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Differential Diagnosis of Lipomatous Tumors Using ^{18}F-Fluorodeoxygulcose Positron Emission Tomography/Computed Tomography: A Retrospective Observational Study

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Abstract. *Background/Aim: Lipomatous tumors, including lipomas, atypical lipomatous tumors (ALTs), myxoid liposarcomas (MLs), and dedifferentiated liposarcomas (DLs), are often diagnosed using magnetic resonance imaging (MRI). Differential diagnosis of lipomas and ALTs by MRI is often challenging. ^{18}F-fluorodeoxyglucose positron emission tomography/computed tomography (^{18}F-FDG PET/CT) has recently been used for the diagnosis and evaluation of tumor staging and recurrence of soft tissue tumors. The maximum standardized uptake value (SUV_{max}) is positively associated with malignant grade in several cancers. This study aimed to evaluate SUV_{max} of ^{18}F-FDG PET/CT in the differential diagnosis of lipomatous tumors. Patients and Methods: Patients who underwent ^{18}F-FDG PET/CT for the diagnosis of lipomatous tumors between January 2013 and September 2021 were included in the study. Patients with lipomatous tumors, confirmed by pathological diagnosis or surgical specimens, were evaluated for lipomatous tumor SUV_{max}. Results: This study included 44 patients with lipomas (n=19), ALTs (n=12), MLs (n=9), and DLs (n=4). The mean SUV_{max} of lipomas, ALTs, MLs, and DLs was 0.99±1.41, 1.92±0.95, 5.21±4.94, and 9.29±1.43, respectively. Lipomas showed a significantly lower SUV_{max} than did ALTs, MLs, and DLs ($p<0.05$). ALTs demonstrated a significantly lower SUV_{max} than did MLs and DLs ($p<0.05$). No significant differences were observed between MLs and DLs. Conclusion: Lipomas or ALTs had a significantly lower SUV_{max} than lipomatous sarcomas. Lipomas had a significantly lower SUV_{max} than ALTs, aiding in their preoperative differentiation. ^{18}F-FDG-PET/CT could serve as a potent tool for the differential diagnosis of lipomatous tumors.*

Lipomatous tumors/sarcomas, including lipomas, atypical lipomatous tumors (ALTs), myxoid liposarcomas (MLs), and dedifferentiated liposarcomas (DLs), are often diagnosed using magnetic resonance imaging (MRI) in orthopedic oncology settings (1-3). Few reports have been published on the effectiveness of MRI for differential diagnosis, especially between lipomas and ALTs (4, 5). However, the differential diagnosis of lipoma and ALT using MRI is often difficult because of the similarity in imaging characteristics in clinical settings (6, 7).

^{18}F-fluorodeoxyglucose positron emission tomography/computed tomography (^{18}F-FDG PET/CT) has recently been utilized for the diagnosis and evaluation of tumor staging and recurrence of soft tissue sarcomas. In previous reports, the maximum standardized uptake value (SUV_{max}) is positively related to malignant grade in several cancers (8-10). Although the effectiveness of ^{18}F-FDG PET/CT in the diagnosis of soft tissue tumors has been reported (11-17), only a few studies have reported the efficacy of ^{18}F-FDG PET/CT in the differential diagnosis of lipomatous tumors.

Therefore, this study aimed to evaluate the SUV_{max} of ^{18}F-FDG PET/CT in the differential diagnosis of lipomatous tumors.

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Key Words: Lipoma, atypical lipomatous tumor, liposarcoma, ^{18}F-FDG PET/CT, SUV_{max}.

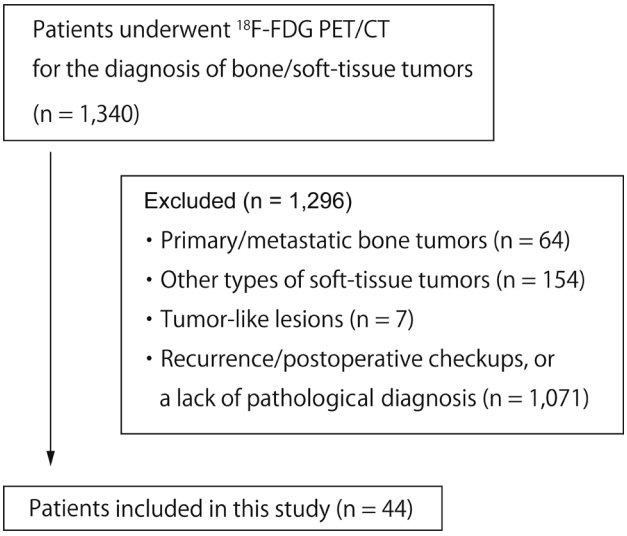

Figure 1. *Flow chart of the study design.*

Patients and Methods

Study design and patient selection. This was a single-institution, retrospective, and observational study. Patients who underwent ^{18}F-FDG PET/CT for the diagnosis of lipomatous tumors between January 2013 and September 2021 were included in the study. Patients with lipomatous tumors, with a pathological diagnosis confirmed by biopsy or surgical specimens, were included. Patients who underwent ^{18}F-FDG PET/CT for recurrence or postoperative checkups were excluded. Additionally, patients with a lack of pathological diagnoses were excluded from the study. The data were collected between October 2021 and December 2021. This study was approved by our Institutional Review Board (University of the Ryukyus Hospital IRB No. 2074). Written informed consent or an opt-out form was obtained on the poster at our institution (those who rejected it were excluded). This study was conducted in accordance with the principles of the Declaration of Helsinki.

Image acquisition. PET/CT imaging of all patients of the study was performed using the Biograph mCT (Siemens Healthineers, Erlangen, Germany). After avoiding glucose intake in food and beverages for at least 5 h, an intravenous injection of 3.7 MBq/kg ^{18}F-FDG was administered. Sixty minutes after the injection, patients underwent PET/CT scanning. The PET/CT images were taken from the skull to both lower limbs. SUV_{max} was calculated as the highest FDG uptake in the tumor. Furthermore, preoperative MRI was performed jointly in all patients with lipomatous tumors in this study.

Analyses of SUV_{max} among lipoma, ALT, and liposarcomas. After image acquisition, the SUV_{max} of lipomatous tumors was evaluated, and the mean SUV_{max} was calculated.

Statistical analyses. Statistical analyses were performed using the JMP software version 13 (SAS Institute Inc., Cary, NC, USA). Data are presented as means±standard deviations. The Steel–Dwass test was used to compare SUV_{max} values among lipomatous tumors. Probability (p) values less than 0.05 indicated statistically significant differences.

Table I. *Characteristics of patients with lipoma, atypical lipomatous tumor, myxoid liposarcoma, or dedifferentiated liposarcoma.*

Total, n	44
Sex	
Male, n	24
Female, n	20
Age (years), median (range)	57.0 (10-88)
Follow-up (months), median (range)	14.9 (0.6-88.7)
Pathological diagnosis	
Lipoma, n (%)	19 (43.2)
Atypical lipomatous tumor, n (%)	12 (27.3)
Myxoid liposarcoma, n (%)	9 (20.5)
Dedifferentiated liposarcoma, n (%)	4 (9.1)

n: Number.

Results

Patient characteristics. In total, 1,340 patients underwent ^{18}F-FDG PET/CT for the diagnosis of bone and soft tissue tumors between January 2013 and September 2021 at our institution. Data were derived from electronic medical charts. A total of 1,296 patients were excluded because of primary or metastatic bone tumors (n=64), other types of soft tissue tumors (n=154), tumor-like lesions (n=7), recurrent tumors/postoperative checkups, or lack of pathological diagnosis (n=1,071). The study included 44 patients with lipomas (n=19), ALTs (n=12), MLs (n=9), and DLs (n=4) (Figure 1). This study included 24 men and 20 women. The median age at the time of the ^{18}F-FDG PET/CT scan was 57.0 years (range=10-88 years). The median follow-up period was 14.9 months (range=0.6-88.7 months) (Table I).

SUV_{max} in lipomatous tumors. The mean SUV_{max} of lipomas, ALTs, MLs, and DLs was 0.99±1.41, 1.92±0.95, 5.21±4.94, and 9.29±1.43, respectively. Lipomas showed a significantly lower SUV_{max} than did ALTs, MLs, and DLs (p<0.05); ALTs demonstrated a significantly lower SUV_{max} than did MLs and DLs (p<0.05). No significant differences were observed between MLs and DLs (p=0.084) (Figure 2 and Figure 3) (Table II).

Discussion

This study demonstrated that the SUV_{max} of lipomas was significantly lower than that of ALTs, MLs, and DLs. Moreover, the SUV_{max} of ALTs was significantly lower than that of MLs and DLs. In this study, ^{18}F-FDG PET/CT was useful in distinguishing between lipomas and ALTs.

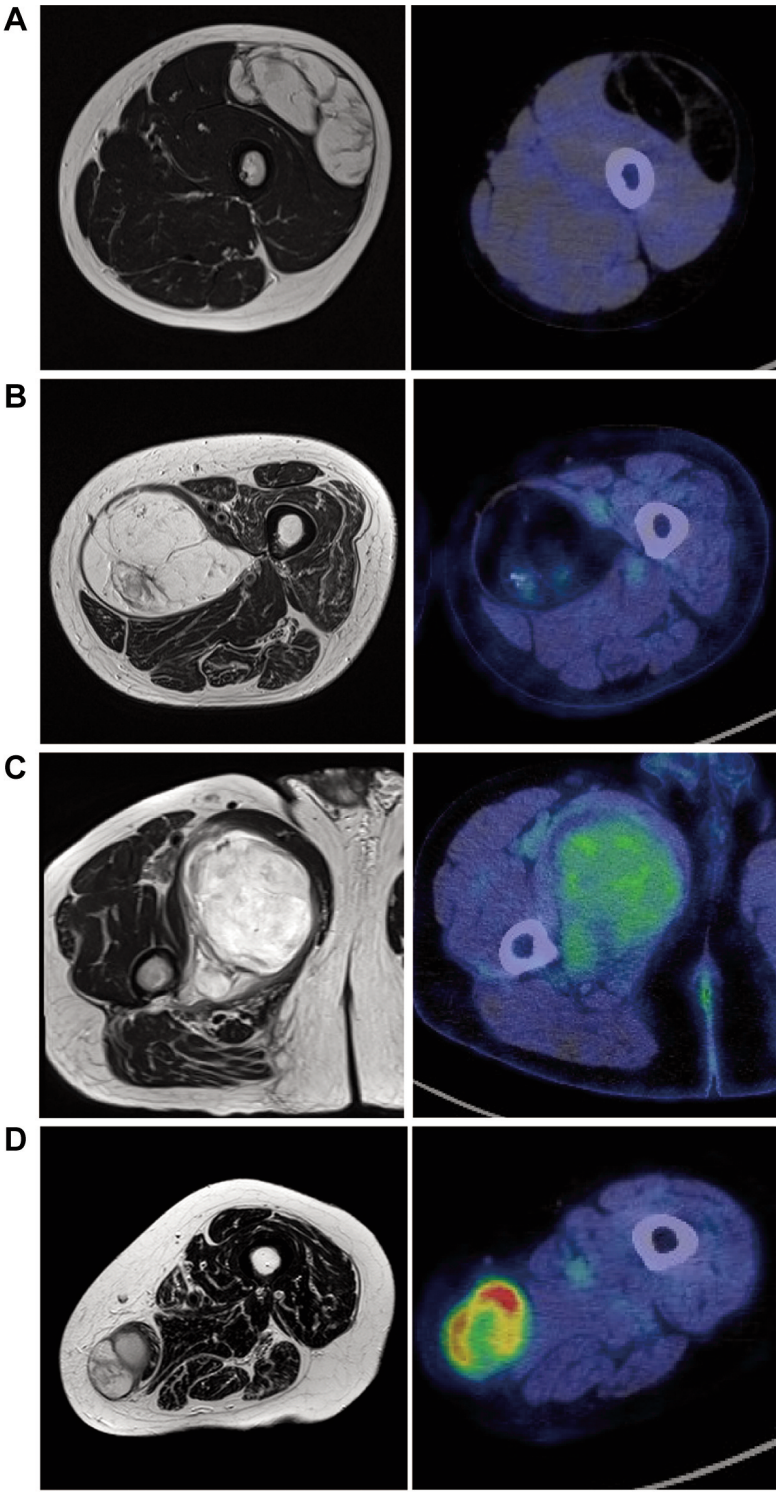

Figure 2. *Representative images of magnetic resonance imaging (MRI) and ^{18}F-fluorodeoxyglucose positron emission tomography/computed tomography (^{18}F-FDG PET/CT) in lipomatous tumors. (A) 10-year-old boy with lipoma of the left thigh. Left, T2-weighted MRI. Right, PET/CT fused image. Maximum standard uptake value (SUV_{max}) of lipoma in the left thigh was 0.00. (B). A 72-year-old woman with an atypical lipomatous tumor (ALT) of the left thigh. Left, T2-weighted MRI. Right, PET/CT fused image. The SUV_{max} of ALT in the left thigh was 2.33. (C). A 48-year-old man with myxoid liposarcoma (ML) of the right thigh. Left, T2-weighted MRI. Right, PET/CT fused image. The SUV_{max} of ML in the right thigh was 3.63. (D). An 81-year-old woman with dedifferentiated liposarcoma (DL) of the right thigh. Left, T2-weighted MRI. Right, PET/CT fused image. The SUV_{max} of DL in the right thigh was 7.94.*

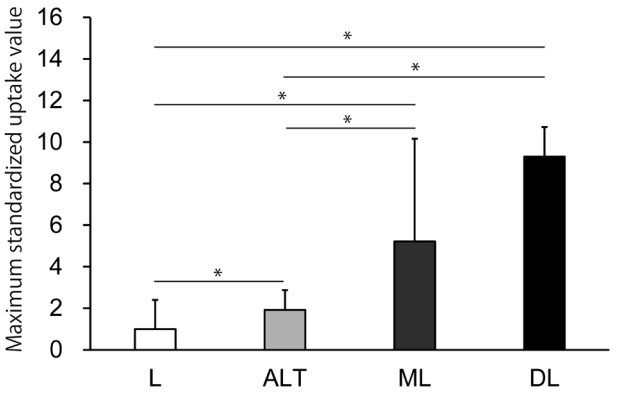

Figure 3. *Comparison of maximum standard uptake value (SUV_{max}) in lipomatous tumors. Data are presented as means±standard deviations. L, Lipoma; ALT, atypical lipomatous tumor; ML, myxoid liposarcoma; DL, dedifferentiated liposarcoma. *p<0.05 (Steel–Dwass test).*

Moreover, FDG stimulation in lipomatous tumors tended to increase as the tumor grade increased. However, no significant differences were observed between MLs and DLs.

The SUV_{max} of ^{18}F-FDG PET/CT is useful for the differential diagnosis between benign and malignant soft tissue tumors, wherein malignant soft tissue tumors showed a relatively higher SUV_{max} than benign tumors (16, 18). ^{18}F-FDG PET/CT has high sensitivity and specificity for the detection of local recurrence and distant metastases for staging soft tissue sarcomas (16, 19). In addition, the effectiveness of ^{18}F-FDG PET/CT in evaluating the response to chemotherapy has been reported in patients with soft tissue sarcoma, wherein a decrease in SUV_{max} is observed with decreasing tumor size (20, 21). In previous reports, the usefulness of ^{18}F-FDG PET/CT to distinguish between benign and malignant lipomatous tumors has been demonstrated, wherein the SUV_{max} of lipomas was significantly lower than that of malignant lipomatous tumors, such as ALTs, MLs, and DLs (22, 23). Moreover, a high SUV_{max} in liposarcoma is associated with poor prognosis, depending on the histopathological grade and subtype (11, 24). Regarding differential diagnosis, previous reports have not shown a statistically significant difference in SUV_{max} between lipomas and ALTs (22, 23). However, in this study, the SUV_{max} of lipomas was significantly lower than that of ALTs, which is useful for distinguishing lipomas from ALTs. Additionally, some reports have revealed the inability of ^{18}F-FDG to detect spinal bone metastases from MLs with a sensitivity of 14%. The reason for the inability of ^{18}F-FDG to detect bone metastases from MLs is unclear; however, myxoid stroma may prevent glucose metabolism and uptake of ^{18}F-FDG (25, 26). In this study, the SUV_{max} of MLs was lower than that of DLs in lipomatous sarcomas, but there was no significant difference between both. In both MLs and DLs, the myxoid stroma might have prevented the uptake of ^{18}F-FDG, as previously reported.

Table II. *The SUV_{max} in lipogenic tumors.*

Diagnosis	SUV_{max}
Lipoma, means±SD	0.99±1.41
Atypical lipomatous tumor, means±SD	1.92±0.95
Myxoid liposarcoma, means±SD	5.21±4.94
Dedifferentiated liposarcoma, means±SD	9.29±1.43

SD: Standard deviation; SUV_{max}: maximum standardized up-take value.

MRI has been frequently performed to diagnose soft tissue tumors, including lipomatous tumors (1, 2). ALTs are locally aggressive lipomatous tumors that occur in deep soft tissues and are frequently large. Additionally, ALTs have a high rate of local recurrences, few incidences of distant metastases, and malignant changes (6, 27). In contrast, lipomas are benign lipomatous tumors with very low local recurrence and no distant metastases (28). ALTs and lipomas are known to have mostly similar MRI findings, which demonstrate high intensity on T1- and T2-weighted images and suppression of fat saturation (5). It is occasionally difficult to differentiate between lipomas and ALTs in preoperative MRI (1, 29, 30). Therefore, preoperative diagnosis based on imaging findings of lipomas and ALTs is important for deciding the surgical strategy. Few reports discuss the differentiation between lipomas and ALTs with MRI features, such as the septum, nodules, and signal intensity, with a sensitivity of 90.9-100% and a specificity of 37.0-77% (4, 5, 31). In this study, the SUV_{max} of lipomas was found to be significantly lower than that of ALTs. By combining ^{18}F-FDG-PET/CT with MRI, patients with lipomas or ALTs can be accurately diagnosed before surgery.

Study limitations. This was a single-institution, retrospective study. Therefore, the sample size was small. Multicenter prospective studies with larger numbers of patients are warranted in the future. However, this study showed that lipomas had a lower SUV_{max} than did other types of lipomatous tumors, such as ALTs, MLs, and DLs. Furthermore, ALTs had a lower SUV_{max} than did either MLs or DLs. Another limitation of this study was that patients with diabetes mellitus were not considered. Patients with diabetes mellitus may experience a negative influence on the uptake of ^{18}F-FDG. Therefore, the presence of diabetes mellitus may interfere with the differential diagnosis between lipomas and ALTs on ^{18}F-FDG-PET/CT.

Conclusion

Patients with lipomas or ALTs had a significantly lower SUV_{max} than those with lipomatous sarcomas. Additionally, patients with lipomas had a significantly lower SUV_{max} than

those with ALTs; this difference could help in distinguishing between lipomas and ALTs preoperatively. ^{18}F-FDG-PET/CT could serve as a potent tool for the differential diagnosis of lipomatous tumors.

Conflicts of Interest

H.O. received a grant from the Japan Orthopaedics and Traumatology Research Foundation (No. 521). Y.To. is on the editorial board of the Cancer Diagnosis and Prognosis. K.N. is on the editorial board of the Journal of Orthopaedic Research and is a board member of the International Society for the Study of the Lumbar Spine.

Authors' Contributions

H.O., K.M., Y.Ts, Y.A., R.K., and Y.To. participated in the conceptualization, investigation, methodology, and project administration. H.O. and K.M. participated in the data collection and analysis. H.O., K.M., Y.Ts, Y.A., R.K., and Y.To. drafted the manuscript. Y.To. and K.N. revised the manuscript. Y.To. and K.N. supervised the study. All Authors have read and approved the manuscript for publication.

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