specific treatment was not planned, even for a highly suspicious lesion. We did not biopsy these lesions because pathologic confirmation is an invasive procedure, although it is the gold standard. To overcome this verification bias, we included all of the advanced lesions seen on the 6-month follow-up as true positives.

Even with several limitations, our study obtained significant results. The study is the first to show that whole-body MRI is a feasible method to detect metastasis of myxoid liposarcoma. In addition, it is expected that whole-body MRI will prevent radiation exposure to patients in lieu of CT scan of the chest, abdomen, and pelvis.

Table 4

<table>
<thead>
<tr>
<th>Outcome +</th>
<th>MRI +</th>
<th>MRI −</th>
<th>Total</th>
<th>Sensitivity: 80%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outcome −</td>
<td>4</td>
<td>1</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Outcome −</td>
<td>3</td>
<td>97</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>7</td>
<td>98</td>
<td>105</td>
<td></td>
</tr>
<tr>
<td>PPV: 57.1%</td>
<td>NPV: 99.0%</td>
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</table>

Table 5

<table>
<thead>
<tr>
<th>Outcome +</th>
<th>MRI +</th>
<th>MRI −</th>
<th>Total</th>
<th>Sensitivity: 84.6%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outcome −</td>
<td>11</td>
<td>2</td>
<td>13</td>
<td></td>
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<tr>
<td>Outcome −</td>
<td>5</td>
<td>447</td>
<td>452</td>
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<tr>
<td>Total</td>
<td>16</td>
<td>449</td>
<td>465</td>
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<td>PPV: 68.8%</td>
<td>NPV: 99.6%</td>
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</tbody>
</table>

Abbreviations: +, positive; −, negative; MRI, magnetic resonance imaging; NPV, negative predictive value; PPV, positive predictive value.

References

7. Schwab JH, Boland PJ, Antonescu C, Brisky MH, Healey JH. Spinal metastases from


