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# Correlation of the $SUV_{max}$ of FDG-PET and ADC values of diffusion-weighted MR imaging with pathologic prognostic factors in breast carcinoma

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ABSTRACT

*Purpose:* To correlate both primary lesion maximum standardized uptake values ($SUV_{max}$) of FDG-PET/CT, and apparent diffusion coefficient (ADC) values of diffusion-weighted imaging (DWI) with clinicopathologic prognostic factors in patients with breast carcinoma.

*Materials and methods:* 214 patients with 216 mass-type invasive breast carcinomas underwent whole-body FDG-PET/CT and 3-Tesla breast MRI including DWI before initial therapy. The primary tumor's $SUV_{max}$ and ADC values were measured using FDG-PET/CT and DWI, respectively. Histologic analysis parameters included tumor size, expression of estrogen receptor (ER), progesterone receptor (PR), human epidermal growth factor receptor 2 (HER2), and Ki-67, nuclear grade, histology subtype, and axillary lymph node (LN) metastasis. The relationships among $SUV_{max}$, ADC values, and pathologic prognostic factors were evaluated.

*Results:* The mean $SUV_{max}$ and $ADC_{mean}$ were $5.63 \pm 3.79$ (range, 1.2–24.17) and $894 \pm 204 \times 10^{-6}$ $mm^2/s$ (range, $452–1550 \times 10^{-6}$), respectively. There was a significant but weak inverse correlation between the $SUV_{max}$ and $ADC_{mean}$ values (correlation coefficient $r = -0.30$, $p < 0.0001$). $SUV_{max}$ was associated with numerous prognostic factors such as tumor size ($p < 0.0001$), expression levels of ER ($p = 0.00041$), PR ($p = 0.00028$), HER2 ($p = 0.00021$), and Ki-67 ($p < 0.0001$), nuclear grade ($p < 0.0001$), histology subtype ($p = 0.00061$), axillary LN metastasis ($p < 0.0001$), and TNM staging ($p < 0.0001$). Meanwhile, $ADC_{mean}$ value was associated with tumor size ($p = 0.013$), expression of Ki-67 ($p = 0.0010$), histology subtype ($p = 0.00013$), axillary LN metastasis ($p = 0.00059$), and TNM staging ($p = 0.0011$).

*Conclusions:* Primary tumor $SUV_{max}$ on FDG-PET/CT has a stronger relationship with known prognostic parameters and may be a more useful for predicting the prognosis of breast carcinoma than ADC values.


## 1. Introduction

Breast carcinoma is a heterogeneous tumor that exhibits various patterns of progression, results and treatment responses. The management plans for breast carcinoma are determined in accordance with the preoperative tumor-node-metastasis (TNM) stage, histologic classification of postoperative TNM stage, and the levels of hormone receptor and molecular markers in the specimens [1]. The immunohistochemical prognostic factors include hormone receptors such as estrogen receptor (ER), progesterone receptor (PR), human epidermal growth factor receptor 2 (HER2), and Ki-67. Noninvasive diagnostic tools for prediction of tumor behavior are becoming more important for the management of breast carcinoma.

$^{18}$F-fluorodeoxyglucose positron emission tomography/computed tomography (FDG PET/CT), which reflects glucose metabolism in terms of the increased level of glycolysis in cancer cells, has been shown to be a useful imaging technique for the

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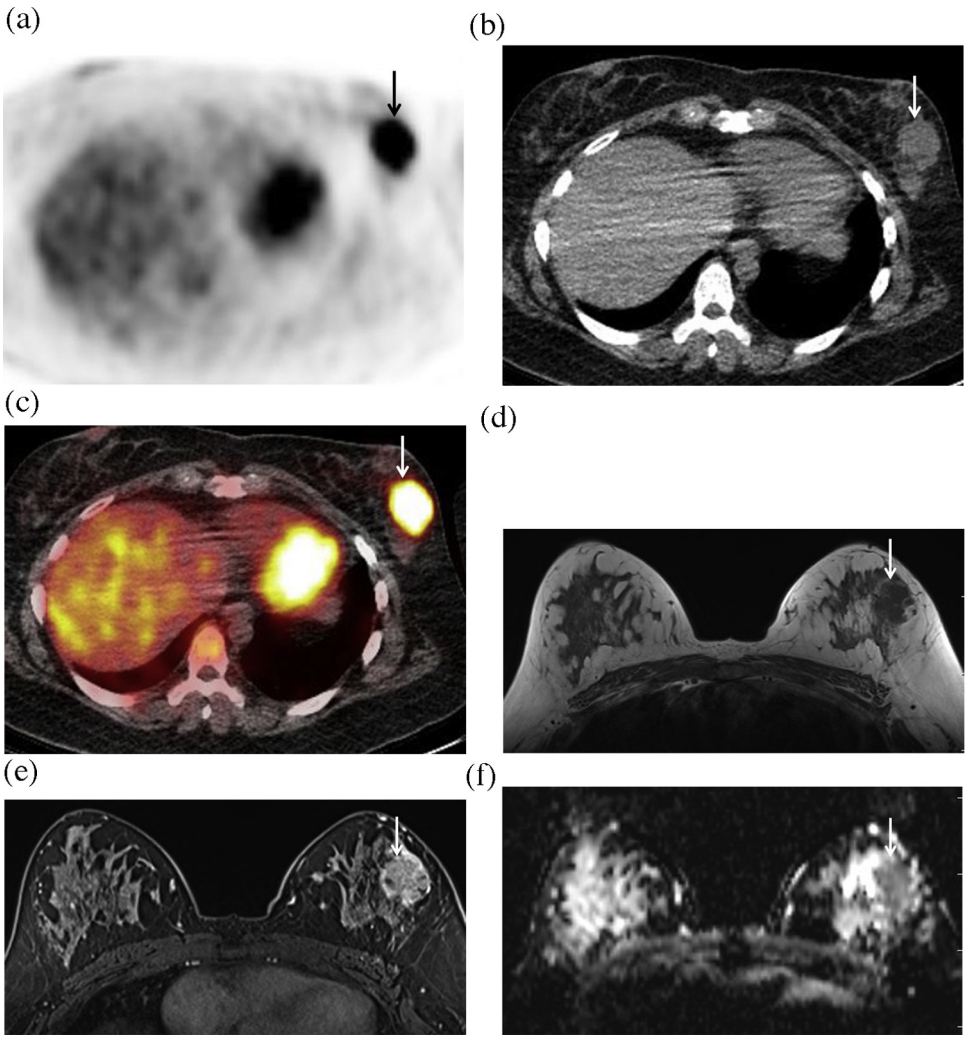


**Fig. 1.** A 40-year-old woman with triple negative type invasive ductal carcinoma (ER 0%, PR 0%, HER2 0, Ki-67 30%, grade 3, T2N1M0).
Axial (a) FDG PET, (b) CT, and (c) fused image show intense uptake ($SUV_{max}$ 9.64) in left breast tumor (arrow). Axial (d) T1WI shows a well-defined hypointense mass (arrow) measuring 40 mm in size and (e) fat-suppressed T1-weighted three dimensional imaging obtained after 2 min after gadolinium injection shows a strong enhancement (arrow). (f) Axial apparent diffusion coefficient (ADC) map shows low signal intensity (arrow) in tumor ($ADC_{mean}$ and $ADC_{min}$ values are $642 \times 10^{-6}$ $mm^2/s$ and $576 \times 10^{-6}$ $mm^2/s$, respectively).

diagnosis, staging, evaluation of response to therapy, restaging, and prognostication of malignant diseases including breast carcinoma. FDG uptake, expressed as the maximum standardized uptake value ($SUV_{max}$), is usually used to assess the biological aggressiveness of a malignant tumor and is reportedly associated with several histopathological and immunohistochemical prognostic factors of breast carcinoma [2–13].

Magnetic resonance imaging (MRI), especially dynamic contrast-enhanced imaging (DCEI), is widely used in the diagnosis of breast carcinoma and evaluation of tumor localization and its extension to adjacent tissue. The diffusion-weighted image (DWI) is a modality used to evaluate the microstructural characteristics of water diffusion in biological tissues. DWI has a potential role in the characterization of malignancy, including determination of lesion aggressiveness and monitoring of the response to therapy, and its clinical application is becoming more frequent. The apparent diffusion coefficient (ADC) value is calculated using DWI. Highly cellular malignant tumors display low ADC values due to the inverse relationship of ADC with tumor cellularity. Some groups have reported an association between ADC values and pathologic prognostic factors in patients with breast carcinoma [9–17].

FDG-PET and DWI are both functional modalities that indirectly represent the biological characteristics of cancer, but few studies have explored the association between them and prognostic factors in patients with breast carcinoma [9–13]. The superiority of two indexes has not been clarified yet. Our present study attempted to assess the correlation between the $SUV_{max}$ and ADC values and to compare their correlation with pathologic prognostic factors in patients with breast carcinoma.

## 2. Materials and methods

### 2.1. Patient selection

The institutional review board of our hospital approved this retrospective study; the requirement for informed consent was waived. Between January 2012 and March 2015, 263 female patients with newly diagnosed invasive ductal breast carcinoma underwent whole-body FDG-PET/CT and 3-Tesla mammary gland MRI including DWI for initial staging. Of these patients, 33 with an apparent tumor size of less than 1 cm, 8 with no focal uptake on PET, and 8 with no abnormal signal intensity on the ADC map were excluded. Finally, 216 index breast carcinomas in 214 patients