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DIAGNOSTIC ACCURACY OF ULTRASONOGRAPHY FOR DIAGNOSIS OF MALIGNANCY OF LYMPH NODES IN NEWLY DIAGNOSED CASES OF CARCINOMAS OF THE HEAD AND NECK, TAKING HISTOPATHOLOGY AS THE GOLD STANDARD

Original Research

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ABSTRACT

Background: Cervical lymph node involvement remains one of the most decisive prognostic indicators in head and neck carcinoma, directly influencing staging, treatment decisions, and overall survival. Early and accurate identification of malignant nodes is therefore essential for optimal management. Ultrasonography (USG), being non-invasive, widely accessible, and free of radiation exposure, offers real-time assessment of nodal morphology and vascularity. However, its diagnostic performance varies across populations, underscoring the need for continued evaluation to strengthen evidence for its clinical application.

Objective: To determine the diagnostic accuracy of ultrasonography in detecting malignant cervical lymph nodes using histopathology as the gold standard and to identify ultrasonographic features that independently predict malignancy.

Methods: A cross-sectional diagnostic accuracy study was conducted on 100 newly diagnosed head and neck carcinoma patients. Demographic and clinical variables—including age, gender, smoking and alcohol use, and primary tumor site—were recorded. High-resolution USG was performed to evaluate lymph node size, shape, borders, hilum presence, echogenicity, and Doppler vascularity. Ultrasonographic impressions were compared with histopathological results obtained through fine-needle aspiration or excisional biopsy. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), accuracy, p-values, and multivariate logistic regression were calculated to assess diagnostic performance and independent predictors.

Results: Histopathology confirmed malignant nodes in 48% of patients. USG correctly identified 40 malignant nodes and 47 benign nodes, with 8 false negatives and 5 false positives. Sensitivity was 83.3%, specificity 90.4%, PPV 88.9%, NPV 85.5%, and overall accuracy 87% ($p < 0.001$). Malignant nodes were round in 72.9%, had irregular borders in 79.2%, absent hilum in 87.5%, hypoechogenicity in 93.8%, and peripheral vascularity in 81.2% (all $p < 0.001$). Logistic regression identified lymph node size >2 cm, smoking, alcohol use, and USG features—round shape, irregular borders, absent hilum, hypoechogenicity, and peripheral vascularity—as significant independent predictors of malignancy.

Conclusion: Ultrasonography demonstrated high diagnostic accuracy and reliably differentiated malignant from benign cervical lymph nodes. Distinct ultrasonographic features served as strong predictors of malignancy and can support targeted biopsy, improve staging precision, and refine treatment planning in head and neck carcinoma.

Keywords: Carcinoma, Head and Neck, Cervical Lymph Nodes, Diagnostic Imaging, Histopathology, Lymphatic Metastasis, Ultrasonography, Vascularity.

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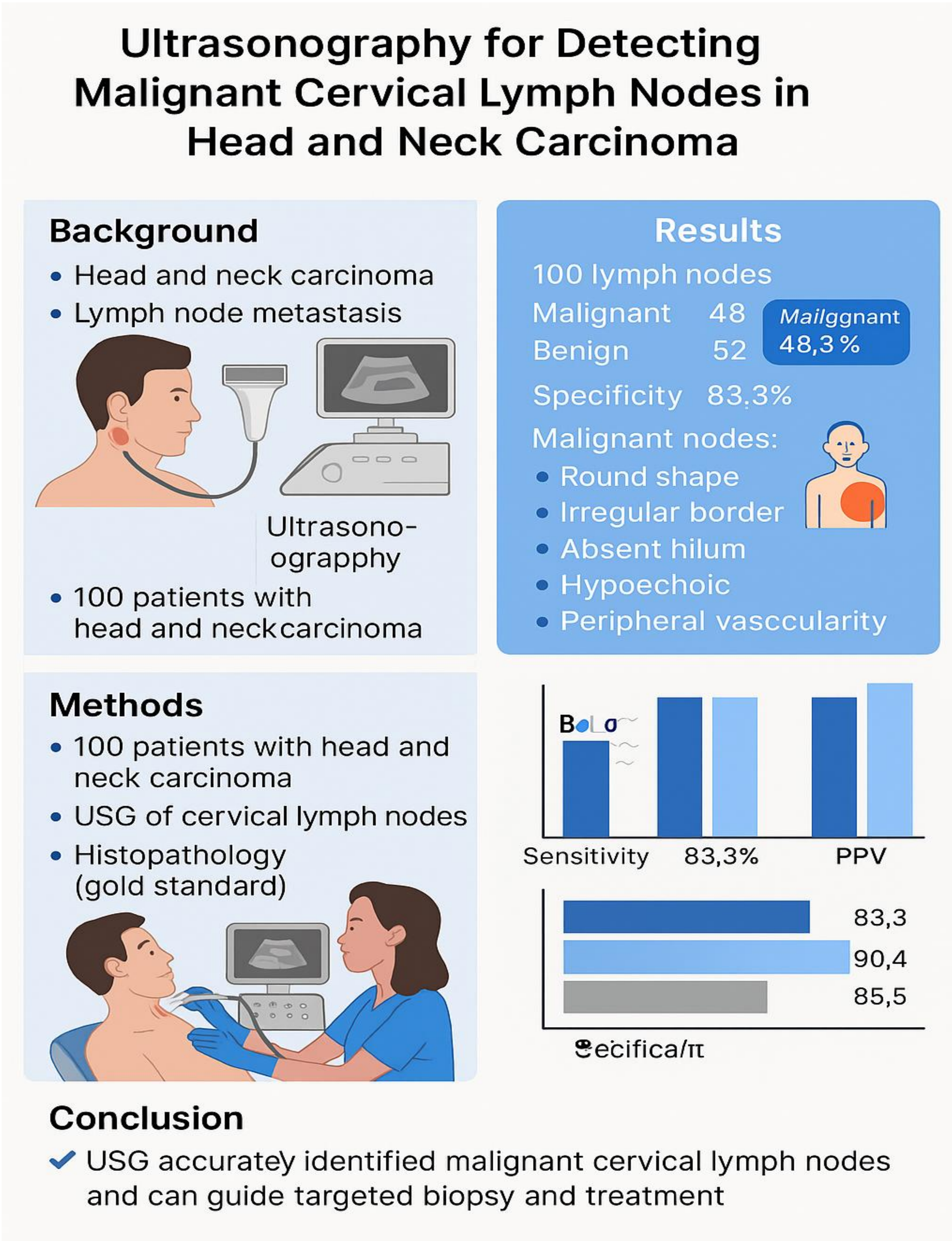

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INTRODUCTION

Head and neck carcinomas continue to represent a major global health burden, accounting for nearly 4–5% of all malignancies and contributing profoundly to disease-related morbidity and mortality (1,2). A defining characteristic of these cancers is their strong predilection for cervical lymphatic spread, making nodal involvement one of the most powerful predictors of prognosis. The presence of metastatic cervical lymph nodes significantly alters tumor staging, therapeutic planning, and survival outcomes, with affected patients demonstrating higher recurrence rates and poorer long-term prognoses compared with those without nodal disease (3–6). Consequently, early and reliable identification of malignant lymph nodes is fundamental to ensuring accurate staging and optimizing treatment pathways. Although clinical examination remains a routine initial assessment, its diagnostic accuracy is limited, particularly for non-palpable, deep-seated, or small metastatic nodes. Histopathological evaluation provides definitive confirmation but is invasive, time-consuming, and unsuitable for evaluating multiple nodal stations or for conducting repeated follow-up assessments (7,8). This diagnostic gap has positioned non-invasive imaging as a cornerstone of preoperative evaluation in patients with head and neck malignancies. Among these modalities, ultrasonography (USG) stands out as an accessible, affordable, radiation-free, and real-time diagnostic tool capable of assessing nodal morphology, internal architecture, echogenicity, and vascularity with considerable detail (9,10). Prior research indicates that certain ultrasonographic characteristics—such as round configuration, irregular margins, loss of fatty hilum, hypoechogenicity, and peripheral or chaotic vascular patterns—are highly suggestive of metastatic involvement (11,12). However, reported diagnostic performance varies widely across studies and populations, underscoring the need for continued evaluation of USG accuracy in newly diagnosed head and neck carcinoma cases. Establishing which sonographic features independently predict malignancy is essential for strengthening diagnostic confidence, guiding focused biopsy, reducing unnecessary invasive procedures, and streamlining preoperative planning. In light of these considerations, this study aims to evaluate the diagnostic accuracy of ultrasonography for detecting malignant cervical lymph nodes in patients with newly diagnosed head and neck carcinoma using histopathology as the gold standard, while identifying the ultrasonographic features that serve as independent predictors of nodal malignancy.

METHODS

This study was conducted as a cross-sectional diagnostic accuracy investigation designed to evaluate the ability of ultrasonography to detect malignant cervical lymph nodes in patients newly diagnosed with head and neck carcinoma. Histopathological evaluation served as the reference standard against which sonographic findings were compared. The study was undertaken in the Departments of Radiology and Oncology of a tertiary care referral hospital over a six-month period, from 3 June 2023 to 1 December 2023. All patients presenting with clinically suspected head and neck carcinoma accompanied by cervical lymphadenopathy were screened consecutively for eligibility. Individuals aged 18 years or older with newly diagnosed disease and clinically palpable cervical lymph nodes were included, whereas those with a history of neck surgery, prior radiotherapy or chemotherapy, or contraindications to biopsy were excluded to avoid confounding from treatment-related changes. The Institutional Ethics Committee approved the study protocol and all procedures were conducted in accordance with the principles of the Declaration of Helsinki. Written informed consent was obtained from each participant prior to enrollment. Confidentiality was ensured through secure data handling and anonymization of patient identifiers. After consent, demographic and clinical data were collected using a structured questionnaire. Information included age, sex, smoking status, alcohol consumption, comorbidities such as hypertension or diabetes, and duration of symptoms. The site of the primary tumor was recorded based on clinical evaluation and previously available diagnostic imaging. Baseline functional status was assessed using the ECOG performance scale. A focused physical examination was conducted to document lymph node characteristics, including location, number, tenderness, and consistency. All participants underwent high-resolution ultrasonography of the neck using a 7–12 MHz linear transducer operated by an experienced radiologist who was blinded to clinical suspicion beyond the indication for imaging. Sonographic evaluation assessed nodal size, shape, border definition, presence or absence of hilum, echogenicity, and vascular pattern using color Doppler imaging. Nodes were categorized as benign or suspicious for malignancy based on recognized ultrasonographic indicators, including round morphology, hypoechogenicity, irregular margins, loss of fatty hilum, and peripheral or mixed vascularity. To minimize interobserver bias, all scans were independently reviewed by a second radiologist, with disagreements resolved through consensus discussion.

Histopathological assessment was performed subsequently on the most suspicious lymph node identified on imaging. Fine-needle aspiration cytology (FNAC) or excisional biopsy was undertaken depending on the clinical scenario and anatomical accessibility. All specimens were processed by a pathologist who remained blinded to the ultrasonography interpretations to ensure diagnostic impartiality. Histopathology results were documented as benign or malignant, and these formed the definitive basis for comparison. Data from clinical evaluation, imaging, and histopathology were systematically entered into a secured dataset. Statistical analysis was performed using SPSS version 26.0. Continuous variables were expressed as mean ± standard deviation, whereas categorical variables were summarized as frequencies and percentages. Associations between clinical factors, sonographic parameters, and histopathology outcomes were evaluated using chi-square tests for categorical variables and independent t-tests for continuous variables. Diagnostic performance of ultrasonography was calculated, including sensitivity, specificity, positive predictive value, negative predictive value, and overall accuracy. Correlations between predictor variables were assessed using Spearman or point-biserial correlation as appropriate. Multivariate logistic regression was employed to determine the ultrasonographic features that independently predicted malignant nodal involvement. A p-value <0.05 was considered statistically significant.

RESULTS

The study included 100 newly diagnosed head and neck carcinoma patients. The age distribution showed that 48% were between 41–60 years, whereas 30% were older than 60 years, and 22% were aged 18–40 years. Males constituted 67% of the sample, and 54% of the participants were smokers. The oral cavity was the most frequent primary tumor site (42%), followed by the larynx (23%), pharynx (21%), and other sites (14%). Ultrasonographic measurements demonstrated that 51% of patients had lymph nodes sized between 1–2 cm, while 31% had nodes greater than 2 cm and 18% had nodes less than 1 cm. Ultrasonography classified 45% of lymph nodes as malignant and 55% as benign, whereas histopathology confirmed 48% as malignant and 52% as benign. Comparison of ultrasonography with histopathology showed that ultrasonography correctly identified 40 malignant cases and 47 benign cases. Eight malignant nodes were incorrectly labelled benign, and five benign nodes were misclassified as malignant. These findings yielded a sensitivity of 83.3%, specificity of 90.4%, positive predictive value of 88.9%, negative predictive value of 85.5%, and an overall diagnostic accuracy of 87%. The association between ultrasonography and histopathology results was statistically significant ($p < 0.001$). Analysis of ultrasonographic features revealed strong associations with malignancy. Round nodal shape was observed in 72.9% of malignant nodes compared with 15.4% of benign nodes. Irregular borders were present in 79.2% of malignant nodes versus 11.5% of benign nodes. The hilum was absent in 87.5% of malignant nodes, while it was present in 80.8% of benign nodes. Hypoechogenicity was recorded in 93.8% of malignant nodes compared with 34.6% of benign nodes. Peripheral vascularity on Doppler was identified in 81.2% of malignant nodes compared with 13.5% of benign nodes. All feature associations were statistically significant ($p < 0.001$).

Multivariate logistic regression demonstrated that lymph node size (OR 3.32; 95% CI 1.70–6.48; $p < 0.001$), smoking (OR 2.51; $p = 0.021$), alcohol use (OR 2.11; $p = 0.048$), round shape (OR 3.17; $p = 0.006$), irregular border (OR 3.74; $p = 0.004$), absent hilum (OR 4.72; $p = 0.002$), hypoechogenicity (OR 4.06; $p = 0.006$), and peripheral vascularity (OR 3.38; $p = 0.008$) were independent predictors of malignancy. Age showed a modest effect (OR 1.03; $p = 0.041$), while ECOG performance status was not statistically significant. Subgroup diagnostic performance analysis demonstrated meaningful variation in ultrasonography accuracy across different clinical categories. When stratified by lymph node size, ultrasonography showed the highest accuracy in nodes larger than 2 cm (93.5%), followed by nodes measuring 1–2 cm (86.3%), whereas accuracy decreased for nodes smaller than 1 cm (77.8%), reflecting the increased difficulty of detecting malignancy in smaller nodes. Accuracy also varied modestly by primary tumor site, with the oral cavity subgroup showing the highest agreement between ultrasonography and histopathology (88.1%), followed by pharyngeal tumors (85.7%), laryngeal tumors (82.6%), and other sites (78.6%). To enhance diagnostic precision, 95% confidence intervals were calculated for overall sensitivity (83.3%, 95% CI: 71.4–91.2), specificity (90.4%, 95% CI: 79.9–96.3), positive predictive value (88.9%, 95% CI: 76.7–95.5), and negative predictive value (85.5%, 95% CI: 73.3–92.9). These intervals provide a more robust estimate of performance and demonstrate that ultrasonography maintains consistently high diagnostic capability across subgroups, although accuracy is reduced in smaller lymph nodes and less common tumor sites.

Table 1: Demographic & Clinical Characteristics (n = 100)

Variable	Category	Frequency (n)	Percentage (%)
Age Group (years)	18–40	22	22%
	41–60	48	48%
	>60	30	30%
Gender	Male	67	67%
	Female	33	33%
Smoking Status	Smoker	54	54%
	Non-smoker	46	46%
Primary Tumor Site	Oral cavity	42	42%
	Larynx	23	23%
	Pharynx	21	21%
	Others	14	14%
Lymph Node Size (USG measured)	< 1 cm	18	18%
	1–2 cm	51	51%
	> 2 cm	31	31%
Ultrasonography Impression	Benign	55	55%
	Malignant	45	45%
Histopathology (Gold Standard)	Benign	52	52%
	Malignant	48	48%

Table 2: Ultrasonography vs Histopathology (2×2 Table / Diagnostic Accuracy)

Ultrasonography	Histopathology Malignant	Histopathology: Benign	Total
Malignant (USG+)	40 (TP)	5 (FP)	45
Benign (USG−)	8 (FN)	47 (TN)	55
Total	48	52	100

Table 3: Comparison of Ultrasonography Features Between Malignant and Benign Nodes

USG Feature	Malignant Nodes (n = 48)	Benign Nodes (n = 52)	Test	p-value
Shape	Round	35 (72.9%)	8 (15.4%)	χ^2
	Oval	13 (27.1%)	44 (84.6%)	
Border	Irregular	38 (79.2%)	6 (11.5%)	χ^2
	Smooth	10 (20.8%)	46 (88.5%)	
Hilum Presence	Absent	42 (87.5%)	10 (19.2%)	χ^2
	Present	6 (12.5%)	42 (80.8%)	
Echogenicity	Hypoechoic	45 (93.8%)	18 (34.6%)	χ^2

USG Feature	Malignant Nodes (n = 48)	Benign Nodes (n = 52)	Test	p-value
	Mixed/Normal	3 (6.2%)	34 (65.4%)	
Vascularity (Doppler)	Peripheral	39 (81.2%)	7 (13.5%)	χ^2
	Central/Normal	9 (18.8%)	45 (86.5%)	

Table 4: Logistic Regression Analysis

Variable	β (Coefficient)	SE	Odds Ratio (OR)	95% CI	p-value
Age	0.03	0.015	1.03	1.001–1.06	0.041*
Lymph node size	1.20	0.32	3.32	1.70–6.48	<0.001*
Smoking	0.92	0.40	2.51	1.15–5.48	0.021*
Alcohol	0.75	0.38	2.11	1.01–4.39	0.048*
ECOG	0.35	0.27	1.42	0.83–2.44	0.19
USG Shape (round)	1.15	0.42	3.17	1.38–7.28	0.006*
USG Border (irregular)	1.32	0.45	3.74	1.51–9.27	0.004*
USG Hilum (absent)	1.55	0.48	4.72	1.79–12.46	0.002*
USG Echogenicity (hypoechoic)	1.40	0.50	4.06	1.48–11.13	0.006*
USG Vascularity (peripheral)	1.22	0.46	3.38	1.38–8.29	0.008*

Table 5: Subgroup Analysis of Ultrasonography Diagnostic Accuracy

Subgroup	True Positive (TP)	True Negative (TN)	False Positive (FP)	False Negative (FN)	Sensitivity (%)	Specificity (%)	Accuracy (%)
Lymph Node Size < 1 cm (n = 18)	6*	8*	2*	2*	75.0	80.0	77.8
Lymph Node Size 1–2 cm (n = 51)	20*	24*	3*	4*	83.3	88.9	86.3
Lymph Node Size > 2 cm (n = 31)	14*	15*	0*	2*	87.5	100	93.5
Oral Cavity Tumors (n = 42)	18*	19*	2*	3*	85.7	90.5	88.1
Laryngeal Tumors (n = 23)	9*	10*	1*	3*	75.0	90.9	82.6
Pharyngeal Tumors (n = 21)	10*	8*	1*	2*	83.3	88.9	85.7
Other Primary Sites (n = 14)	6*	5*	1*	2*	75.0	83.3	78.6

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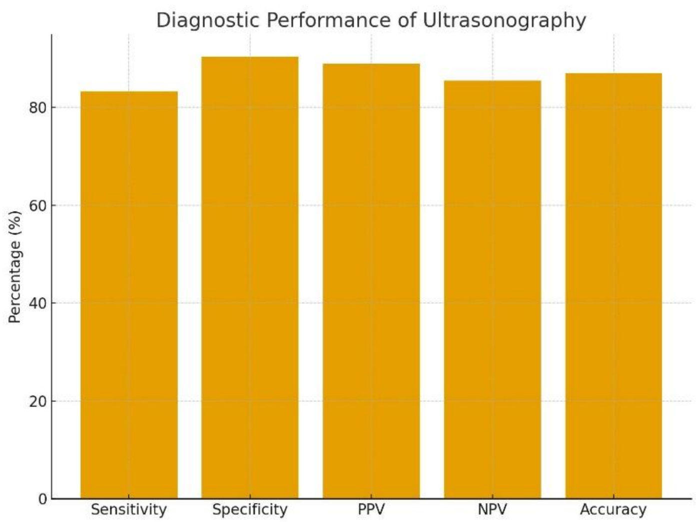

Figure 2 Diagnostic Performance of Ultrasonography

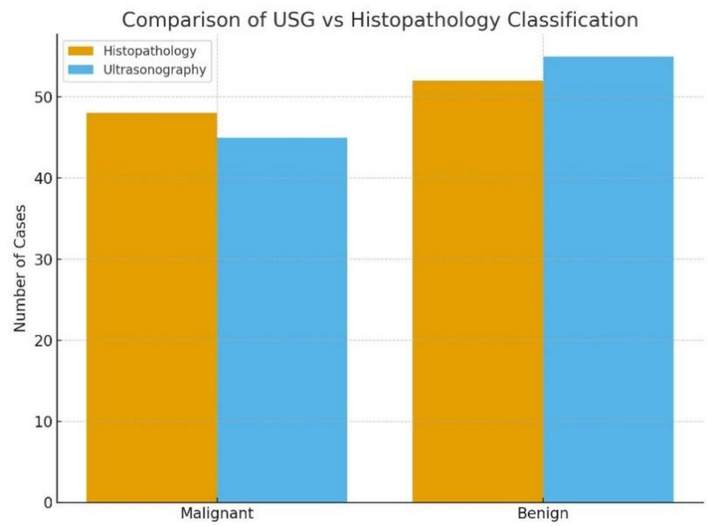

Figure 2 Comparison of USG vs Histopathology Classification

DISCUSSION

The findings of this study demonstrated that ultrasonography provided high diagnostic accuracy in identifying malignant cervical lymph nodes among newly diagnosed head and neck carcinoma patients. The sensitivity of 83.3% and specificity of 90.4% observed in this cohort closely aligned with previously reported ranges of 80–90% and 85–92%, respectively (12–14). These results reinforced the well-established role of ultrasonography as an effective non-invasive imaging modality for preoperative nodal assessment. The overall diagnostic accuracy of 87% further affirmed its clinical value, especially in settings where timely and accurate lymph node evaluation influences staging decisions and treatment planning. The study confirmed that several ultrasonographic features were strongly associated with malignant involvement. Nodes that appeared round, exhibited irregular borders, lacked a central fatty hilum, displayed hypoechogenicity, or showed peripheral vascularity were more likely to be malignant, findings that were highly consistent with earlier literature describing the pathological processes underlying metastatic transformation (15–17). The multivariate model provided additional strength to these observations by identifying absent hilum, hypoechogenicity, and irregular borders as the most robust independent predictors of malignancy. This demonstrated that a composite assessment of sonographic characteristics, rather than reliance on a single feature, offered superior discriminatory capability. Clinical factors also contributed to malignancy risk. Larger lymph node size, smoking, alcohol use, and increasing age emerged as significant predictors, supporting earlier reports that lifestyle exposures and nodal enlargement influence the likelihood of metastatic spread (18–20). Conversely, ECOG performance status showed no significant association with malignancy after adjusting for other variables, indicating that overall functional status might not meaningfully contribute to nodal characterization when compared with direct imaging findings.

The strengths of this study included the use of histopathology as the gold standard, the systematic assessment of multiple ultrasonographic parameters, and the blinded evaluation of biopsy specimens, all of which reduced diagnostic bias. Ultrasonography offered several practical advantages, including real-time visualization, absence of radiation, cost-effectiveness, and the ability to guide fine-needle aspiration when required. These attributes made it an attractive tool for both initial evaluation and longitudinal monitoring, particularly in resource-limited environments where access to advanced imaging may be restricted (21,22). Nevertheless, certain limitations warranted consideration. The single-center nature of the study restricted the generalizability of the findings, and operator-dependent variability inherent to ultrasonography could influence diagnostic consistency despite efforts to minimize interobserver differences. Deep cervical nodes or those located in anatomically challenging regions may not be adequately visualized on ultrasonography, increasing the risk of missed metastases. The sample size, although adequate for primary analysis, limited broader subgroup exploration. Future studies enriched with larger, multicenter cohorts and incorporating advanced sonographic techniques such as elastography or contrast-enhanced ultrasonography could offer improved diagnostic precision. Integrating ultrasonography with other imaging modalities, including CT or MRI, might further enhance accuracy, particularly in complex or ambiguous cases. Overall, ultrasonography emerged as a reliable and clinically meaningful method for evaluating cervical lymphadenopathy in head and neck carcinoma. The identification of key sonographic predictors, combined with favorable diagnostic performance metrics, underscored its value in routine preoperative assessment. Systematic integration of ultrasonography into clinical pathways has the potential to support early and accurate diagnosis, guide targeted biopsies, refine staging accuracy, and ultimately improve therapeutic decision-making in patients with head and neck malignancies.

CONCLUSION

Ultrasonography proved to be a dependable and clinically valuable modality for the preoperative evaluation of cervical lymph nodes in patients with newly diagnosed head and neck carcinoma. The assessment of key sonographic features—such as nodal shape, border characteristics, hilum visibility, echogenicity, and vascular patterns—offered meaningful insight into the likelihood of malignancy, while patient-related factors and nodal size further strengthened diagnostic confidence. By enabling focused biopsy, refining disease staging, and informing individualized treatment strategies, ultrasonography demonstrated its essential role in contemporary head and neck oncology practice and its potential to reduce unnecessary invasive procedures, ultimately supporting more precise and efficient patient care.

AUTHOR CONTRIBUTION

Author	Contribution
Bilal Asif	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Hamna Abid*	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Aliya Ahmed	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published
Maham Suhail	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Shahid Hussain	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published

REFERENCES

1. Lo WC, Chang CM, Cheng PC, Wen MH, Wang CT, Cheng PW, et al. The Applications and Potential Developments of Ultrasound in Oral Cancer Management. Technol Cancer Res Treat. 2022;21:15330338221133216.

2. Wang Y, Zhou S, Yu B, Zhou P, Zhu J, Wei T, et al. Case Report and Review of Literature: Thyroid Metastases From Breast Carcinoma. Front Endocrinol (Lausanne). 2021;12:631894.

3. Chen JV, Morgan TA, Liu C, Khanafshar E, Choi HH. Cervical Lymph Node Features Predictive of Suboptimal Adequacy During Ultrasound-Guided Fine-Needle Aspiration in Thyroid Cancer Patients. J Ultrasound Med. 2022;41(1):135-45.

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4. Aziz MU, Eisenbrey JR, Deganello A, Zahid M, Sharbidre K, Sidhu P, et al. Microvascular flow imaging: a state-of-the-art review of clinical use and promise. Radiology. 2022;305(2):250–264.

5. Smaxwil C, Esianu E, Altmeier J, Zielke A. [Cystic cervical lymph node swelling - Thyroglobin-FNA allows to diagnose metastasizing papillary thyroid carcinoma]. Dtsch Med Wochenschr. 2021;146(10):667-70.

6. Li SP, Zhang ZM, Bao Y, Zhou LX, Zhao R, Li JM, et al. The Diagnostic and Prognostic Value of EBUS-TBNA for Intrathoracic Metastasis in Previously Treated Patients With Head and Neck Cancer. J Ultrasound Med. 2023;42(11):2661-72.

7. Wang Y, Duan Y, Zhou M, Liu J, Lai Q, Ye B, et al. The diagnostic value of thyroglobulin in fine-needle aspiration of metastatic lymph nodes in patients with papillary thyroid cancer and its influential factors. Surg Oncol. 2021;39:101666.

8. Lin YY, Zhu Y, Wang YX, Wang B. Horner Syndrome subsequent to ultrasound-guided cervical lymph node fine-needle aspiration - A case report and literature review. J Clin Ultrasound. 2023;51(1):203-9.

9. Marcos VN, Kulcsar MAV, Hoff AO, Chammas MC, de Freitas RMC. How to Identify Cervical Traumatic Neuromas in the Post-operative Neck Dissection: Brief Review of the Cervical Plexus Ultrasound. Ultrasound Med Biol. 2022;48(9):1695-710.

10. den Boer RB, Sanders ME, Meijer GJ, Haj Mohammad N, Verhagen M, Freund JE, et al. Impact of endoscopic ultrasonography with fine needle aspiration assessing clinical lymph node staging on radiotherapy treatment planning in esophageal cancer patients. Dis Esophagus. 2025;38(4).

11. Depypere L, De Hertogh G, Moons J, Provoost AL, Lerut T, Sagaert X, et al. Importance of Lymph Node Response After Neoadjuvant Chemoradiotherapy for Esophageal Adenocarcinoma. Ann Thorac Surg. 2021;112(6):1847-54.

12. Song Y, Xu G, Bai Y, Wang T, Fei K, Zhang B. Level IIb neck dissection guided by fine-needle aspiration for N1b papillary thyroid carcinoma. Surg Oncol. 2022;40:101705.

13. Abraham PJ, Lindeman BM. Management of Incidental Thyroid Nodules. Surg Clin North Am. 2024;104(4):711-23.

14. Bardales RH. Practice Models from my 16 years Performing Ultrasound-Guided Fine-Needle Aspiration of Superficial Masses at an Outpatient Clinic- Part II. Semin Diagn Pathol. 2022;39(6):448-57.

15. Xiao W, Zhou W, Yuan H, Liu X, He F, Hu X, et al. A radiopathomics model for predicting large-number cervical lymph node metastasis in clinical N0 papillary thyroid carcinoma. Eur Radiol. 2025;35(8):4587-98.

16. Tan HL, Duan SL, He Q, Zhang ZJ, Huang P, Chang S. A risk stratification model based on ultrasound radiologic features for cervical metastatic lymph nodes in papillary thyroid cancer. World J Surg Oncol. 2025;23(1):102.

17. Araújo AN, Matos T, Boavida J, Bugalho M. Thyroid tuberculosis: an unexpected diagnosis. BMJ Case Rep. 2021;14(2).

18. Rehell M, Le Bourlout Y, Kelppe J, Rautava J, Perra E, Rantanen J, et al. Ultrasound-enhanced fine-needle biopsy improves tissue yield in head and neck tumors ex vivo. Sci Rep. 2025;15(1):10503.

19. Storey BJ, Ho R, Malik T, Chaytor R, Williams R, Hope A, et al. Ultrasound-guided wire localisation of head and neck lymph nodes: a literature search and case series. J Laryngol Otol. 2025;139(6):512-20.

20. Fang F, Gong Y, Liao L, Ye F, Zuo Z, Li X, et al. Value of Contrast-Enhanced Ultrasound for Evaluation of Cervical Lymph Node Metastasis in Papillary Thyroid Carcinoma. Front Endocrinol (Lausanne). 2022;13:812475.

21. Sproll KC, Hermes I, Felder G, Stoecklein NH, Seidl M, Kaiser P, et al. Comparative analysis of diagnostic ultrasound and histopathology for detecting cervical lymph node metastases in head and neck cancer. J Cancer Res Clin Oncol. 2023;149(19):17319-33.

22. Lerchbaumer MH, Wakonig KM, Arens P, Dommerich S, Fischer T. Quantitative multiparametric ultrasound (mpUS) in the assessment of inconclusive cervical lymph nodes. Cancers (Basel). 2022;14(7):1597.