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Original Research Paper

Radiology

ROLE OF NECK IMAGING REPORTING AND DATA SYSTEM IN PREDICTION OF RESIDUAL OR RECURRENT HEAD AND NECK CANCERS IN POST-TREATMENT PATIENTS BY CONTRAST-ENHANCED COMPUTED TOMOGRAPHY

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ABSTRACT In the Neck imaging and reporting data systems(NIRADS system) , both the primary tumour and neck sites are independently assessed for suspicion of cancer and assigned a numerical category based on imaging features. this study aims to evaluate the role/ the diagnostic accuracy of (NIRADS system) in the prediction of residual or recurrent head and neck cancers in post-treatment patients by CECT with the objectives to predict the residual or recurrent head and neck cancers in post-treatment patients based on 3 month follow up CECT scan and assign NIRADS category. This study concluded that there was a significant association between recurrence and primary/ nodal/ combined tumour site NIRADS on 6 months of follow-up clinical, pathological and /or CECT scans.NIRADS > 3 had the overall highest PPV, NPV and diagnostic accuracy. The performance of NIRADS was good, demonstrating significant discrimination between groups, with overall recurrence rates.

KEYWORDS : NIRADS, Recurrence, Residual Or Recurrent Head And Neck Cancers

Head and neck cancers are prevalent in developing countries, particularly Southeast Asia, making them a significant health concern. Overall, 57.5% of global head and neck cancers occur in Asia, especially in India. Despite recent treatment advancements, about 20-50% of patients experience loco regional recurrence within the first two years post-treatment. Disease recurrence is a significant challenge in head and neck malignancies, necessitating early detection of tumour recurrence through post-treatment surveillance for salvage procedures.

ACR (American College of Radiology) developed the Head and Neck Imaging Reporting and Data System (NIRADS) for the surveillance of contrast-enhanced computed tomography (CECT) with and without positron-emission tomography (PET) in patients with treated head and neck cancer.

In the NIRADS system, both the primary tumour and neck sites are independently assessed for suspicion of cancer and assigned a numerical category based on imaging features ranging from 1–4, with specific linked management recommendations in each category. PET/CECT at 12 weeks is often the first post-treatment study, though a recent study suggests that it can be performed at 8 weeks.

The study aims to evaluate the effectiveness of the NIRADS rating scale and CECT criteria in predicting local and regional recurrence.

Hence this study aims to evaluate the role of Neck imaging and reporting data systems in the prediction of residual or recurrent head and neck cancers in post-treatment patients by CECT with the objectives to predict the residual or recurrent head and neck cancers in post-treatment patients based on 3 month follow up CECT scan and assign NIRADS category. And to find out the diagnostic accuracy of NIRADS in the prediction of residual or recurrent head and neck cancers in post-treatment patients by CECT.

MATERIALS AND METHOD

This Descriptive observational study was conducted in **the** Department of Radiodiagnosis Santokba Durlabhji Memorial Hospital Cum Research Institute, Jaipur from August 2022 to July 2023.The sample size was calculated at a 95% confidence level, assuming 22.8% recurrence in the total targeted site of a scan of patients with head and neck cancers as found in the reference study. At the relative allowable error of 20% of recurrence, a minimum of 325 targets were required as samples which was further increased to 358 target sites as the final sample size for the present study expecting a 10% drop out/loss to follow up.

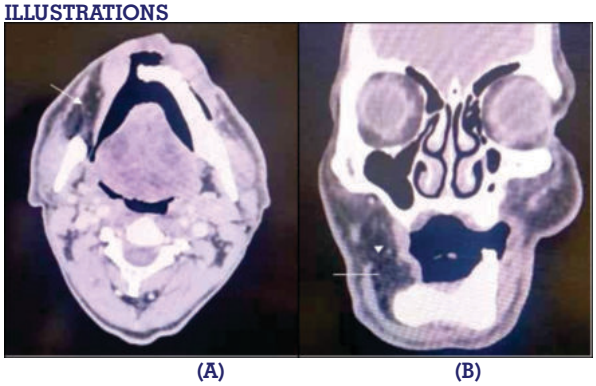
For 348 target sites total of 174 scans were needed which were obtained from 87 patients clearance from the Institutional Ethics Committee and written informed consent were taken. All Patients presented to the hospital for follow-up investigation after 3 months of treatment (surgery or chemoradiation) and underwent CECT neck and who gave consent were included in the study. Patients known to have an allergy to contrast media, who refused to give consent, cooperative patients, Severely ill patients Patients with renal impairment and a history of renal disease (renal transplant, single kidney, renal cancer and Patients on dialysis were excluded. NIRADS scoring was given to the post-treated patients based on CECT findings and further managed according to the NIRADS guidelines. The patients with recommendations for follow-up were subsequently followed up for 6 months.

The quantitative variable was summarised as mean and standard deviation while the qualitative variable was presented as a proportion. ROC analysis Sensitivity, and specificity were calculated using standard formulae. P value < 0.05 was taken as significant. Standard statistical software was used for all statistical calculations.

NIRADS grade	Lexicon and Imaging Appearance
NIRADS 1	Expected posttreatment changes and non-mass-like tissue distortion.[5] No abnormal FDG uptake.[5] Diffuse linear mucosal enhancement after radiation.[5] Low-density mucosal oedema (likely post-radiation oedema).[5] If residual nodal tissue, no FDG uptake.[7]
NIRADS 2	Focal mucosal enhancement but not mass-like or focal mild to moderate mucosal FDG uptake (2a).[5] Deep ill-defined soft tissue, not discrete enhancement.[5] or little to no differential Mild to moderate contrast enhancement or FDG uptake (2b).[5] Enlarging or new lymph node without definitive abnormal morphologic features on CECT or only mild/moderate FDG.[7]

NIRADS 3	New or enlarging primary mass or lymph node.[5] Discrete nodule or mass with differential enhancement.[5] Intense focal FDG uptake.[5]
NIRADS 4	Pathologically proven or definite radiologic and clinical progression.[5]

ILLUSTRATIONS



(A) (B)

Figure 1: Primary site NIRADS 1 (A) Axial section and (B) Coronal section of CECT scan of a patient after 3 month of treatment showing myofatty flap at operative site in right buccal space (white arrow). The case was negative for recurrence on follow

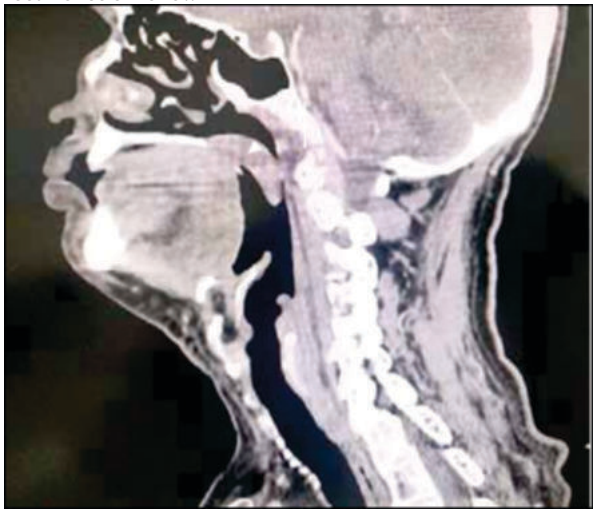


Figure 2: Primary site NIRADS 1 - Sagittal section of follow up CECT scan of ca base of tongue patient after 3 month of treatment showing edamatous soft palate (White arrow). The case was negative for recurrence on follow up.

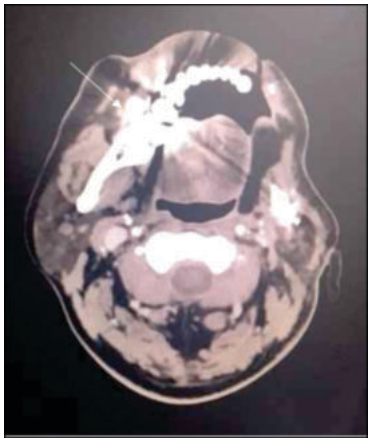
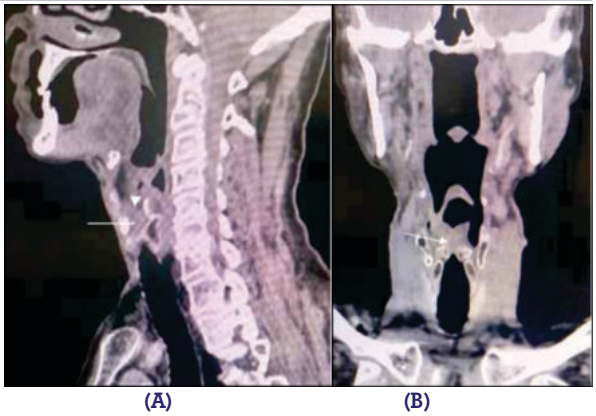


Figure 3: Primary site NIRADS 1- Axial section of follow up CECT scan of a patient of buccal mucosa carcinoma after 3 months of treatment showing diffuse soft tissue thickening at post operative site. The case was positive for recurrence on follow up.



(A) (B)

Figure 4: Primary site NIRADS 2b (A) Sagittal and (B) Coronal section of follow up CECT scan of laryngeal carcinoma patient after 3 month of treatment showing asymmetrical enhancing thickening in laryngeal region (White arrow). The case was positive for recurrence on follow up.

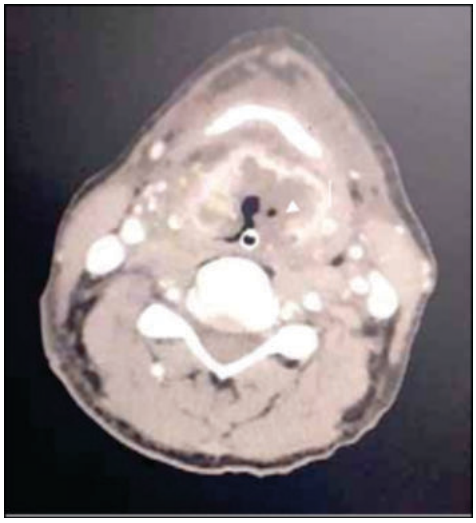


Figure 5: Primary site NIRADS 3 - Axial section of follow up CECT scan of laryngeal carcinoma patient after 3 month of treatment showing heterogenously enhancing necrotic SOL in laryngeal area (White arrow). The case was positive for recurrence.

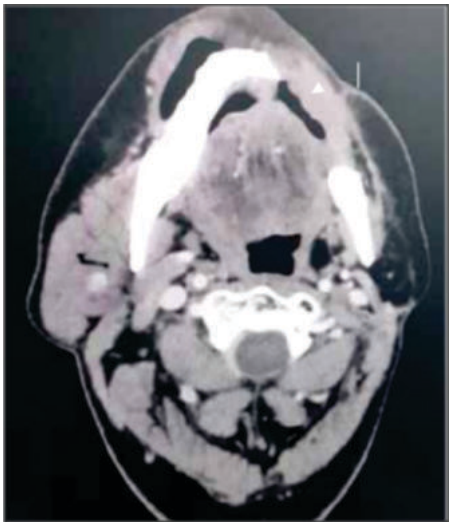


Figure 6: Primary site NIRADS 3 - Axial section of follow up CECT scan of buccal mucosa carcinoma patient after 3 month of treatment showing irregularly enhancing thickening in left buccal mucosa (White arrow). The case was positive for recurrence.

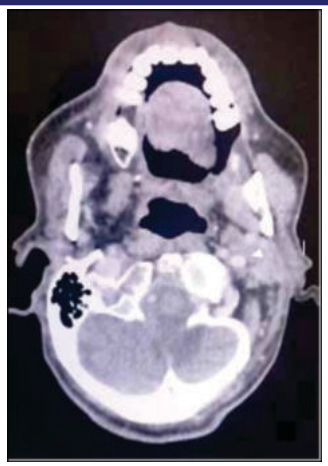


Figure 7: Nodal site NIRADS 2 - Axial Section of follow up CECT scan of buccal mucosa carcinoma patient after 3 month of treatment showing enlarge lymph nodes in left level V (White arrow). The case was positive for recurrence on follow up.

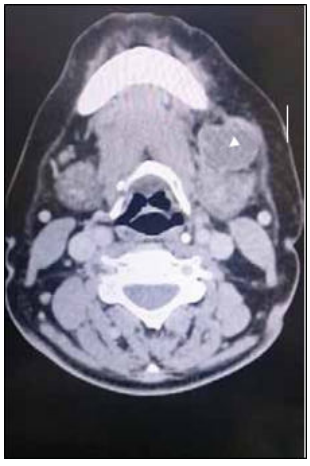


Figure 8: Nodal site NIRADS 3 - Axial section of follow up CECT scan of tongue carcinoma patient after 3 month of treatment showing large necrotic lymph node in left level Ib (White arrow). The case was positive for recurrence.

OBSERVATIONS

In our study, the most common age group was 51–60 years (32.18%), followed by 61–70 years (27.59%). Out of the total 87 patients 73.56 % (64) patients were male, and the rest were female. The male-to-female ratio was 2.7:1. The majority of the patients had buccal mucosa carcinoma (36.78%) followed by supraglottic carcinoma (21.83%). The other tumour sites were CA tongue (20.68%) and glottis carcinoma (11.49%). In our study, recurrence was seen in 6 (18.75%)

Table No 1 : Characteristics Of The Study Population

		No. of cases	Percentage (%)
	Total	87	100
Age Group (years)	31-40	6	6.9
	41-50	22	25.29
	51-60	28	32.18
	61-70	24	27.59
	>70	7	8.05
sex	Male	64	73.56
	Female	23	26.44
Tumor site	CA buccal mucosa	32	36.78
	CA tongue	18	20.68
	Glottis CA	10	11.49
	Supraglottic CA	19	21.83
	Pyriform sinus CA	7	8.09
	Post cricoid CA	1	1.14

Table 2: Tumor Recurrence Rate In Different NIRADS Categories

Primary tumour Site NIRADS	Percentage of patients with recurrent disease	Nodal Site NIRADS	Percentage of patients with recurrent disease	Combined site NIRADS	Percentage of patients with recurrent disease
NIRADS 1	5.77	NIRADS 1	11.59	NIRADS 1	5.77
NIRADS 2a	20.00	NIRADS 2	14.29	NIRADS 2	21.05
NIRADS 2b	22.22				
NIRADS 3	81.25	NIRADS 3	100.00	NIRADS 3	81.25

Out of the 87 patients in our study, 52 (59.77%) were assigned NIRADS 1, 10 (11.49%) in NIRADS 2a, 9 (10.34%) in NIRADS 2b and 16 (18.39%) in NIRADS 3 at primary tumour site after 3-month post-treatment CECT scan. In our study, 69 (79.31%) patients were assigned NIRADS 1, 7 (8.05%) in NIRADS 2 and 11(12.64%) in NIRADS 3 at the nodal site after 3-month post-treatment CECT scan. With 6 months of follow-up up-clinical, pathological **and** CECT scans, 174 primary tumour sites, 174 nodal sites and 348 combined sites were evaluated for recurrence.

In our study, recurrence was seen in NIRADS 1, with 5.77% at the primary tumour site, 11.59% at the nodal site, and 5.77% at the combined sites in NIRADS 1. Recurrence was detected at 20.00% and 22.22% in NIRADS 2a and NIRADS 2b, respectively, at the primary tumour site, 14.29% at the nodal site, and 21.05% at the combined sites in NIRADS 2.81.25% recurrence was detected in NIRADS 3 at the primary tumour site, 100% at the nodal site, and combined in 81.25% of patients.

STATISTICAL ANALYSIS OF NIRADS IN THE DETECTION OF RECURRENCE AT PRIMARY, NODAL AND COMBINED SITES

Primary Tumor Site NIRADS Analysis

Table 3: Sensitivity, Specificity, PPV, And NPV Of Individual NIRADS Score At The Primary Tumour Site Of Malignancy

		Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Diagnostic accuracy (%)
NIRADS (primary site)	≥ 1	100	0	22.99	-	22.99
	≥ 2a	85	73.13	48.57	94.23	75.86
	≥ 2b	75	85.07	60	91.93	90.8
	≥2	85	73.13	48.57	94.23	75.86
	≥ 3	65	95.52	81.25	90.14	88.5

In our study, it was seen that a NIRADS score of >3 at the primary tumour **site** had a high specificity of 95.52% but a low sensitivity of 65%. It had a PPV of 81.25% and a NPV of 90.14%. The diagnostic accuracy of the NIRADS> 3 score was 88.50%.

NIRADS score of 2 or higher at the primary tumour site had a sensitivity of 85% and a specificity of 73.13%. Its NPV was high (94.23%). Its diagnostic accuracy was 75.86%. NIRADS score of 2b or higher had high sensitivity and specificity (75% and 85.07 % respectively). Its NPV was 91.93% and diagnostic accuracy was 90.80%. NIRADS score of 2a or higher had a sensitivity of 85% and a high negative predictive value (94.23%) with a diagnostic accuracy of 75.86%.

NIRADS score of 1 or higher at the primary tumour site shows 100% sensitivity and 22.99% PPV with a diagnostic accuracy of 22.99%. For the primary tumour site, the ROC curve indicated an AUC of 0.860 and a significant level of P < 0.0001.

Nodal site NIRADS analysis

Table 4: Sensitivity, Specificity, PPV, And NPV Of Individual NIRADS Score At The Nodal Site Of Malignancy

NIRADS	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Diagnostic accuracy (%)
≥ 1	100.00	0.00	22.99	-	22.99
≥2	60.00	91.04	66.67	88.40	83.90
≥ 3	55.00	100.00	100.00	88.15	89.65

In our study, it was seen that a NIRADS score of >3 at the nodal site had high specificity(100 %) but low sensitivity (55%). It had a PPV of 100% and a high NPV = 88.15%. The diagnostic accuracy of the NIRADS > 3 score was 89.65%. NIRADS score of 2 or higher had a sensitivity of 60% and specificity of 91.04%. Its NPV was high (88.40%) and its PPV was 66.67%. Its diagnostic accuracy was 83.90% at the nodal site of malignancy.

NIRADS score of 1 or higher at the nodal site had 100% sensitivity and PPV was 22.99% with a diagnostic accuracy of 22.99%.

Combined Sites NIRADS Analysis

Table 5: Sensitivity, Specificity, PPV, And NPV Of Individual NIRAD Scores At Combined Sites Of Malignancy

NIRADS	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Diagnostic accuracy (%)
≥ 1	100.00	0.00	22.99	-	22.99
≥2	85.00	73.13	48.57	94.23	75.86
≥ 3	65.00	95.52	81.25	90.14	88.50

In our study, it was seen that a NIRADS score of > 3 at combined sites had high specificity (95.52%) but low sensitivity (65.00%). It had a high (PPV=81.25%) and a high (NPV = 90.14%). The diagnostic accuracy of the NIRADS > 3 score was 88.50%.NIRADS score of ≥2 had high sensitivity (85.00%) but low specificity (73.13%). Its NPV was high (94.23%). Its diagnostic accuracy increased with the score.

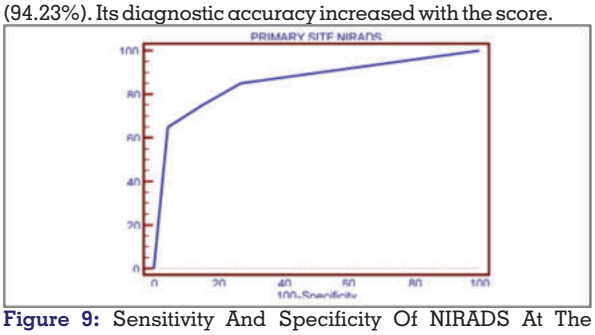


Figure 9: Sensitivity And Specificity Of NIRADS At The Primary Tumour Site For Detecting Recurrence

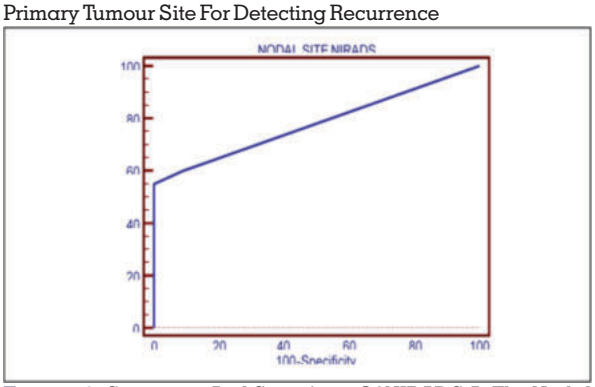


Figure 10: Sensitivity And Specificity Of NIRADS At The Nodal Site For Detecting Recurrence

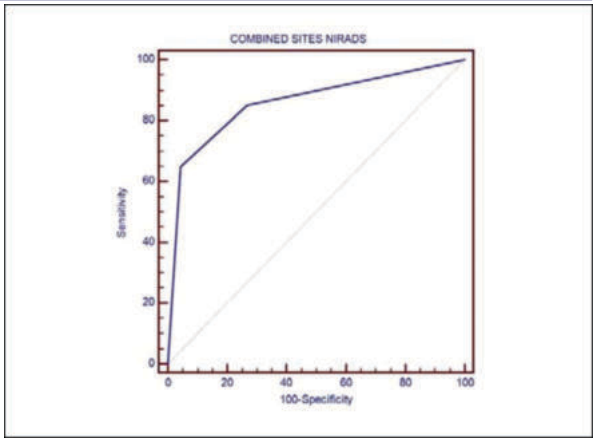


Figure 11: Sensitivity And Specificity Of NIRADS At Combined Sites For Detecting Recurrence

DISCUSSION

This study was conducted on 87 patients, CECT scan was done on 128 helical CT OPTIMA scanners. The majority of the patients32.18%.belonged to the age group of 51-60 years This was similar to the study conducted by Hsu et al [6]where the mean age of their cohort was 63.4 + 11 years with a range of 19.3 to 89.4 years. Male preponderance was observed which was comparable with the study conducted by Abdelrahman et al in which they had taken thirty-four treated patients of laryngeal and oral cavity SCC out of which, 27 (79.4%) patients were males and 7 (20.6%) were females. In this study, recurrence was detected in 13 (20.31%) male patients and the rest were female patients. Our result is in concordance with the study conducted by Kumar et al in which they also observed recurrence in 10 (35.71%) male patients. The majority of the patients were of CA buccal mucosa (36.78%) followed by supraglottic carcinoma (21.83%). This was in contrast to the study conducted by Kumar et al[54] where the maximum number of patients were of glottic carcinoma because they did not include cases of CA buccal mucosa.

In our study, the highest recurrence was detected in CA tongue patients (33.33%). This was in contrast to the study conducted by Kumar et al[8] Their study showed maximum recurrence in supraglottic carcinoma because they did not include post-surgery patients and a relatively smaller sample size in their study.

In our study, Recurrence in NIRADS 1 at the primary tumour site was 5.77%, at the nodal site 11.59% and at combined sites 5.77% in our study. This was comparable with the study by Kumar et al8 in which recurrence was seen in 5.3% at the nodal site and 4% at combined sites, however, no recurrence was seen at the primary tumour site. Recurrence was detected in 20 % and 22.22% of NIRADS 2a and NIRADS 2b respectively at the primary tumour site, 14.29% at the nodal site and 21.05% at combined sites. This was comparable with the study conducted by Kumar et al[54] in which recurrence was found in 20% and 28.5% in NIRADS 2a and NIRADS 2b respectively at the primary tumour site, 25% at the nodal site and 24% at combined sites.

In our study, recurrence was detected in 81.25% of NIRADS 3 at the primary tumour site, 100% at the nodal site and 81.25% at combined sites. This was comparable with the study conducted by Kumar et al in which recurrence was present in 85.7% at the primary tumour site, 66.7% at the nodal site and 80% at the combined site.

The study found that NIRADS 2b had high specificity as compared to NIRADS 2a.NIRADS score of 1 or higher at the primary tumour site showed 100% sensitivity and a diagnostic accuracy of 22.99%. This was comparable with the study

conducted by Kumar et al[54]in which 6 patients were assigned NIRADS 1 for the primary site, of which none showed signs of recurrence on follow-up for 6 months. A NIRADS score of 2 or higher had high sensitivity and NPV (100%) but low specificity (30%) in the prediction of recurrent disease. NIRADS score of 2b or higher had high specificity (70%) compared with a score of 2a that had low specificity (30%). A NIRADS score of 3 had high specificity (95%), PPV (86%), and NPV (83%) but low sensitivity (60%). Kumar et al concluded in their study that at the primary site, the diagnostic accuracy of NIRADS > 1, NIRADS > 2a, NIRADS > 2b and NIRADS > 3 was 33.33%, 53.33%, 73.33%,53.33% and 83.33% for detection of recurrence, which were lower than our study.

In our study, a NIRADS score of >3 at the nodal site showed high specificity (100 %) and NPV (88.15%) but low sensitivity (55%). It had a high PPV of 100 %. The diagnostic accuracy of the NIRADS >3 score was 89.65%. NIRADS score of 2 or higher at the nodal site had high specificity (91.04%), and NPV (88.40%) but low PPV (66.67%) and sensitivity (60%). Its diagnostic accuracy was 83.90%. A study conducted by Kumar et al showed NIRADS score of 3 had high specificity (96%) and NPV (86%) but a low sensitivity (40%) and PPV (66.7%). PPV for NIRADS 3 was higher in our study as compared to their study. Kumar et al concluded that a NIRADS score of 2 or higher had high sensitivity (80%) and NPV (94.7%) but low specificity (72%) and PPV (36%), however, our study showed high specificity and NPV low sensitivity and PPV.

In our study, a NIRADS score of >3 at combined sites had 88.50% diagnostic accuracy, a NIRADS score of 2 or higher showed diagnostic accuracy was 75.86% and at least ≥ 1 NIRADS score. A study conducted by Paul et al showed sensitivity, specificity, PPV, NPV, and overall accuracy of the NIRADS template combining primary site and neck, the corresponding metrics of diagnostic accuracy were 84.4%, 69.7%, 46.3%, 93.5%, and 73.2%, respectively. However, to the best of our knowledge, no study was found to compare the sensitivity and specificity of individual NIRADS categories at combined sites and the diagnostic accuracy for nodal and combined sites.

In the previous study conducted by Krieger et al4, the ROC curves depicted similar results with a strong association between NIRADS scores and disease recurrence. In their study, the ROC curve for NIRADS at the primary site had AUC 0.786 while the ROC curve for NIRADS at the lymph nodes had AUC 0.71. The ROC curve for NIRADS for the primary site and lymph nodes combined had AUC 0.756. In our study, the ROC curve for NIRADS at the primary site AUC of 0.860 for the nodal site AUC of 0.780. For the combined NIRADS score, AUC of 0.859.This study concluded that there was a significant association between recurrence and primary/ nodal/ combined tumour site NIRADS on 6 months of follow-up clinical, pathological and /or CECT scans.NIRADS > 3 had the overall highest PPV, NPV and diagnostic accuracy. The performance of NIRADS was good, demonstrating significant discrimination between groups, with overall recurrence rates. In our study, NIRADS 3 showed the highest recurrence rate at primary, nodal and combined sites on 6 months of follow-up.

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