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Original Article

MRI and PET–CT: Comparison in post-treatment evaluation of head and neck squamous cell carcinomas

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ABSTRACT

Background: Treatment of patients with head and neck cancers includes surgery, radiation therapy and chemotherapy due to which the complex anatomy in this region is further complicated by post surgical or radiation changes making the distinction between post therapy changes and recurrence or residual tumor challenging. We decided to compare the diagnostic performance of FDG-PET/CT and MRI scans in the response assessment of patients with Head and Neck Squamous Cell Carcinomas (HNSCC).

Methods: Fifty consecutive patients with carcinoma of the head and neck region undergoing treatment at our center were enrolled in the study and evaluated with both MRI scan and PET–CT scan at presentation, at 12 weeks after treatment and at 24 weeks post-treatment.

Results: Post treatment evaluation at 24 weeks revealed a sensitivity, specificity, PPV, NPV of 95.83%, 82.37%, 78.91%, 96.3% for MRI respectively while corresponding values for PET–CT scans were 95.83%, 91.97%, 85.45% and 96.3%. Evaluation by treatment modality showed a concurrence rate of positive biopsies of 71.33% and 74.54% respectively for MRI and PET–CT scans in surgical patients, 93.33% and 91.25% respectively for the chemo-radiotherapy and 71.43% and 85.71% respectively for patients treated with surgery and radiotherapy.

Conclusion: In our study, both modalities were useful for evaluation at 12 weeks, however by 24 weeks PET–CT was superior. Both the modalities suffer from high negative predictive values and relatively low positive predictive values. These persisted irrespective of the treatment modality with MRI being slightly better for patients on chemo-radiotherapy while PET–CT scans were better if surgery was one of the modalities of treatment.

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Introduction

Treatment for patients with head and neck cancers may include surgery, radiation therapy and chemotherapy, depending on the extent of disease, site, nodal status, metastatic workup and performance status. These treatment modalities elicit a partial or complete response in the tumors. They are also associated with changes in the tumor bed due to anatomical distortion by the effects of the treatment modality itself. Imaging plays a vital role in initial staging, guiding therapy^{1,2} and post-treatment follow-up. The imaging modalities usually utilized for this include CT scans, MRI scans and FDG¹⁸ PET-CT scans.

MRI has been reported to have a sensitivity and specificity of 36% and 94% respectively³ while the corresponding values for PET-CT scans have been reported to be 79 and 86% for initial staging and 91% and 88% respectively in the post-treatment evaluation of head and neck cancers.^{3,4} In addition whole-body PET-CT scans have good diagnostic performance in initial metastatic staging of head and neck cancer.⁵

The objective of this study was to compare the diagnostic performance of non-contrast FDG-PET/CT and MRI scans in response assessment of patients with Head and Neck Squamous Cell Carcinomas (HNSCC).

Material and methods

This study was carried out between 2006 and 2009. Fifty (50) consecutive patients with carcinomas of the head and neck region presenting in the Oncology Centre, INHS Asvini were enrolled in a prospective study to evaluate the diagnostic performance of MRI and PET-CT scans in the post-treatment evaluation of patients with head and neck cancers. Inclusion criteria were clinical suspicion of malignancy in the oral cavity, oro-pharyngeal or laryngo-pharyngeal region and histopathological confirmation by biopsy. Exclusion criteria included patients with uncontrolled diabetes mellitus, renal failure patients who were critically ill, already treated cases of head and neck malignancy and patients with evidence of any associated inflammatory or infective lesion involving head and neck region. After informed consent was obtained, all patients enrolled were subjected to a detailed clinical examination and endoscopic evaluation of the extent of the disease. Fine-needle aspiration from palpable nodes as well as biopsy of the primary lesion were accepted for histopathological confirmation. All the patients were evaluated with PET-CT scan and MRI scan and the findings were correlated with clinical findings. After staging of the disease, tumor board was held at INHS Asvini for treatment decision. The patients were treated with surgery and/or chemo-radiotherapy. The radiation therapy was delivered at Tata Memorial Hospital till 2008 and subsequently at INHS Asvini. All patients receiving radiotherapy received a total tumor dose of 70 Gy in 35 fractions over 7 weeks in 2–3 sequential phases. Concurrent weekly Cisplatin (30 mg/m²) was offered to all patients with bulky T2, T3, T4 or node-positive disease as per the institutional policy. All the patients were asked to report after 06 weeks of the primary treatment for a clinical evaluation and

toxicity monitoring and subsequently at 06 weekly intervals. Pre- and post-treatment MRI scans at the Department of Radiodiagnosis, INHS Asvini and FDG-PET/CT at Department of Bio-imaging, Tata Memorial Hospital were also performed on all these patients after informed consent at 12 weeks and 24 weeks for response assessment. Recurrences seen on imaging were further evaluated by clinical examination. Biopsy of the lesion/fine needle aspirations of lymph nodes as applicable were done at 24 weeks if persistent.

The MRI scan was performed using a 1.5T Magnetom MR (Siemens) scanner with surface coil. Initially, coronal, sagittal and transverse planes localizer images were obtained. Subsequently, T1W, T2W SE and T1W FS sequences as well as post contrast (after administration of 10 ml of IV Gadolinium) T1W FS sequences were done in all patients. Imaging parameters include a slice thickness of 3 or 4 mm with a 0- to 1-mm intersectional gap, a field of view of 20 × 20 cm or less and acquisition matrix 256 × 256. MRI studies (primary site and nodes) were evaluated for the presence of recurrent tumor by the radiologist who was aware of the site of the primary tumor.

Whole-body PET-CT scans were performed using BGO plus, Full ring PET-CT (GE Discovery ST, GE Medical Systems, Milwaukee, WI, USA). 370 MBq ¹⁸F-FDG radioisotope was used and image acquired after 45 min uptake period. CT was acquired from top of skull through mid-thigh region in one imaging procedure using 110 kVp, 80 mAs, 5 mm collimation and a pitch of 1.6. After the CT, 3D PET data were acquired using 3-min bed positions. The helical CT scan was reconstructed to match the PET scan. The images were reconstructed using the standard iterative method with Ordered Subset Expectation Maximization (OSEM) algorithm. Fusion images of the PET and CT were obtained using inbuilt software. Standardized Uptake Value (SUV) was calculated in regions of interest drawn on trans-axial images around the areas with increased FDG uptake. The maximum SUV within this volume was documented as SUVmax. One nuclear medicine physician, at the institution where a study was performed, evaluated the PET-CT studies for abnormal uptake, and was aware of clinical details with histopathological diagnosis. Focal and asymmetric FDG uptake with intensity greater than that in surrounding normal tissues was considered suggestive of residual disease, while diffuse uptake within the radiation field was considered post-radiotherapy inflammation and disregarded. The results were calculated with pathology confirmation and clinical follow-up information in all patients in our study who had strong suspicion of disease recurrence. The data of pre-treatment evaluation (with MRI and non-contrast PET scan) and post therapy follow-up (with PET-CT and MRI) were tabulated as per the initial stage of the disease. This data was analyzed separately with regard to the sensitivity, specificity, positive predictive value and negative predictive values of the two diagnostic modalities. The results were compared at 0 and 24 weeks individually with the gold standard (biopsy) for both modalities. For purposes of data analyses with respect to mid-term comparison of the 02 diagnostic modalities, a retrospective analysis of measurements made separately with MRI and PET-CT (non-contrast) at 12 weeks of follow-up, was carried out. This facilitated equitable comparison of study values at 0, 12, 24 weeks of follow-up. Further, data on response of the

Table 1 – Distribution of patients as per age and sex.

	Age/sex	Numbers (frequency)	Percentage
01(Age)	a <40 years	7	14.0
	b 41–50 years	4	8.0
	c 51–60 years	20	40.0
	d 61–70 years	15	30.0
	e >70 years	4	8.0
02(Sex)	a Male	40	80
	b Female	10	20

malignancy to different modalities of treatment viz. only surgery, only radiotherapy and combined (both surgery and radiotherapy), were analyzed in order to compare the validity of the two diagnostic modalities (MRI and non-contrast PET–CT).

Results

The mean age of the patients included in the study was 56.43 yrs (Table 1) with a male preponderance (nearly 80%). There were 4 (8%) Stage I cancers while 17 (34%), 16 (32%) and 13 (26%) patients were stage II, III and IV cancers respectively (Table 2). 11 (22%) of the patients were treated with only surgery while 13 (26%) received both surgery and radiotherapy while 26 (52%) of the patients were treated with only radiotherapy (Table 3). Post-treatment evaluation at 24 weeks revealed a sensitivity and specificity of 95.83% and 82.37% of MRI respectively with positive predictive value of 78.91% and negative predictive value of 96.3%; while PET–CT scans had a sensitivity of 95.83% and specificity of 91.97% with positive predictive value of 85.45% and negative predictive value of 96.3% (Table 4). Evaluation by treatment modality showed a concurrence rate of positive biopsies of 71.33% and 74.54% respectively for MRI and PET–CT scans in surgical patients, 93.33% and 91.25% respectively for the radiotherapy alone patients and 71.43% and 85.71% respectively for patients treated with both surgery and radiotherapy (Table 5).

All events/outcomes were treated as recurrences; one patient died of tumor progression during treatment (imaging not available).

Discussion

The objective of this study was to compare the diagnostic performance of FDG-PET/CT and MRI scans in patients with

Table 2 – Distribution of patients as per initial staging of disease.

Stage of disease	Numbers (frequency)	Percentage
I	4	8
II	17	34
III	16	32
IV	13	26
Total	50	100

Table 3 – Distribution of patients as per treatment given.

Treatment given	Numbers (frequency)	Percentage
Only surgery	11	22
Only Radiotherapy	26	52
Both surgery and radiotherapy	13	26
Total	50	100

HNSCC. Various authors have studied the optimal imaging modality to be used for staging as well as for follow-up. Kyzas et al⁴ documented a sensitivity of 79%, (95% CI ~72%–85%) and specificity of 86%, (95% CI ~83%–89%) for PET–CT scans in staging the cervical neck nodal basins before locoregional treatment while Xu⁵ and Braams³ have called it the modality of choice for staging of patients with advanced HNSCC in view of its greater sensitivity for the detection of metastatic lesions as compared to the conventional modalities.

Ghanooni et al⁶ evaluated ¹⁸F-FDG PET/CT and MRI for the assessment of head and neck squamous cell carcinoma (HNSCC) relapse by imaging before treatment and at 4 and 12 months after treatment and comparing with histopathology or a minimum of 18 months follow-up as gold standard. For relapse detection at 4 months, sensitivity was significantly higher for PET/CT (92%) vs MRI (70%), but the diagnostic performances were not significantly different at 12 months. At 2 weeks post-radiotherapy, sensitivity and specificity of PET/CT for the detection of residual malignant tissue were respectively 86 and 85% (SUV cut-off value 5.8). They concluded that performance of PET/CT and MRI are similar except for a higher sensitivity of PET/CT at 4 months. ¹⁸F-FDG PET/CT can differentiate between residual tumor and radiation-induced changes as early as 2 weeks after treatment of a primary HNSCC. Another study⁷ which evaluated ¹⁸F-FDG PET/CT and CT/MRI with histopathologic correlation in patients undergoing salvage surgery for head and neck squamous cell carcinoma revealed that PET–CT and CT/MRI had accuracies of 91 and 75%, respectively for positive hemi necks ($P = 0.004$). A meta-analysis by Tejpal Gupta and colleagues⁸ of 51 studies involving 2335 patients found that the weighted mean (95% CI) pooled sensitivity, specificity, PPV and NPV of post treatment FDG PET–CT for the primary site was 79.9% (73.7–85.2%), 87.5% (85.2–89.5%), 58.6% (52.6–64.5%) and 95.1% (93.5–96.5%), respectively. Similar estimates for the neck were

Table 4 – Comparison of validity of MRI and PET–CT at various times of follow-up.*

Measure of validity (in percentages)	Diagnostic modality			
	MRI		PET–CT	
	At 12 weeks	At 24 weeks	At 12 weeks	At 24 weeks
Sensitivity	69.57%	95.83%	73.91%	95.83%
Specificity	74.23%	82.37%	74.23%	91.97%
Positive predictive value	67.33%	78.91%	84.9%	85.45%
Negative predictive value	79.41%	96.3%	81.81%	96.3%

* Data at 12 weeks represents retrospectively collated data for purposes of mid-term analysis and comparison of the two diagnostic modalities.

Table 5 – Comparison of accuracy of MRI and PET-CT (as per diagnosis of response to treatment modalities).

Treatment given	Concurrence as percentage (accuracy of diagnosis as compared to gold standard)		
	Diagnostic modality		
	Result	MRI	PET-CT
Only surgery	Abnormal	71.33	74.54
	Normal	100	100
Radiotherapy	Abnormal	93.33	91.25
	Normal	90.91	100
Radiotherapy and surgery	Abnormal	71.43	85.71
	Normal	66.67	83.33

72.7% (66.6–78.2%), 87.6% (85.7–89.3%), 52.1% (46.6–57.6%) and 94.5% (93.1–95.7%), respectively. Scans done ≥ 12 weeks after completion of definitive therapy had moderately higher diagnostic accuracy on meta-regression analysis using time as a covariate. They concluded that the overall diagnostic

performance of post-treatment FDG PET–CT for response assessment and surveillance imaging of HNSCC is good, but its PPV is somewhat suboptimal. Its NPV remains exceptionally high and a negative post-treatment scan is highly suggestive of absence of viable disease that can guide therapeutic decision-making. Isles et al⁹ in their meta-analysis have also reported negative predictive value of 95% for PET–CT scans and have suggested it may have the potential to obviate the requirement for planned neck dissections or surveillance endoscopies. Ong et al¹⁰ have also suggested that normal ¹⁸F-FDG PET/CT after chemo-radiotherapy has a high NPV and specificity for excluding residual locoregional disease, hence in patients without residual lymphadenopathy, neck dissection may be withheld safely. Lack of sensitivity of PET scanning is decreased if the interval between treatment and scan is more than 10 weeks.

In our study, MRI had a sensitivity of 95.83% at 24 weeks; its specificity was 82.37 at 24 weeks. The corresponding sensitivity and specificity for PET–CT were 95.83% and 91.97% respectively. The positive predictive values of MRI was 78.91%

Fig. 1 – (a) Pre-treatment axial section of contrast enhanced MRI showing the primary in the left base of tongue. (b) ¹⁸F-FDG PET–CT prior to treatment showing active disease in the left base of tongue. (c) Contrast enhanced MRI scan 24 weeks after concurrent chemo-radiotherapy showing progression of primary residual lesion. (d) ¹⁸F-FDG PET–CT scan at 24 weeks post-treatment confirming activity in the primary residual lesion.

and 85.45 for PET–CT scan at 24 weeks while the negative predictive values was 96.3% for both MRI scans and PET–CT scans at 24 weeks. Most of the recurrences were detected at both primary and the nodal sites. On further analysis, the scans done at 12 weeks revealed the recurrences with a sensitivity of 69.57% and specificity of 74.23%. Positive predictive values of MRI was 67.33% at 12 weeks while the negative predictive values was 79.41%. The high NPV for both modalities at 24 weeks correlates well with the data. However the apparently high specificity and PPV especially for PET–CT scans as compared to the data may be due to the relatively smaller sample size studied in this project.

Further evaluation of the data as per the treatment modality used (Table 5) revealed that both MRI and PET–CT scans had a concurrence with positive FNAC at 24 weeks of nearly 70–75% in surgical patients (22%). MRI scans in patients (26%) receiving both surgery and radiotherapy had a concurrence with positive FNACs in only 71.43% while the PET–CT scans were slightly better with 85.71% (Table 5). This is probably because of the extensive anatomical distortion produced by surgery for head and neck cancers hence a metabolic scan may be better.

The post-treatment evaluation of the patients (52%) treated with chemo-radiotherapy revealed a 93.33% positive MRI while 91.25% of the recurrences were detected by the PET-CT scans (Fig. 1).

An area of active research today is fused PET and MRI images for better anatomic delineation. In a study evaluating the diagnostic value of fused fluorodeoxyglucose positron emission tomography and magnetic resonance imaging (PET/MRI) compared with PET/computed tomography (CT), MRI, and CT in assessing surrounding tissue invasion of advanced Buccal Squamous Cell Carcinoma (BSCC),¹¹ it was concluded that fused PET/MRI is more reliable for focal invasion assessment and tumor size delineation in advanced SCC compared with PET/CT, MRI, and CT.

Conclusions

In our study, both modalities were useful for evaluation at 12 weeks, however by 24 weeks PET–CT was superior. The modalities lack optimum and desirable positive predictive value in spite of high negative predictive value. However both the modalities suffer from high negative predictive values and relatively low positive predictive values. These persisted irrespective of the treatment modality with MRI being slightly better for patients on chemo-radiotherapy while PET–CT scans were better if surgery was one of the modalities of treatment. Further evaluation of these modalities in specific clinical situations and with larger sample sizes is required to predict the most reliable modality and the optimal time interval between completion of radiation and imaging. Towards this end, this study would serve as a template/workable database for further evaluation.

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Conflicts of interest

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