

Whole-Body 3T MRI with Newly Developed Quick 3D and Enhanced Fat Free Techniques: Capability for Distant Metastasis and/or Recurrence Assessments in Non-Small Cell Lung Cancer as Compared with Conventional Whole-Body 3T MRI and FDG-PET/CT

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Introduction: Assessments of distant metastasis and recurrence are very important for management of patients with non-small cell lung cancer (NSCLC). Currently, FDG-PET/CT has been suggested as useful in this setting. Recently, whole-body MR imaging (MRI) at 1.5T or 3T systems have been also suggesting as another technique in this setting (1, 2). However, major drawbacks on whole-body MRI at 3T system are increased T1 relaxation time and B1 inhomogeneity, decreased signal difference between enhanced lesions and fat on T1-weighted gradient echo (T1W-GRE) sequence, and limited spatial resolution. Recently, newly developed quick and segmented 3D gradient echo sequence (Quick 3D) and double fat suppression pulse technique for enhancing fat free capability (i.e. Enhanced fat Free: EFF) can be clinically utilized for improving diagnostic capability of whole-body MRI at 3T in routine clinical practice. However, no direct comparison of diagnostic capability for distant metastasis and/or recurrence assessment has been made among whole-body 3T MRI with conventional protocol using contrast-enhanced T1W GRE (CE-T1W-GRE) sequence, that with contrast-enhanced (CE-) Quick 3D and EFF and integrated FDG-PET/CT in NSCLC patients. We hypothesized that Quick 3D and EFF could improve diagnostic performance for distant metastases and/or recurrence of whole-body MRI at 3T MR system (whole-body 3T MRI) as compared with previously reported conventional protocol (1, 2), and might be at least as valuable as FDG-PET/CT in NSCLC patients. The purpose of this study was to directly and prospectively compare diagnostic capabilities for distant metastasis and/or recurrence assessment among whole-body 3T MRI with conventional protocol using CE-T1W-GRE sequence, that with CE-Quick 3D and EFF and integrated FDG-PET/CT in NSCLC patients.

Materials and Methods: 45 consecutive NSCLC patients (27 men, 18 women; mean age 73 years) prospectively underwent standard whole-body MRI without and with CE-Quick 3D and EFF, integrated FDG-PET/CT, pre- and post-therapeutic standard radiological examinations for diagnosis of distant metastasis and/or recurrence, and more than one-year follow-up examinations. All whole-body 3T MRIs were obtained by using a 3T MR system (Vantage Titan 3T, Toshiba Medical Systems) with multi-channel whole-body coil as having parallel imaging capability (Atlas SPEEDER coil, Toshiba). Final diagnosis of distant metastasis and/or recurrence in each patient was determined according to the results of standard radiological and follow-up examinations. All FDG-PET/CT examinations were performed by using standard whole-body PET/CT protocol on a PET/CT scanner. According to the final diagnosis, all patients were divided into two groups as follows: distant metastasis and/or recurrence group (n=14) and non-metastasis and recurrence group (n=31). All whole-body MR images and all FDG-PET/CT images were prospectively assessed by two different reader groups. Probability of presence of metastases and/or recurrence on each method was evaluated by using 5-point visual scoring systems on a per patient basis. Final diagnosis in each patient was made by consensus of two readers. A kappa statistic was used to determine the inter-observer agreements for three methods on a per-patient basis. To compare diagnostic capabilities among three methods, ROC analysis was used on a per-patient basis. This was followed by a statistical comparison of sensitivity, specificity and accuracy by means of McNemar's test.

Results: Representative case is shown in Figure 1. The assessments demonstrated that interobserver agreements were substantial ($0.63 < \text{kappa} < 0.71$). The results of ROC analyses of all methods on a per-patient basis are shown in Figure 2. Area under the curve (Az) of whole-body 3T MRI with CE-Quick 3D and EFF ($Az=0.96$) was significantly larger than that of whole-body 3T MRI without CE-Quick 3D and EFF ($Az=0.79$, $p<0.05$). Feasible threshold values and compared diagnostic capabilities of three methods are shown in Table 1. Accuracy ($93.3 < 42/45 > \%$) of whole-body 3T MRI with CE-Quick 3D and EFF was significantly higher than that of whole-body 3T MRI without CE-Quick 3D and EFF ($80.0 < 36/45 > \%$, $p<0.05$).

Conclusion: Quick 3D and EFF can significantly improve diagnostic accuracy of distant metastasis and/or recurrence in NSCLC patients on whole-body 3T MRI. Whole-body 3T MRI with CE-Quick 3D and EFF can be used for distant metastasis and/or recurrence assessment of NSCLC patients with accuracy as good as that of integrated PET/CT.

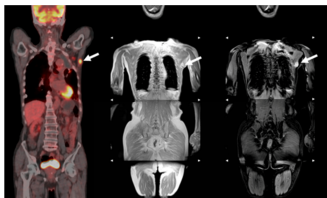


Fig. 1A Fig. 1B Fig. 1C

Figure 1. 69-year-old male patient with chest recurrence after thoracotomy for non-small cell carcinoma.

A: FDG-PET/CT demonstrate FDG uptake in left chest wall, and is scored as 5. This case is true-positive case on PET/CT. B: CE-T1W-GRE sequence on whole-body 3T MRI do not show recurrent lesion, and is scored as 2. This case is false-negative case on whole-body 3T MRI without Quick 3D and EFF. C: CE-Quick 3D with EFF demonstrate enhanced lesion in left chest wall, and is scored as 5. This case is true positive case on whole-body 3T MRI with Quick 3D and EFF.

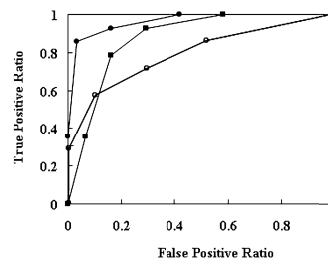


Figure 2. Results of ROC analysis for diagnosis of distant metastasis and/or recurrence on three methods.

Az of whole-body 3T MRI with CE-Quick 3D and EFF (\bullet , $Az=0.96$) was significantly larger than that of whole-body 3T MRI without CE-Quick 3D and EFF (\circ , $Az=0.79$, $p<0.05$), and larger than that of PET/CT (\blacksquare , $Az=0.88$).

Table 1. Feasible threshold value and diagnostic capability of each method on a per-patient analysis.

	Feasible threshold value	SE (%)	SP (%)	PPV (%)	NPV (%)	AC (%)
Whole-body 3T MRI with CE-Quick 3D and EFF	4	85.7 (12/14)	96.8 (30/31)	92.3 (12/13)	93.4 (30/32)	93.3 (42/45)
Whole-body 3T MRI without CE-Quick 3D and EFF	4	57.1 (8/14)	90.3 (28/31)	72.7 (8/11)	82.4 (28/34)	80.0* (36/45)
Integrated FDG-PET/CT	4	71.4 (11/14)	83.9 (26/31)	68.8 (11/16)	89.7 (26/29)	82.2 (37/45)

SE: sensitivity, SP: specificity, PPV: positive predictive value, NPV: negative predictive value, AC: accuracy

*: Significant difference with whole-body 3T MRI with Quick 3D and EFF.

References:

- Ohno Y, Koyama H, Nogami M, et al. J Magn Reson Imaging. 2007; 26(3): 498-509.
- Yi CA, Shin KM, Lee KS, et al. Radiology. 2008; 248(2): 632-642