RESEARCH

Variety and complexity of fluorine-18-labelled fluoro-2-deoxy-D-glucose accumulations in the oral cavity of patients with oral cancers

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Objectives: To elucidate the points that require attention when interpreting fluorine-18-labelled fluoro-2-deoxy-D-glucose (¹⁸F-FDG)/positron emission tomography (PET) images by demonstration of ¹⁸F-FDG accumulation in various areas of the oral cavity other than primary lesions in patients with oral cancers.

Methods: ¹⁸F-FDG accumulations with a maximal standardized uptake value of over 2.5 in various areas of the oral cavity other than primary lesions were identified in 82 patients with oral cancers.

Results: ¹⁸F-FDG/PET-positive areas, excluding primary tumours, included the front intrinsic muscles of the tongue (89.0%), upper and lower marginal parts of the orbicularis oris muscle (64.6%), sublingual glands, palatine tonsil, pharyngeal tonsil, and lingual tonsil. In addition, some areas in the jaws also showed accumulation.

Conclusions: In patients with oral cancers, areas of ¹⁸F-FDG accumulation in the oral cavity should be precisely identified and appropriately diagnosed, because accumulations can be seen in areas other than the primary tumour.

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Introduction

The use of fluorine-18-labelled (¹⁸F) fluoro-2-deoxy-D-glucose (FDG) is an important oncological imaging tool in the oral cavity because high ¹⁸F-FDG uptake

occurs with increased glucose metabolism.^{1–10} However, the ratio of ¹⁸F-FDG accumulation in the oral cavity is relatively high because of tonsil-related tissues, sublingual glands, dental inflammation etc.^{1,11–13} In addition, it is known empirically that various areas in the oral cavity show substantial variations in the uptake that can present difficulties for identifying primary oral cancers.

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In the present study, characteristics such as the ratio, sites and extent of ¹⁸F-FDG accumulation in areas of the oral cavity were analysed precisely using ¹⁸F-FDG/positron emission tomography (PET)/CT, CT, and MRI in patients with oral cancers. The points that require attention when using ¹⁸F-FDG to diagnose patients with oral cancers were examined.

Materials and methods

82 consecutive patients (42 males and 40 females; mean age, 65.2 years; range, 21–90 years) with a pathologically proven oral cancer were evaluated in the present study at Kyushu Dental College Hospital, Kitakyushu, Japan, between 2005 and 2011 (Table 1). CT, MRI, and ¹⁸F-FDG/PET/CT were performed in all 82 patients. All imaging acquisitions were done within one month. Approval of the present study was obtained from the institutional review board at Kyushu Dental College.

All patients fasted for at least 4 h prior to intravenous administration of 0.1 mCi (3.7 MBq) kg⁻¹ body weight of ¹⁸F-FDG. The ¹⁸F-FDG study was performed with a PET/CT inline system (Discovery ST Elite; GE Medical Systems, Waukesha, WI). One hour after ¹⁸F-FDG injection, each patient underwent a single, integrated PET/CT examination. They were instructed to perform breath holding during CT acquisition, which was done first, from the head to the pelvic floor. Immediately following the CT scan, a PET scan was acquired from the pelvic floor to the head. The PET camera had 18 rings of 336 detectors and simultaneously produced 4.34 mm-thick slices along a 152 mm axial field of view (FOV), with a 3-slice overlap at the borders of the FOV. The trans-axial resolution was 4.8 mm with full width at half-maximum at 1 cm radius from the centre, and the sensitivity of the device was 1.3 cps kBq⁻¹, with two-dimensional acquisition time of 2 min, resulting in a total scanning time

of 18–24 min for each scan. The CT data were back-projected to the workstation; the images were degraded from a 512 × 512 matrix to a 128 × 128 matrix size to correspond with the PET images, and they were also forward-projected.

The MR images were acquired using a 1.5-Tesla full-body magnetic resonance system (EXCELART Vantage™ Powered by Atlas; Toshiba, Tokyo, Japan) equipped with a circular polarized neck coil. Enhanced-CT was performed with an Aquilion™ machine (Toshiba) after the patient received an intravenous dose of 100 ml iohexol (300 mgI ml⁻¹; Omnipaque 300™, Daiichi Pharmaceutical Co., Ltd, Tokyo, Japan).

The PET/CT images, MR images, and CT images were assessed according to a set of reference standards by two expert radiologists (SK and HK). PET images of the slice at the upper and inferior dental arch level were assessed. All PET images were analysed on a PC-based digital viewing system (GE View; GE Medical Systems, Dornstadt, Germany) to choose transverse slices for comparison and to adapt the level of greyscale in the images. The extent of ¹⁸F-FDG accumulation was judged by the standardized uptake value of the highest point within the regions of interest (SUV_{max}). A value of 2.5 was selected as the cut-off SUV_{max}, because the extent of ¹⁸F-FDG accumulation into malignant tumour was commonly greater than 2.5.^{11,14–16} In the respective areas, the precise SUV_{max} of ¹⁸F-FDG was measured on PET/CT images. As anatomical landmarks in the oral cavity showed accumulation of ¹⁸F-FDG, the pharynx, pharyngeal tonsil, palatine tonsils, lingual tonsillar tissue and sublingual glands were cited previously¹ and excluded in the present study. ¹⁸F-FDG accumulations into areas in the oral cavity other than the tissues mentioned above were analysed. Then, whether these positive SUV_{max} areas could be identified on CT and MRI was confirmed, and the presence and characteristics of any abnormal findings were analysed to determine the causes of the abnormal ¹⁸F-FDG accumulations.

Table 1 Summary of data from 82 patients with oral cancers

Site of primary cancers (n)	SUV _{max} of primary cancers (mean ± SD)	Age (mean)	Male/female (n)	Pathological diagnosis (n)
Tongue (30)	1.50–19.30 (7.51 ± 3.67)	35–84 (63.6)	14/16	Squamous cell carcinoma (29) Spindle cell carcinoma (1)
Lower gingiva (24)	3.07–49.70 (12.92 ± 6.59)	49–87 (67.8)	14/10	Squamous cell carcinoma (23) Mucoepidermoid carcinoma (1)
Upper gingiva (16)	2.79–26.36 (12.29 ± 5.29)	36–90 (70.6)	7/9	Squamous cell carcinoma (14) Malignant melanoma (2)
Floor of mouth (4)	3.97–18.30 (8.64 ± 4.83)	37–67 (57.3)	2/2	Squamous cell carcinoma (3) Adenoid cystic carcinoma (1)
Buccal mucosa (4)	1.50–5.40 (3.58 ± 1.13)	47–81 (66.5)	2/2	Squamous cell carcinoma (4)
Hard palate (4)	2.48–6.40 (3.99 ± 1.41)	21–59 (47.3)	3/1	Adenoid cystic carcinoma (2) Squamous cell carcinoma (1) Mucoepidermoid carcinoma (1)
Total (82)	1.50–49.70 (9.72 ± 5.33)	21–90 (65.2)	42/40	Squamous cell carcinoma (74) Malignant melanoma (2) Adenoid cystic carcinoma (3) Mucoepidermoid carcinoma (2) Spindle cell carcinoma (1)

SD, standard deviation; SUV_{max}, standardised uptake value with the highest point of fluorine-18-labelled fluoro-2-deoxy-D-glucose.

Differences in mean values between the two groups were analysed by the Mann–Whitney *U*-test. Correlations between two categories were analysed using the Spearman correlation coefficient. $p < 0.05$ was considered to indicate a significant difference.

Results

The distributions of the sites and the SUV_{max} of ^{18}F -FDG accumulations in the primary sites of oral cancers

The distributions of the sites and of the SUV_{max} of the ^{18}F -FDG accumulations in the primary sites of oral

cancers in the 82 patients are shown in Table 1. The most common site was the tongue, followed by the mandibular or maxillary gingiva. The major pathological diagnosis was squamous cell carcinoma (SCC). The SUV_{max} of ^{18}F -FDG in the primary lesions ranged from 1.50 to 49.70 [mean $\pm$ standard deviation (SD): 9.72 ± 5.33 ; Table 1].

^{18}F -FDG accumulations in oral-related muscles in patients with oral cancers

^{18}F -FDG/PET-positive areas with SUV_{max} values of over 2.5, excluding the primary tumours, included the front intrinsic muscles of the tongue, upper and lower marginal part of the orbicularis oris muscle, sublingual glands,

Figure 1 Three imaging examinations [fluorine-18-labelled fluoro-2-deoxy-D-glucose (^{18}F -FDG)/positron emission tomography (PET)/CT, CT, and MRI] of a 60-year-old female with squamous cell carcinoma on the right side of the buccal region. (a) ^{18}F -FDG/PET/CT images demonstrate uptake in the front intrinsic muscles of the tongue (arrowhead), with a maximal standardized uptake value (SUV_{max}) of 4.17. The colour scale bar for the PET/CT images provides a better sense of the intensity; red is the higher uptake of ^{18}F -FDG, while blue is the lower. Specifically, red indicates an SUV_{max} of over 6, orange from under 6 to 5, yellow from under 5 to 4, green from under 4 to 3, blue from under 3 to 2, and black-like under 2. (b) ^{18}F -FDG/PET/CT demonstrates an increased uptake in the mass on the right side of the buccal region (arrow), with an SUV_{max} of 3.40. (c) Axial CT image with a soft-tissue window shows no abnormal findings in the front intrinsic muscles of the tongue with ^{18}F -FDG accumulations on ^{18}F -FDG/PET/CT (arrowhead). (d) T_2 -weighted images show no abnormal findings in the front intrinsic muscles with ^{18}F -FDG accumulations on ^{18}F -FDG/PET/CT (arrowhead)

Figure 2 Two imaging examinations [fluorine-18-labelled fluoro-2-deoxy-D-glucose (¹⁸F-FDG)/positron emission tomography (PET)/CT and CT] of a 79-year-old male with squamous cell carcinoma on the right side of the tongue. (a) ¹⁸F-FDG/PET/CT images demonstrate diffuse uptake in the lower marginal part of the orbicularis oris muscles (arrowhead), with a maximal standardized uptake value (SUV_{max}) of 4.49. Of course, ¹⁸F-FDG/PET demonstrates an increased uptake in the mass on the right side of the tongue (arrow), with an SUV of 9.13. The colour scale bar for the PET/CT images provides a better sense of the intensity; red is the higher uptake of ¹⁸F-FDG, while blue is the lower. Specifically, red indicates an SUV_{max} of over 6, orange from under 6 to 5, yellow from under 5 to 4, green from under 4 to 3, blue from under 3 to 2, and black-like under 2. (b) Axial CT image with a soft-tissue window shows no abnormal findings in the lower marginal part of the orbicularis oris muscles with ¹⁸F-FDG accumulations on ¹⁸F-FDG/PET/CT (arrowhead), and a primary squamous cell carcinoma is visualized as an enhanced mass with central necrosis on the right side of the tongue (arrow)

palatine tonsil, pharyngeal tonsil, lingual tonsil, maxilla and mandible, but not the mimetic muscles, except for the marginal part of the orbicularis oris, buccinator, genioglossus, hyoglossus, styloglossus, mylohyoid and stylohyoid muscles (Figures 1 and 2; Tables 2 and 3). One area of ¹⁸F-FDG accumulation, in the front intrinsic muscles of the tongue, could be visualized in most patients with oral cancers (Figure 1). The SUV_{max} of ¹⁸F-FDG ranged from 1.50 to 9.90 (mean ± SD: 3.38 ± 0.73; Table 2). In the upper marginal part of the orbicularis oris muscles, three ¹⁸F-FDG accumulation areas

could be visualized, and in the lower part, two areas could be visualized as typical imaging findings (Figure 2). The SUV_{max} of ¹⁸F-FDG ranged from 1.41 to 5.52 (mean ± SD: 2.55 ± 0.52) in the upper part, and from 1.06 to 5.33 (mean ± SD: 2.60 ± 0.69) in the lower part (Table 2). In the front intrinsic muscles of the tongue, 73 of 82 patients (89%) had ¹⁸F-FDG accumulations with an SUV_{max} of over 2.5, with 34 (41.5%) on the upper marginal part of the orbicularis oris muscle and 40 (48.8%) in the lower part (Table 3). However, there were no abnormal findings on CT and MRI in the intrinsic muscles of the tongue, the upper marginal part of

Table 2 Extent of fluorine-18-labelled fluoro-2-deoxy-D-glucose (¹⁸F-FDG) accumulations in the oral cavity-related muscles and jaws of patients with oral cancers

Accumulation areas	SUV _{max} (mean ± SD)
Intrinsic muscles of tongue	1.50–9.90 (3.38 ± 0.73)
Upper marginal part of orbicularis oris muscle	1.41–5.52 (2.55 ± 0.52)
Lower marginal part of orbicularis oris muscle	1.06–5.33 (2.60 ± 0.69)
Buccinator muscle	0.81–2.58 (1.50 ± 0.29)
Mylohyoid muscle	0.84–2.25 (1.44 ± 0.22)
Genioglossus muscle	0.69–2.23 (1.30 ± 0.20)
Hyoglossus muscle	1.12–2.45 (1.52 ± 0.19)
Styloglossus muscle	1.15–2.48 (1.59 ± 0.19)
Digastric muscle anterior belly	0.58–1.72 (0.98 ± 0.18)
Geniohyoid muscle	0.52–1.60 (1.02 ± 0.15)
Jaws	1.50–5.39 (3.13 ± 0.76)

SD, standard deviation; SUV_{max}, standardized uptake value with the highest point of ¹⁸F-FDG.

Table 3 Rates of fluorine-18-labelled fluoro-2-deoxy-D-glucose (¹⁸F-FDG) accumulation in the oral cavity-related muscles of patients with oral cancers (n = 82)

Accumulation areas	Numbers of ¹⁸ F-FDG accumulation (%)
Intrinsic muscles of tongue	73 (89.0)
Upper marginal part of orbicularis oris muscle	34 (41.5)
Lower marginal part of orbicularis oris muscle	40 (48.8)
Buccinator muscle	1 (1.2)
Mylohyoid muscle	0 (0.0)
Genioglossus muscle	0 (0.0)
Hyoglossus muscle	0 (0.0)
Styloglossus muscle	0 (0.0)
Digastric muscle anterior belly	0 (0.0)
Geniohyoid muscle	0 (0.0)

Table 4 Differences between males and females in fluorine-18-labelled fluoro-2-deoxy-D-glucose (¹⁸F-FDG) accumulation in the oral cavity-related muscles of patients with oral cancers

Accumulation areas	Mean $\pm$ SD of SUV _{max}		p-value ^a
	Male (n = 42)	Female (n = 40)	
Intrinsic muscles of tongue	3.45 $\pm$ 0.66	3.30 $\pm$ 0.79	0.42
Upper marginal part of orbicularis oris muscle	2.78 $\pm$ 0.46	2.30 $\pm$ 0.48	<0.000 ^b
Lower marginal part of orbicularis oris muscle	2.96 $\pm$ 0.73	2.23 $\pm$ 0.52	<0.000 ^b
Buccinator muscle	1.56 $\pm$ 0.25	1.45 $\pm$ 0.33	0.06
Mylohyoid muscle	1.45 $\pm$ 0.25	1.43 $\pm$ 0.18	0.88
Genioglossus muscle	1.31 $\pm$ 0.18	1.30 $\pm$ 0.21	0.71
Hyoglossus muscle	1.55 $\pm$ 0.22	1.48 $\pm$ 0.15	0.33
Styloglossus muscle	1.60 $\pm$ 0.25	1.58 $\pm$ 0.13	0.88
Digastric muscle anterior belly	0.96 $\pm$ 0.16	1.01 $\pm$ 0.21	0.70
Geniohyoid muscle	1.00 $\pm$ 0.13	1.04 $\pm$ 0.17	0.24

SD, standard deviation; SUV_{max}, standardized uptake value with the highest point of ¹⁸F-FDG.

^aExtent of possible confidence of our null hypothesis that mean values of SUV_{max} of ¹⁸F-FDG between males and females would be equal using the Mann-Whitney *U*-test.

^bStatistically significant difference in values.

the orbicularis oris muscles and the lower marginal part of the orbicularis oris muscles (Figures 1 and 2).

Significant differences in the SUV_{max} of ¹⁸F-FDG in the upper (Mann-Whitney *U*-test; $p < 0.001$) and lower (Mann-Whitney *U*-test; $p < 0.001$) marginal parts of the orbicularis oris muscles were found between males and females, but not in other areas, including the intrinsic muscles of the tongue (Table 4). The SUV_{max} values of ¹⁸F-FDG in the upper and lower parts of the orbicularis oris muscles were higher in males than in females (Table 4). In addition, there were negative correlations between the SUV_{max} of ¹⁸F-FDG accumulations in the lower marginal part of the orbicularis oris ($r = -0.34$; $p < 0.001$) and hyoglossus ($r = -0.19$; $p < 0.04$) muscles, but not others, and age (Spearman correlation coefficient analysis; Table 5).

¹⁸F-FDG accumulations in the jaws in oral cancer patients

In the maxilla and mandible, some ¹⁸F-FDG accumulations could be visualized in almost all patients with oral cancers (Figure 3). The SUV_{max} of ¹⁸F-FDG ranged from 1.50 to 5.39 (mean $\pm$ SD: 3.13 $\pm$ 0.76; Table 2). ¹⁸F-FDG accumulations were present in the maxilla alone in 10 (12.2%) of the 82 patients, in the mandible alone in 21 (25.6%), and in both the maxilla and mandible in 37 (45.1%; Table 6). Therefore, almost all patients (82.9%) with oral cancers had ¹⁸F-FDG accumulations of an SUV_{max} of over 2.5 in the jaws, excluding the primary lesions. There were dental inflammatory findings on CT and MRI in all jaws, such as dental infections including osteomyelitis (Figure 3). Therefore, the number of areas of ¹⁸F-FDG accumulations varied among patients. No significant difference in the sites of ¹⁸F-FDG accumulations in the jaws (Mann-Whitney *U*-test, $p = 0.85$) was found between males (mean $\pm$ SD: 4.26 $\pm$ 3.49) and females (mean $\pm$ SD: 3.45 $\pm$ 2.37). In addition, there was a positive correlation between the SUV_{max} of ¹⁸F-FDG accumulations in the jaws and age (Spearman correlation coefficient analysis; $r = 0.20$; $p < 0.04$).

Complexity of ¹⁸F-FDG accumulations in the oral cavity of patients with oral cancers

The SUV_{max} of ¹⁸F-FDG in oral cancers overlapped that in ¹⁸F-FDG accumulation areas other than the primary lesions and the positive areas mentioned above (Figure 4; Tables 1 and 2). In addition, some ¹⁸F-FDG accumulation areas could be visualized in the oral cavity by looking at the total of ¹⁸F-FDG accumulation areas in jaws, muscles and tongue in the patient (Figure 4). Therefore, the diagnosis of ¹⁸F-FDG accumulations in the oral cavities of patients with oral cancers tended to be very complex (Figure 4). However, a significant difference was commonly found between the SUV_{max} of ¹⁸F-FDG in oral cancers and in positive areas other than oral cancers (Mann-Whitney *U*-test, $p < 0.01$). The SUV_{max} of ¹⁸F-FDG should be higher in oral cancer than in ¹⁸F-FDG accumulation areas other than the primary lesions (Tables 1 and 2).

Table 5 Correlations between SUV_{max} and age in the oral cavity-related muscles of patients with oral cancers

Accumulation areas	Relationship between SUV _{max} and ageing	
	Correlation coefficient	p-value ^a
Intrinsic muscles of tongue	0.13	0.130
Upper marginal part of orbicularis oris muscle	-0.14	0.110
Lower marginal part of orbicularis oris muscle	-0.34	<0.001 ^b
Buccinator muscle	-0.12	0.140
Mylohyoid muscle	-0.11	0.160
Genioglossus muscle	0.05	0.330
Hyoglossus muscle	-0.19	<0.04 ^b
Styloglossus muscle	-0.25	0.250
Digastric muscle anterior belly	0.12	0.140
Geniohyoid muscle	0.05	0.320

SUV_{max}, standardized uptake value with the highest point of fluorine-18-labelled fluoro-2-deoxy-D-glucose (¹⁸F-FDG).

^aPossible confidence in the relationship between SUV_{max} of ¹⁸F-FDG on the relative muscles and ageing analysed by the Spearman correlation coefficient.

^bStatistically significant difference in values.

Figure 3 Two imaging examinations [fluorine-18-labelled fluoro-2-deoxy-D-glucose (¹⁸F-FDG)/positron emission tomography (PET)/CT and CT] of a 62-year-old female with squamous cell carcinoma on the right side of the tongue. (a) ¹⁸F-FDG/PET/CT images demonstrate uptake area by the extraction socket in the left mandible (arrowhead), with a maximal standardized uptake value (SUV_{max}) of 4.18. ¹⁸F-FDG/PET demonstrates an increased uptake in the mass on the right side of the tongue (arrow), with an SUV of 10.40. The colour scale bar for the PET/CT images provides a better sense of the intensity; red is the higher uptake of ¹⁸F-FDG, while blue is the lower. Specifically, red indicates an SUV_{max} of over 6, orange from under 6 to 5, yellow from under 5 to 4, green from under 4 to 3, blue from under 3 to 2, and black-like under 2. (b) Axial CT image with a soft-tissue window shows diffuse bone resorption coincident with the uptake areas in the left mandible with ¹⁸F-FDG accumulations on ¹⁸F-FDG/PET/CT (arrowhead), and a primary squamous cell carcinoma is visualized as an enhanced mass on the right side of the tongue (arrow)

Discussion

The most interesting result of the present study is that most oral cancer patients had various areas in the oral cavity other than the primary lesions with SUV_{max} values of ¹⁸F-FDG of over 2.5. These areas were in the front intrinsic muscles of the tongue, upper and lower marginal parts of the orbicularis oris muscle, sublingual glands, palatine tonsil, pharyngeal tonsil, lingual tonsil, maxilla and mandible. Almost all patients had multiple positive areas in the maxilla and mandible on ¹⁸F-FDG/PET/CT. Moreover, the SUV_{max} of ¹⁸F-FDG on the PET/CT in these areas widely overlapped the SUV_{max} in the primary tumours. Thus, it is no surprise that radiologists are perplexed when attempting to identify primary oral cancers. Therefore, the areas of accumulation should be precisely identified and appropriately diagnosed on CT, MRI and ¹⁸F-FDG/PET/CT, because ¹⁸F-FDG accumulations can occur in multiple areas in the oral cavity of oral cancer patients. In addition, very high SUV_{max} values (more than 5) suggest the presence of tumour.

In the normal population, the tonsil and sublingual gland show relatively high ¹⁸F-FDG accumulation, which

was sometimes similar to tumour accumulation, as indicated in previous reports.^{1,14,15} However, to the best of our knowledge, there have been no reports about ¹⁸F-FDG accumulations in the muscles of the tongue and mimetic muscles;^{1,14,15} this is the first such report. The possible explanation was that patients may tend to move muscles of the tongue and orbicularis oris unconsciously as ¹⁸F-FDG accumulations in the muscles depend on the glucose metabolism. We should advise patients not to move their muscles when taking the ¹⁸F-FDG/PET/CT. At the same time, we will develop new devices that will not move the muscles of the tongue and orbicularis oris. Of course, normal volunteers could not be involved in the present study. Therefore, our results would not apply to normal populations. So far, however, we have been very dismayed in trying to identify the primary tumours in the oral cavity. Cancer detection using ¹⁸F-FDG/PET is a very prominent part of medical examination, and the present results are very helpful in attempting to resolve the problems posed by ¹⁸F-FDG accumulations in the oral cavity. It was interesting to note that, except for the two muscles noted above, there was no ¹⁸F-FDG accumulation in the representative muscles of the oral cavity, such as the buccinator, mylohyoid, stylohyoid, genioglossus, hyoglossus, styloglossus and mimetic muscles. Based on our examination of previous reports, this is the first time this has been reported.^{1,14,15} As the next study, we should examine the alterations of ¹⁸F-FDG accumulations for the diagnosis on the invasions or not of oral cancers to buccinator, mylohyoid, stylohyoid, genioglossus, hyoglossus, styloglossus and the mimetic muscles.

Moreover, the differences between the sexes and the relationship between changes in SUV_{max} and age were

Table 6 Rates of fluorine-18-labelled fluoro-2-deoxy-D-glucose (¹⁸F-FDG) accumulation in the jaws of patients with oral cancers (*n* = 82)

Areas	Numbers of ¹⁸ F-FDG accumulation (%)
Only maxilla	10 (12.2%)
Only mandible	21 (25.6%)
Both maxilla and mandible	37 (45.1%)
Total	68 (82.9%)

Figure 4 Two imaging examinations [fluorine-18-labelled fluoro-2-deoxy-D-glucose (¹⁸F-FDG)/positron emission tomography (PET)/CT and MRI] of a 64-year-old male with malignant melanoma of the left maxillary gingiva. (a) ¹⁸F-FDG/PET/CT images demonstrate some uptake areas in the maxillary gingiva (arrowheads), with a maximal standardized uptake value (SUV_{max}) of 5.35, 4.45, and so on. Of course, ¹⁸F-FDG/PET demonstrates an increased uptake in the mass on the left maxillary gingiva (arrows), with an SUV of 4.20. The colour scale bar for the PET/CT images provides a better sense of the intensity; red is the higher uptake of ¹⁸F-FDG, while blue is the lower. Specifically, red indicates an SUV_{max} of over 6, orange from under 6 to 5, yellow from under 5 to 4, green from under 4 to 3, blue from under 3 to 2, and black-like under 2. (b) T₂-weighted images show some high signal changes in the maxillary gingiva on ¹⁸F-FDG/PET/CT (arrowheads), and a malignant melanoma is visualized as a mass with medium-high signal intensity in the left maxillary gingiva (arrows)

examined. ¹⁸F-FDG accumulations in the upper and lower marginal parts of the orbicularis oris were significantly higher in males than in females, but not in other areas, including the intrinsic muscles of the tongue. In addition, ¹⁸F-FDG accumulations in the lower marginal part of the orbicularis oris and hyoglossus muscles decreased with age. In relatively young males, the various ¹⁸F-FDG accumulations on ¹⁸F-FDG/PET other than the main lesion should be carefully examined and diagnosed precisely.

As expected, various areas in the maxilla and mandible showed ¹⁸F-FDG accumulation in almost all patients. The possible explanation for this was that the oral cavities of oral cancer patients might commonly tend to be unclean, and that dental inflammation might tend to occur in patients with oral cancer. In our previous study,¹¹ ¹⁸F-FDG accumulations in the maxilla and mandible tended to coincide with bone resorption regions owing to periodontal or periapical inflammation around the teeth or osteomyelitis on panoramic radiographs, CT and MRI. The areas of ¹⁸F-FDG accumulation might induce a false-positive diagnosis of primary lesions in gingival cancers, and an appropriate differential diagnosis between periodontal or periapical inflammations and malignant tumours in the gingiva on PET images may not be possible.¹¹ Therefore, careful attention to clinical findings and clinical history is needed, and it is important to note findings such as

dental inflammation, redness, swelling, oppressive pain, spontaneous pain and so on. At the same time, abnormal imaging findings on panoramic radiographs, CT and MR images should be examined in PET-positive and PET-suspected positive areas. In addition, we should advise patients with oral cancers for the improvement of dental inflammations in acquiring the ¹⁸F-FDG/PET/CT.

In the present patients with oral cancers, the most common site of accumulation was the tongue, and the major pathological diagnosis was SCC. Other cancers included mucoepidermoid cell carcinoma, adenoid cystic cell carcinoma, spindle cell carcinoma and malignant melanoma. Based on the literature,¹⁶ the present patients appear to reflect the status of oral cancer patients in Japan. The SUV_{max} for all primary lesions ranged from 1.5 to 49.7 in the present study, which is relatively standard in oral cancers.¹⁷

One possible limitation of the present study is that the sample size was small. In addition, the effects of race could not be studied. Therefore, the present results should be judged carefully, and larger sample sizes are needed to identify unknown ¹⁸F-FDG accumulations.

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