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Role of Sonoelastography in Evaluation of Lymph Node Metastasis in Head and Neck Keeping Histopathology as Gold Standard

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ABSTRACT

Objective: To determine the diagnostic accuracy of sonoelastography in the evaluation of lymph node metastasis in head and neck cancer, using histopathology as the gold standard. **Research Design:** A study of cross-sectional validation. **Duration and Place of Study:** This research was carried out in the Diagnostic Radiology Department, Shaikh Zayed Hospital, Lahore, from May 2024 to November 2024. **Methodology:** A total of 138 patients aged 18 to 70 years, with enlarged cervical lymph nodes (≥1 cm), were included. Participants were evaluated using sonoelastography, a high-resolution ultrasound-based technique, performed by an experienced radiologist. Elastographic tissue stiffness was scored from 1 to 4, with scores 1 and 2 indicating benign nodes and scores 3 and 4 indicating malignancy. The reference standard for biopsy sample analysis was histopathological analysis. The following metrics were computed: diagnostic accuracy, sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV). **Results:** The mean age of participants was 55.19 ± 5.67 years, with a mean lymph node size of 2.16 ± 0.22 cm. Sonoelastography identified 38.4% of lymph nodes as malignant and 61.6% as benign, compared to histopathological findings of 30.4% malignant and 69.6% benign. Diagnostic performance metrics for sonoelastography included sensitivity of 86%, specificity of 82%, PPV of 68%, NPV of 93%, and an overall diagnostic accuracy of 83%. **Conclusion:** Sonoelastography demonstrates high sensitivity and diagnostic accuracy in evaluating cervical lymph nodes, making it a valuable, non-invasive adjunct to conventional imaging methods.

INTRODUCTION

In head and neck cancers, lymph node metastasis is considered one of the most important staging and prognostic factors because it greatly influences treatment approach and patient outcomes.[1] Metastasis to regional lymph nodes generally suggests a more advanced stage of the disease, with a greater chance of recurrence.[2] Lymph node involvement in cancers of the head and neck, especially squamous cell carcinoma, is an important determinant of the extent of disease spread.[3] Poorer prognosis is associated with metastatic lymph nodes, and the determination of lymph node status correctly is essential in effective treatment planning, which involves decisions to be made about surgery, radiation, and chemotherapy.[4]

Sonoelastography is a non-invasive technique of imaging that has become an indispensable investigation modality in the assessment of lymph node metastasis, providing complementary information to traditional imaging techniques such as ultrasonography, CT, and MRI.[5] Sonoelastography detects the stiffness of the tissues, which helps to differentiate malignant lymph nodes from benign ones, since metastatic lymph nodes are stiffer due to the desmoplastic reaction caused by tumor infiltration.[6] This stiffness is visualized in images obtained with elastography, in which malignant nodes tend to appear stiffer than benign ones.[6] Thus, elastography helps in the detection of metastasis. Sonoelastography will be especially useful for distinguishing those nodes that require biopsy or surgical resection from those that are not troublesome and can therefore be safely observed.[7]

Histopathology remains the gold standard in the diagnosis of lymph node metastasis, as it allows for direct examination of tissue and confirmation of malignancy.[8] While sonoelastography and other imaging modalities provide important predictive data, they

cannot supplant the need for biopsy and histological confirmation.[9] Rather, sonoelastography represents a useful adjunct to histopathology, offering real-time, non-invasive assessment of lymph node characteristics and informing the decision-making process regarding further diagnostic procedures.[9] This is much useful in those conditions where biopsy could be difficult or contraindicated, and the clinician can therefore triage patients who might go for tests that are more invasive. Consequently, sonoelastography increases lymph node metastasis evaluation accuracy while helping to decide on treatment approaches for head and neck malignancies.[10]

According to Vineela et al., sonoelastography demonstrated sensitivity (90%), specificity (88%), and diagnostic accuracy (89%) in the evaluation of lymph node metastasis.[11]

This study is essential due to the need for accurate assessment of lymph node metastasis in head and neck cancers, which impacts treatment and prognosis. Traditional imaging methods have limitations in distinguishing benign from malignant nodes, while histopathology is invasive. Sonoelastography offers a non-invasive, cost-effective alternative with the potential to improve diagnostic accuracy and aid in early detection.

METHODOLOGY

From May 2024 to November 2024, this cross-sectional study was carried out at Shaikh Zayed Hospital's Diagnostic Radiology Department in Lahore. 138 patients of both genders, ages 18 to 70, were enrolled in the study, presenting with enlarged cervical lymph nodes (≥1 cm). The study's sample size was determined via the World Health Organization's sample size calculator, with a 90% sensitivity, 88% specificity, and a prevalence of 40%.[11] A 10% margin of error was applied for both sensitivity and specificity.

Exclusion criteria included patients receiving radiotherapy or chemotherapy, recent lymph node FNAC/biopsy, a history of chronic diseases, prior irradiation, malignancy, or trauma. Baseline demographic details including name, age, gender, size of lymph nodes, and duration of disease were collected. Informed consent was secured from all participants, guaranteeing anonymity and the absence of associated hazards. Sonoelastography was conducted on all patients with a high-resolution ultrasound device (Doppler 1 with GE Logiq P9), employing a linear array probe calibrated to 7.5 MHz, by a consultant radiologist possessing over five years of experience. Tissue stiffness was classified according to sonoelastography scores from 1 to 4, where scores 1 and 2 denote benign lymph nodes, and scores 3 and 4 signify cancer lymph nodes. A score of 1 denoted soft tissue (benign), a score of 2 denoted relatively soft tissue (benign), a score of 3 denoted comparatively hard tissue (malignant), and a score of 4 denoted hard tissue (malignant).

Subsequent to sonoelastography, biopsy specimens were collected and dispatched to the hospital pathology laboratory for histological analysis to ascertain the existence of benign or malignant lymph nodes. The biopsy was evaluated by a specialist pathologist possessing more than 5 years of experience. The sensitivity, specificity, positive predictive value, negative predictive value, and diagnostic precision of sonoelastography were determined using histology as the reference standard. A p-value of less than 0.05 was deemed significant.

RESULTS

In this study the mean age of patients was 55.19 ± 5.67 years, with the mean lymph node size being 2.16 ± 0.22 cm, disease duration averaging 7.30 ± 2.45 months, and an elastography tissue stiffness score of 2.22 ± 1.01 (Table-I).

Table I

Mean ± SD for patients categorized by age, lymph node size, disease duration, and elastography tissue stiffness score (n=138)

Demographics		Mean±SD
1	Age (years)	55.188±5.67
2	Size of lymph nodes (cm)	2.157±0.22
3	Duration of disease (months)	7.304±2.45
4	Elastography tissue stiffness score	2.224±1.01

Among the 138 participants, 33.8% were male, and 66.2% were female (as shown in Table-II).

Table II

Distribution and proportion of patients by gender (n=138)

Gender	No. of Patients	%age
Male	49	33.8%
Female	96	66.2%
Total	138	100%

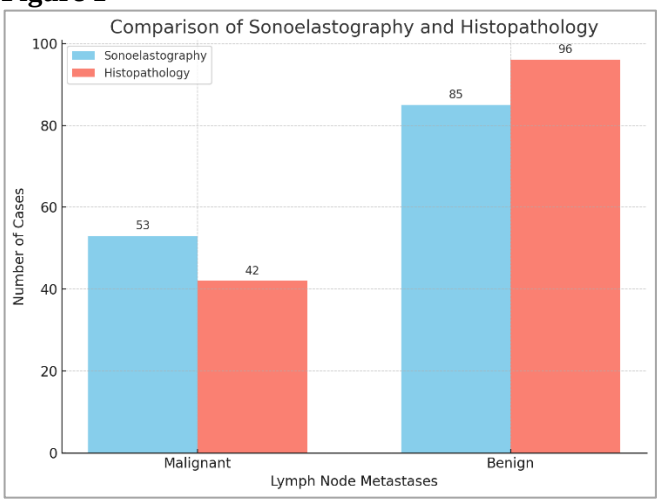
Sonoelastography identified lymph node metastases in 38.4% as malignant and 61.6% as benign, while histopathology diagnosed 30.4% as malignant and 69.6% as benign (Table-III).

Table III

Overall results of Sonoelastography and Histopathology in diagnosis of lymph node metastases (n=138)

Lymph node metastases	Sonoelastography	Histopathology
Malignant	53(38.4%)	42(30.4%)
Benign	85(61.6%)	96(69.6%)
Total	138 (100%)	138 (100%)

Figure 1



When comparing sonoelastography against histopathology, 36 were true positives, 79 true negatives, 17 false positives, and 6 false negatives, with a statistically significant chi-square value of 57.12 (p = 0.000, Table-IV).

Table-IV

Comparison of Sonoelastography versus Histopathology in diagnosis of lymph node metastases (n=138)

Sonoelastography	Histopathology		Total
	Malignant	Benign	
Malignant	36 (TP)	17 (FP)	53
Benign	6 (FN)	79 (TN)	85
Total	42	96	138

Chi square = 57.12
P value = 0.000

Key:
TP = True positive
FP = False positive
FN = False negative
TN = True negative

The sensitivity, specificity, diagnostic accuracy, positive predictive value (PPV), and negative predictive value (NPV) of sonoelastography for diagnosing lymph node metastases were 86%, 82%, 83%, 68%, and 93%, respectively (Table-V).

Table V

Sensitivity, Specificity, Diagnostic Accuracy, PPV and NPV of Sonoelastography for diagnosis of lymph node metastases

Diagnostic Parameter	Result
Sensitivity	86%
Specificity	82%
Diagnostic Accuracy	83%
PPV	68%
NPV	93%

DISCUSSION

Sonoelastography, an advanced ultrasound-based imaging technique, evaluates tissue stiffness to differentiate between benign and malignant lymph nodes. Malignant nodes typically exhibit increased stiffness due to fibrosis, tumor infiltration, or calcification. Sonoelastography scores, ranging from 1 to 4, help categorize nodes, with higher scores indicating malignancy.

Sonoelastography demonstrated high diagnostic accuracy across many studies, ranging from 83.3% to 93%. Mahesh Seetharam et al.[12] reported an accuracy of 92%, while Mahsa Ghajarzadeh et al.[13] found pooled accuracy estimates with an area under the curve (AUC) of 0.95 for strain ratio analysis. Farzana Alam et al.[14] observed an accuracy of 89% for elastography, which increased to 93% when combined with B-mode sonography. Müberra Pehlivan et al.[15] reported an accuracy of 83.3% for ultrasound elastography in detecting lymph node metastases in head and neck cancer. In our study, sonoelastography achieved an accuracy of 83% for differentiating malignant from benign lymph nodes. Sensitivity values were consistently high, ranging from 82.4% to 95.2%. Sensitivity was 95.2% in Seetharam et al.[12] 83% in Alam et al. [14] and 82.4% in Pehlivan et al.[15]. Ghajarzadeh et al.[13] calculated pooled sensitivity values of 76% and 83% for scoring systems and strain ratios, respectively. Our study demonstrated an intermediate sensitivity of 86%, reflecting its robustness in detecting malignancy.

Specificity varied among studies, with values ranging from 75% to 100%. Mahesh Seetharam et al. reported a specificity of 75%,[12] while Farzana Alam et al.[14] found 100% specificity for elastography. Ghajarzadeh et al. calculated pooled specificity values of 80% and 84% for scoring systems and strain ratios, respectively.[13] Pehlivan et al. reported a specificity of 84.6%.[15] In our study, specificity was recorded at 82%, demonstrating a good ability to correctly identify benign lymph nodes, though slightly lower than the maximum reported in other studies.

When compared to B-mode sonography, sonoelastography consistently outperformed in specificity and overall diagnostic performance. Alam et al. reported that B-mode had a specificity of 59% and accuracy of 84%, while elastography achieved 100% specificity and 89% accuracy.[14] Similarly, Pehlivan et al. found that elastography surpassed both CT scans and palpation in sensitivity and accuracy, although its specificity (84.6%) was slightly lower than that of CT.[15] Our study further corroborates these findings, as sonoelastography achieved a diagnostic accuracy of 83%, outperforming traditional approaches.

The ability of sonoelastography to detect malignancy was reinforced by findings such as an AUC of 0.95 for strain ratio analysis in Ghajarzadeh et al. [13] and 83% accuracy for malignant node detection in Alam et al.[14] Elastography patterns were found to be a

significant differentiator, with malignant nodes exhibiting higher stiffness scores (e.g., patterns 3–5 on a scale).[12,14,15] In our study, sonoelastography's positive predictive value (68%) and negative predictive value (93%) highlighted its strength in ruling out malignancy and its potential for use as a reliable diagnostic adjunct to histopathology.

These findings collectively highlight the growing importance of sonoelastography as a diagnostic tool in the evaluation of cervical lymph nodes, particularly in distinguishing malignant from benign nodes.[16] Its high sensitivity and diagnostic accuracy make it a valuable adjunct to traditional imaging methods like gray-scale sonography, Doppler ultrasound, and CT scans.[17] While limitations in specificity and positive predictive value were observed in some studies,[18] the integration of sonoelastography with other diagnostic techniques consistently improved overall diagnostic performance. Future research focusing on standardizing elastography parameters and integrating advanced imaging technologies may further enhance its clinical utility and ensure more precise and non-invasive diagnosis of lymph node metastases.

CONCLUSION

Sonoelastography is a reliable and non-invasive diagnostic tool for differentiating malignant from benign cervical lymph nodes. It demonstrates high diagnostic accuracy and sensitivity, making it an effective adjunct to conventional imaging methods. While limitations in specificity remain, its ability to enhance diagnostic confidence and guide clinical decision-making underscores its value in the comprehensive evaluation of lymph node pathology.

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Authors Contribution

- **Dr. Maaza Javed**: Provided leadership in study conceptualization, authored the initial draft of the manuscript, and oversaw the acquisition of hospital data.
- **Dr. Saulat Sarfraz**: Played a pivotal role in refining the manuscript, contributed to the study's conceptual framework, and was instrumental in the analysis and interpretation of data.

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