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Original Research Article

Evaluation of metastatic cervical lymph nodes by clinical examination, ultrasonography and diffusion weighted MRI in patient of head and neck squamous cell carcinoma: a prospective study

Awanish Kumar Verma[1]*, Vinit Kumar Sharma[1], Nikunj Jain[1], Yasmeen Usmani[2], Neha Singh[3], Deepti Singh[1]

[1]Department of ENT and Head and Neck Surgery, LLRM Medical College, Meerut, Uttar Pradesh, India
[2]Department of Radiodiagnosis, LLRM Medical College, Meerut, Uttar Pradesh, India
[3]Department of Pathology, LLRM Medical College, Meerut, Uttar Pradesh, India

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***Correspondence:**
Dr. Awanish Kumar Verma,
E-mail: dr.awnishverma@gmail.com

ABSTRACT

Background: Accurate evaluation of cervical lymph node metastasis is essential for staging and management of head and neck cancers. Clinical examination has limited sensitivity in detecting occult disease. Ultrasonography improves assessment through morphological and vascular evaluation, while diffusion-weighted magnetic resonance imaging provides functional information based on tissue cellularity. This study aimed to compare the diagnostic performance of these three modalities.

Methods: This prospective observational study was conducted on 50 patients with histopathologically confirmed head and neck carcinoma over a period of 18 months. All patients underwent systematic evaluation using clinical examination, ultrasonography, and diffusion-weighted MRI for assessment of cervical lymph nodes. The diagnostic sensitivity of each modality was determined, and apparent diffusion coefficient (ADC) values were quantitatively analyzed.

Results: In this study, the mean age was 54.18±12.16 years, with a male predominance of 44 patients (88%). The most common primary site was the border of tongue in 10 patients (20%). Tobacco use, either alone or in combination with smoking, was the most common risk factor observed. Level II nodes were most frequently involved 89%. The sensitivity of clinical examination, USG, and DW-MRI was 76%, 86%, and 98% respectively. On ultrasonography, loss of fatty hilum was observed in 95% and intranodal necrosis in 93%. DW-MRI demonstrated diffusion restriction in 98%. The mean ADC value was $0.918 \pm 0.077 \times 10^{-3}$ mm²/s, which was statistically significant ($p<0.001$).

Conclusions: DW-MRI demonstrated the highest sensitivity among the evaluated modalities. A combined approach improves detection of metastatic and occult cervical lymph nodes, thereby enhancing diagnostic accuracy.

Keywords: Diffusion-weighted MRI, Cervical lymph nodes, Metastasis, Clinical palpation, Ultrasonography, ADC

INTRODUCTION

Head and neck cancers are among the most common malignancies worldwide, predominantly squamous cell carcinomas of the upper aerodigestive tract.[1,2] Tobacco remains the most significant risk factor, with a large proportion of patients reporting a history of smoking. It contains numerous carcinogenic substances, including polycyclic aromatic hydrocarbons (PAHC) and nitrosamines.[3] Tobacco and alcohol act synergistically, increasing carcinogenic potential beyond either agent alone; this interaction is multiplicative in the oral cavity and additive in the larynx. Smoking cessation markedly decreases the risk of head and neck cancer.[4] The risk of oral cancer declines by nearly 30% within 1-9 years of cessation and by approximately 50% after more than 9 years of abstinence.[5]

Human papillomavirus (HPV), particularly HPV-16, has emerged as an important etiological factor in oropharyngeal cancers, often affecting younger patients.[6,7] Genetic susceptibility also contributes, especially in those with minimal exposure to traditional risk factors.

Cervical lymph node metastasis is a key prognostic factor, significantly influencing staging, treatment planning, and survival. The presence of a single metastatic lymph node is associated with a 5-year survival rate of approximately 50%, whereas contralateral nodal involvement reduces survival to nearly 33%.[8] In oral cancer, regional nodal metastasis significantly worsens prognosis, with overall survival decreasing to around 50%. Bilateral nodal involvement further compromises survival, and the presence of extranodal extension is associated with an additional decline in survival rates.[9]

Malignancy of the oral cavity usually metastasize first to Level I lymph nodes, with subsequent spread to Levels II and III. Tumors of the oropharynx, especially those originating from the tonsil and base of tongue, commonly involve Level II nodes and may exhibit bilateral or contralateral nodal spread. In contrast, cancers of the larynx and hypopharynx predominantly drain to levels II, III, and IV. Clinical examination is the initial assessment but has limited sensitivity. During palpation, nodes are evaluated based on their location, number, size, consistency, surface features, margins, tenderness, and degree of fixation to surrounding structures.

Ultrasonography improves morphological assessment of nodes including parameters such as location, size, shape, number, margins, internal echotexture, presence or absence of fatty hilum, vascularity, calcification and vascularity but is operator-dependent and has limitations in assessing deeper nodal stations as well as in detecting micro metastatic disease.[10,11]

Diffusion-weighted MRI (DW-MRI) evaluates Brownian motion of water molecule and provides quantitative Apparent diffusion coefficient (ADC) values. Metastatic nodes demonstrate restricted diffusion and lower ADC values. ADC serves as a valuable quantitative biomarker for differentiating malignant from benign lymph nodes.[12,13] This study compares the diagnostic accuracy of clinical examination, USG, and DW-MRI.

METHODS

Prospective observational study conducted over 18 months (April 2024-September 2025) in the Department of ENT and Head and Neck surgery, LLRM Medical College, Meerut, Uttarpradesh, India. Fifty patients with biopsy-proven head and neck squamous cell carcinoma were included in the study after informed consent.

Inclusion criteria

Patients aged 18 years and above who were diagnosed with head and neck carcinoma confirmed by histopathology.

Exclusion criteria

Patients with contraindications to Magnetic resonance imaging (MRI) were excluded from the study. In addition, patients who had undergone previous surgery, radiation therapy, or chemotherapy to the head and neck region before imaging were not included. Patients with recurrent disease and those who were unwilling to participate in the study were also excluded.

All patients underwent detailed history taking followed by comprehensive general physical, head and neck examination. Clinical assessment of cervical lymph nodes was performed by palpation with the patient in sitting position and neck slightly flexed. Lymph nodes were evaluated for level, size, number, laterality, consistency, mobility, fixation, matting, and skin involvement. Nodes that were enlarged, hard, and fixed were considered suspicious for metastasis.

All patients underwent ultrasonography (USG) of the neck using a high-resolution linear transducer (7-12 MHz). A systematic evaluation of cervical lymph node levels (I-VI) was performed. Nodes were assessed for morphological characteristics including long- and short-axis diameter, shape (oval/round), margins, presence or absence of fatty hilum, echotexture, intranodal necrosis or cystic change, and vascularity on doppler (hilar, peripheral, or mixed). Round shape, loss of hilum, necrosis, irregular margins, and peripheral/mixed vascularity were considered suggestive of malignancy.

Diffusion-weighted MRI (DW-MRI) was performed on a 1.5 Tesla system with the patient in supine position. Lymph nodes were evaluated for diffusion restriction and necrosis. Apparent diffusion coefficient (ADC) values were calculated by placing regions of interest within the solid component of the node, avoiding necrotic areas, and mean ADC values were recorded. Metastatic nodes were characterized by high signal intensity on DWI, low signal on ADC maps, and reduced ADC values.

All observations were recorded in a structured proforma. Data were analyzed using appropriate statistical software. Quantitative variables were expressed as mean±standard deviation and categorical variables as frequency and percentage. Sensitivity and diagnostic accuracy of clinical examination, USG, and DW-MRI were calculated, and a p value <0.05 was considered statistically significant.

RESULTS

A total of 50 patients were included in the study. The study population showed a predominance in the 41–50-year age group (Table 1). The mean age of 54.18±12.16 years suggests that overall disease burden still lies in the fifth to sixth decade. The presence of 10% cases below 40 years highlights early exposure to risk factors. The age distribution pattern aligns with changing epidemiological trends in India. It also suggests earlier onset due to combined carcinogenic habits.

Table 1: Age distribution.

Age group (years)	Frequency (n)	Percentage (%)
<40	5	10
41-50	20	40
51-60	12	24
61-70	8	16
>70	5	10
Total	50	100

Table 2: Gender distribution.

Gender	Frequency (n)	Percentage (%)
Male	44	88
Female	6	12
Total	50	100

Table 3: Risk factor distribution.

Risk factors	Frequency (n)	Percentage (%)
Tobacco+smoking	26	52
Smoking+alcohol	5	10
Tobacco+smoking+ alcohol	9	18
Tobacco only	5	10
Smoking only	4	8
Alcohol only	0	0
No substance abuse	1	2
Total	50	100

There was a marked male predominance (88%), indicating a strong gender predisposition in head and neck cancers (Table 2). This disparity is likely attributable to higher prevalence of tobacco, smoking, and alcohol consumption among males. Female representation was significantly lower (12%), reflecting comparatively lesser exposure to risk factors.

The most common risk factor combination was tobacco use with smoking, observed in 26 patients (52%). Tobacco use with smoking and alcohol consumption was seen in 9 patients (18%). Smoking with alcohol consumption was noted in 5 patients (10%), while tobacco alone and smoking alone were each observed in 5 (10%) and 4 (8%) patients, respectively. Only 1 patient (2%) had no identifiable risk factor. Combined tobacco use and smoking was the most common risk factor, demonstrating the additive and synergistic effects of multiple carcinogens. Patients with combined exposure, including alcohol, also constituted a significant proportion, further emphasizing cumulative risk. In contrast, isolated habits were less frequently associated with disease occurrence (Table 3).

Table 4: Primary tumor site distribution.

Site	Right (RT)	Left (LT)	Total	Percentage (%)
Lip	1	0	1	2
GBS	1	0	1	2
Buccal mucosa	2	5	7	14
Border of tongue	5	5	10	20
Hard palate	0	1	1	2
Soft palate	1	1	2	4
Retromolar trigone (RMT)	1	1	2	4
Tonsillar fossa	2	1	3	6
Base of tongue (BOT)	6	3	9	18
Supraglottic	4	3	7	14
Pyriform sinus (PFS)	2	2	4	8
Glottic	3	0	3	6
Total	28	22	50	100

Table 5: Histopathological distribution.

Histopathology	Frequency (n)	Percentage (%)
Well-differentiated SCC	25	50
Moderately differentiated SCC	19	38
Poorly differentiated SCC	6	12
Total	50	100

The most common primary tumor site was the border of the tongue with 10 cases, followed by the base of the tongue with 9 cases and the supraglottic region with 7 cases. The border of the tongue emerged as the most common primary site, followed by the base of tongue, indicating a predominance of tumors arising from the oral cavity and oropharynx. This distribution is likely related to prolonged and direct exposure of these mucosal regions to carcinogenic substances. Buccal mucosa accounted for 7 cases, while the pyriform sinus was observed in 4 cases. Other sites such glottic region and tonsillar fossa were less frequently involved. Overall, lesions were more commonly observed on the right side (28 cases) compared to the left side (22 cases) (Table 4).

Table 6: Nodal laterality.

Node side	Frequency (N)	Percentage (%)
Right	14	28
Left	16	32
Bilateral	8	16
Non palpable	12	24

Table 7: Nodal level involvement.

Neck level	Frequency (N)	Percentage (%)
Level 1	15	39
Level 2	34	89
Level 3	17	44
Level 4	6	15
Level 5	2	5

The majority of patients had well-differentiated squamous cell carcinoma, accounting for 50% of the cases. Moderately differentiated squamous cell carcinoma was observed in 38% of patients, while poorly differentiated squamous cell carcinoma constituted 12% of the cases. This indicates that well-differentiated tumors were the most common histopathological type in the study population (Table 5).

Table 8: Ultrasonographic findings.

Parameters	Frequency (N)	Percentage (%)
Loss of hilum	41	95
Heterogeneous echotexture	18	41
Hypoechoic echotexture	23	53
Homogenous echotexture	2	4
Necrosis	40	93
Peripheral vascularity	11	25
Mixed vascularity	30	69
Central vascularity	2	4

The left side (32%) was the most commonly involved nodal side, followed closely by the right side (28%). Bilateral involvement (16%) suggests advanced or cross-midline disease. A significant proportion (24%) had clinically impalpable nodes indicating the presence of occult metastasis. This finding highlights the limitation of clinical examination in detecting early nodal disease. Right and left-sided nodal involvement were comparable, suggesting no side predilection (Table 6). Level II lymph nodes were the most frequently involved (89%), demonstrating their role as the principal nodal basin for lymphatic drainage of the oral cavity, particularly in buccal mucosa carcinoma. Level I involved in 39% and Level III nodes were involved in 44% of cases in contrast, involvement of level IV (15%) and level V (5%) was relatively infrequent and is typically associated with more advanced disease or extensive nodal dissemination (Table 7).

On ultrasonography, Loss of hilum (95%) and necrosis (93.0%) were the most frequently observed ultrasonographic features strongly indicating metastatic involvement. Mixed vascularity (69%) and hypoechoic echotexture (53%) were also commonly seen. In contrast, heterogeneous echotexture (41%) and peripheral vascularity (25%) were less frequent, while homogeneous echotexture and central vascularity (4%) were the least observed findings (Table 8).

Table 9: DW-MRI findings.

Restricted diffusion	Frequency (N)	Percentage (%)
Present	49	98
Absent	1	2
Total	50	100

DW-MRI detected necrosis in 48 patients (98%), while only 1 patient (2%) showed no necrosis. This reflects increased cellular density and reduced extracellular space in malignant tissue.

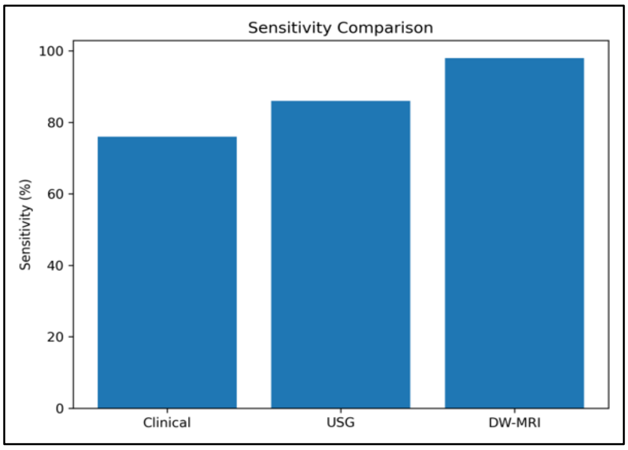

Figure 1: Bar graph showing sensitivity comparison.

The near-universal presence of diffusion restriction highlights its diagnostic reliability. The minimal number of negative cases suggests very low false-negative rates. DW-MRI provides functional information beyond conventional imaging. It is especially useful in identifying early metastatic change. This suggests that MRI identified nodal necrosis in almost all cases in the study population (Table 9). DW-MRI demonstrated the highest sensitivity (98%) in detecting metastatic neck nodes, followed by ultrasonography (86%) and clinical examination (76%). This indicates that DW-MRI is the most sensitive modality among the three, with clinical examination being the least sensitive (Figure 1).

DISCUSSION

Cervical lymph node metastasis is one of the most important prognostic factors in head and neck cancer. The presence of nodal involvement has been associated with a reduction in survival by nearly 50%. The tendency for early lymphatic spread in these cancers is attributed to the rich lymphatic network of the head and neck region. Accurate evaluation of cervical lymph node status is essential in patients with head and neck cancer, as it directly impacts staging, therapeutic decisions, and prognosis.

Nodal involvement increases the likelihood of both regional recurrence and distant metastasis, thereby adversely affecting outcomes. Even small metastatic deposits, including micro metastasis, can alter treatment planning by influencing decisions regarding surgical extent, neck dissection, and the use of adjuvant therapies such as radiotherapy or chemotherapy.

The present study demonstrates that DW-MRI has superior diagnostic performance compared to clinical examination and ultrasonography in detecting metastatic cervical lymph nodes. Clinical examination showed limited sensitivity (76%), particularly in detecting occult metastasis. A significant proportion of patients had non-palpable nodes, highlighting its limitations. Study by Haberal et al showed that clinical palpation had limited sensitivity (64%).[14] Also study by Hallur et al showed that clinical examination demonstrated relatively high accuracy (87.77%) but low sensitivity (41.66%), highlighting its limitations in detecting occult metastasis.[15]

Ultrasonography improved detection (86%) by evaluating nodal morphology. Loss of hilum and necrosis were strong indicators of malignancy. However, USG failed to detect small or deep nodes in some cases, reflecting its limitations. Jank et al reported a sensitivity of 71% and specificity of 87% for ultrasonography, particularly in detecting smaller metastatic nodes.[16] Study by Rottey et al ultrasonography demonstrated better sensitivity (65.8%) and specificity (83%), suggesting that USG adds value over clinical examination, especially for non-palpable nodes. DW-MRI showed the highest sensitivity (98%), attributed to its ability to detect microstructural changes. Restricted diffusion reflects increased cellularity, a hallmark of malignancy. Study by Vandecaveye V et al showed that DWI was particularly effective in identifying sub-centimeter nodes that were clinically occult and morphologically indeterminate.[17]

ADC values provided quantitative support. Lower ADC values were significantly associated with malignancy, making it a reliable biomarker. Previous study by Seber et al demonstrated ADC cut-off value of 0.8×10^{-3} mm^2/s for malignancy. Using this cut-off, DWI demonstrated good specificity (85.7%) but moderate sensitivity (76.4%). This reduces dependence on subjective assessment.[18] DW-MRI was particularly effective in detecting sub-centimetric and occult nodes, which are often missed by conventional methods. A multimodal approach combining clinical examination, USG, and DW-MRI provides the best diagnostic accuracy.

CONCLUSION

The present study highlights the pivotal role of accurate cervical lymph node assessment in the management of head and neck cancers. Clinical examination, although indispensable as an initial and readily available tool, demonstrated limited sensitivity and failed to detect a significant proportion of occult metastatic lymph nodes. Ultrasonography improved diagnostic accuracy through detailed morphological evaluation, particularly with features such as loss of fatty hilum and intranodal necrosis; however, it remained limited in identifying small, deep-seated, and early metastatic nodes.

Diffusion-weighted magnetic resonance imaging (DW-MRI) emerged as the most sensitive modality in this study, demonstrating superior diagnostic performance compared to both clinical examination and ultrasonography. Its ability to detect microstructural changes related to tumour cellularity allows identification of metastatic involvement even in sub-centimetric lymph nodes that appear morphologically normal on conventional imaging. The quantitative assessment provided by Apparent diffusion coefficient (ADC) values further enhances diagnostic confidence, with significantly lower ADC values reliably correlating with malignancy. The findings of this study highlight that reliance on a single diagnostic modality may lead to underestimation of nodal disease.

A multimodal approach integrating clinical examination, ultrasonography, and DW-MRI provides a more comprehensive and accurate evaluation of cervical lymph node status. Incorporation of DW-MRI into routine diagnostic protocols has the potential to improve staging accuracy, guide appropriate therapeutic decision-making, and reduce both undertreatment and unnecessary surgical interventions.

In conclusion, DW-MRI, with its high sensitivity and ability to provide functional as well as quantitative information, represents a valuable addition to the diagnostic armamentarium in head and neck oncology. Its routine use, particularly in cases with clinically or radiologically equivocal findings, can significantly enhance detection of metastatic cervical lymph nodes and contribute to improved patient outcome.

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