Diagnostic Accuracy of Diffusion-Weighted Magnetic Resonance Imaging (DW-MRI) in Differentiating Benign and Malignant Thyroid Nodule

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ABSTRACT

Objective: To determine the diagnostic accuracy of diffusion-weighted magnetic resonance imaging (DW-MRI) in differentiating benign and malignant thyroid nodules, keeping histopathology as the gold standard. **Study Design:** Cross-sectional study. **Settings:** Radiology Department, Allied Hospital, Faisalabad, Pakistan. **Duration:** 24th June 2021 to 23rd December 2021. **Methods:** From a total of 145 patients with palpable thyroid nodules on clinical examination of size >5mm and duration >3 months of age 25-65 years of either gender were included. DW-MRI was performed on all patients and correlated with histopathology reports. **Results:** From 145 patients, 55.86% were from 25 to 45 years. The majority (57.93%) are females. Overall sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and diagnostic accuracy of DW-MRI were 94.29%, 90.61%, 90.41%, 94.44%, and 92.41%, respectively. **Conclusion:** The findings of this study indicate that DW-MRI is a non-invasive modality that exhibits high accuracy in distinguishing malignant from benign thyroid lesions.

Keywords: Thyroid cancer, DWI, Diagnostic accuracy.

INTRODUCTION

Thyroid nodules are common pathological conditions affecting the thyroid gland and are characterized by distinct lesions located inside the gland. These lesions are often detectable by palpation and typically exhibit a remarkable sonographic appearance.[1] Current guidelines suggest that 7–15% of thyroid nodules may be malignant.[2] Diagnosis of malignancy in sufferers with thyroid nodules is of paramount importance as it is one of the maximum curable malignancies. Preferably, diagnostic procedures should be no longer the simplest of excessive accuracy but less invasive. After identifying the thyroid nodule, referring the patient to an endocrinologist may be necessary. Ultrasound is used to confirm nodule presence and gland size. Quantifying TSH and anti-thyroid antibodies can help identify purposeful thyroid illnesses.[3] Despite ongoing research, consensus on optimal cut-off value b value for thyroid nodule assessment remains continued.[4]

There has been little research on using DWI to detect thyroid nodule malignancy, but values of apparent diffusion coefficient (ADC) can help distinguish malignant from benign nodules.[5] Increased b-values for ADC calculation do not always translate to better diagnostic performance in differentiating benign from malignant lesions.[6] According to research, the incidence of malignant thyroid nodules was 36.59%, and the sensitivity and specificity of DW-MRI were 93% and 87%, respectively.[7] Several studies have proven the sensitivity and specificity of DW-MRI.[8,9,10]

This study aims to determine the diagnostic accuracy of DW MRI in identifying thyroid nodules in the surrounding population that are benign and malignant.

To lower the chance of needless surgical operations and the monetary burden. The results of this examination will provide those particular patients with a non-invasive diagnostic modality that can be carried out mechanically in our trendy exercise in figuring out the pre-operative reputation of thyroid nodules.

METHODS

This cross-sectional validation study was done in the radiology department of Allied Hospital FSD from 24th June 2021 to 23rd December 2021. After taking permission from ERC vide letter no. 48.ERC/FMU/2023-24/412 dated 16-03-2024, 145 consecutive patients who the clinician referred are selected. The sample size was calculated with a 95% confidence level of 7% absolute precision, taking the expected prevalence of malignant thyroid nodules as 36.59% and sensitivity and specificity of DW-MRI as 93.0% and 87%, respectively.[8]

These Patients were between the ages of 25-65 years of either gender. All these patients had palpable thyroid nodules on clinical examination, having a size of>5mm and a duration of>3 months. Patients with already biopsy-proven malignant thyroid nodules and with contraindications to MRI, i.e., claustrophobia and cardiac pacemakers assessed on history and patients with CRF, were excluded.

Each patient provided informed written consent. DWI MRI was conducted on each patient utilizing a 1.5 Tesla full-body GE MR equipment. DW-MR images were acquired of thyroid glands in the axial plane. The imaging was performed at b values of 50, 500, and 1000. The whole duration of the scan was 4 minutes and 54 seconds. After acquiring images, regions of interest were delineated in each suspected nodule on ADC maps. These regions range from 5 to 10 mm2, excluding areas exhibiting necrosis, calcification, and cystic components. The DW-MRI results were examined and compared to the histopathology report, which was the gold standard. A positive DW-MRI was defined as exhibiting hyperintensity on both T2-weighted and DW images at a b-0 s/mm2 intensity level while maintaining hyperintensity at a b-1000 s/mm2 intensity level, with an ADC value below 1.00 mm2/s.

All data, malignant thyroid nodules on DW-MRI, and histopathology were recorded. The presence of pathological evidence of malignancy, including nuclear inclusion and vascular invasion, on histopathological analysis was taken as positive. The data collected was subjected to analysis using the computer program SPSS 16. Mean and SD were used to display age, illness duration, ADC value, and nodule size. Frequency and percentage of gender, malignant thyroid nodule on DW-MRI, and histology were reported. Stratification was

used to adjust for effect modifiers such as age, gender, illness duration, and nodule size.

RESULTS

From 145 patients, 55.86%were from 25 to 45 years. The majority (57.93%) are females—the mean duration of disease and size of the nodule. The mean value of ADC was 1.38 ± 0.64 mm2/s. ADC value in malignant cases was 0.77 ± 0.11 and in benign cases was1.94 ± 0.33. DW-MRI supported the diagnosis of malignant thyroid nodules in 73 patients. Histopathology confirmed malignant thyroid nodules in 70 cases. The number of actual positive cases in DW-MRI was 66, whereas seven false positive cases were07. Among patients with negative DW-MRI results, 68 were confirmed as negative, and 04 were incorrectly identified as negative. The DW-MRI has a sensitivity of 94.29%, specificity of 90.61%, PPV of 90.41%, NPV of 94.44%, and diagnostic accuracy of 92.41%. Table 3 presents the stratification of diagnostic accuracy based on age groups, gender, disease duration, and nodule size.

Table 1: Baseline characters of the study population

Variables		Frequency (Percentage)	Mean +/-SD
Age (years)	25-45 46-65	81 (55.86%) 64 (44.14%)	44.69+/-9.68
Gender	Male Female	61 (42.07%) 84 (57.93%)	
Duration of disease months	< 6 >6	67 (46.21%) 78 (53.79%)	8.13 ± 3.52 months
Size of nodule cm	< 3 >3	61 (42.07%) 84 (57.93%)	4.27 ± 1.49 cm

Table 2: Diagnostic accuracy of DW-MRI

On DW-MRI	Histopathology		P-value
	Positive	**Negative**	
Positive	66*	07 ***	0.0001
Negative	04**	68****	

*-TP=True positive **-FP=False Negative***-FN=False positive ****-TN=True negative
Specificity: 90.61%, Sensitivity: 94.29%, PPV: 90.41%, NPV: 94.44%, Diagnostic Accuracy: 92.41%

Table 3: Stratification DW MRI accuracy according to different variables

Variables		Sensitivity	Specificity	PPV	NPV	DA	P value
Age (years)	25-45 46-65	95.24% 92.86%	89.74% 91.67%	90.91% 89.66%	94.59% 94.29%	92.59% 92.19%	0.0001 0.0001
Gender	Male Female	96.30% 93.02%	91.18% 90.24%	89.66% 90.91%	96.88% 92.50%	93.44% 91.67%	0.0001 0.0001
Duration of disease months	<6 >6	93.33% 95.00%	91.89% 89.47%	90.32% 90.48%	94.44% 94.44%	92.54% 92.31	0.0001 0.0001
Size of nodule cm	<3 >3	92.86% 95.24%	90.91% 90.48%	89.66% 90.91%	93.75% 95.00%	91.80% 92.86%	0.0001 0.0001

DISCUSSION

Prevalence and occurrence of thyroid disease have visible first-rate growth in recent years. A growing occurrence of thyroid cancers has been pronounced internationally.[11] Most popular non-invasive imaging technique for thyroid lesions is ultrasound; nonetheless, there are still unreliable criteria to differentiate benign from malignant tumors. Even with remarkable advancements in diagnostic tools like CT, radionuclide imaging, and ultrasound, developing a reliable and non-invasive method to differentiate benign from malignant tumors remains significant. MRI advances may also indicate that some methods are diagnostically cost-effective for various pathologies. Routine imaging can locate and measure thyroid lesions. However, such guidelines still lack the precision needed to determine whether a thyroid nodule is benign or cancerous or how common these nodules are.

DWI is a form of purposeful MRI. This phenomenon is predicated upon the process of water molecule diffusion by tumor tissue. DWI can offer significant information on the molecular characteristics of the underlying disease and the processes by which it operates.[12] DWI offers a convenient and non-invasive method for assessing thyroid nodules, eliminating the need for intravenous contrast agents.[13] Several studies[14, 15] demonstrate that DWI can discriminate among benign and malignant nodules but with low sample size and inconclusive findings. The current study found that the sensitivity, specificity, PPV, NPV, and diagnostic accuracy of DW-MRI were 94.29%, 90.61%, 90.41%, 94.44%, and 92.41%, respectively. In a study, the incidence of malignant thyroid nodules was 36.59%, and the sensitivity and specificity of DW-MRI were 93.0% and 87%, respectively.[7] Another study reported sensitivity, specificity, PPV, NPV, and accuracy of DWI of 84.4%,82.3%,97.4%,40%, and 84.2%, respectively.[8] Kong *et al*[9] demonstrated 84.9%

and 92.20% sensitivity and specificity of DW-MRI. Galal *et al*[10] have shown the sensitivity and specificity of DW-MRI at 100.0% and 88.90%, respectively. A study on 35 individuals revealed a marked distinction in mean ADC readings of malignant and benign thyroid nodules. An ADC value of 1.6 x 10-3mm2/s has been employed as a threshold. DWI and ADC readings exhibited sensitivity, specificity, PPV, NPV, and diagnostic accuracy of 93%, 95%, 93%, 95%, and 92.3%, respectively.[16]

Elshafey *et al*[14] stated a sensitivity of 96% and a specificity of 92%. A study by Razeket *et al*[17] reported that malignant nodules have lower ADC values. Observed elevation in ADC values in benign nodules can be attributed to several factors. ADC values from normal parenchyma in the study conducted by Razek *et al*[17] would have provided significant benefit in comparing these values with those of diseased thyroid tissue and establishing an internal standard of reference. Moreover, the study conducted by the researchers had a limited number of malignant thyroid nodules (n = 7), as only the solitary lesion found using sonography was included in their analysis. findings of this study indicate that utilization of a combined diagnostic approach enhances the probability of encountering further cancers in cases with single thyroid nodules.

A study conducted by Bilgen Mehpare Özer[18] examined the effects of DWI on thyroid nodules. The mean value of ADC was lower in malignant nodules at b values of 500 and 800 compared to benign nodules. Maximum 83.3% sensitivity and 90.0% specificity were observed with ADC value at b 500 and they observed the sensitivity was 71.4%, with specificity of 89.7% for the ADC values at b 800. indicating its potential as a diagnostic marker

This study further substantiated the significance of DW MRI as a crucial diagnostic modality for distinguishing

between malignant and benign thyroid lesions, aligning with previously reported data.[8,15,17]

CONCLUSION

The findings of this study indicate that DW-MRI is a non-invasive modality that exhibits high sensitivity and accuracy in differentiating malignant from benign thyroid lesions. This advancement has significantly enhanced our capacity for precise diagnosis of thyroid lesions and improved patient care through timely and appropriate treatment while minimizing unnecessary diagnostic biopsies.

LIMITATIONS

The present investigation exhibited some limitations. The scope of this investigation was limited to a singular hospital, thereby limiting the generalizability of the findings to a broader population. Furthermore, while we made a deliberate effort to exclude cystic sections of thyroid nodules during signal intensity assessments, it is important to acknowledge that the micro-cystic composition of thyroid nodules might potentially impact our findings.

SUGGESTIONS / RECOMMENDATIONS

We propose the employment of DW-MRI as the primary method for detecting and accurately distinguishing between benign and malignant thyroid nodules rather than relying on biopsy.

CONFLICT OF INTEREST / DISCLOSURE

None.

REFERENCES

1. Liu J, Zheng D, Li Q, Tang X, Luo Z, Yuan Z, Gao L, Zhao J. A predictive model of thyroid malignancy using clinical, biochemical and sonographic parameters for patients in a multi-center setting. BMC Endocr Disord. 2018 Mar 7;18(1):17.
2. Grussendorf M, Ruschenburg I, Brabant G. Malignancy rates in thyroid nodules: a long-term cohort study of 17,592 patients. Eur Thyroid J. 2022 Jun 29;11(4):e220027.
3. Wang Q, Guo Y, Zhang J, Ning H, Zhang X, Lu Y, et al. Diagnostic value of high b-value (2000s/mm2) DWI for thyroid micronodules. Medicine (Baltimore). 2019;98(10):e 14298.
4. Meyer HJ, Wienke A, Surov A. Discrimination between malignant and benign thyroid tumors by diffusion-weighted imaging–a systematic review and meta analysis. Magnetic Resonance Imaging. 2021 Dec 1;84:41-57.
5. Wang H, Wei R, Liu W, Chen Y, Song B. Diagnostic efficacy of multiple MRI parameters in differentiating benign vs. malignant thyroid nodules. BMC medical imaging. 2018 Dec;18:1-9.
6. Zhu X, Wang J, Wang YC, Zhu ZF, Tang J, Wen XW, et al. Quantitative differentiation of malignant and benign thyroid nodules with multi-parameter diffusion-weighted imaging. World J Clin Cases. 2022 Aug 26;10(24):8587-8598.
7. Aghaghazvini L, Sharifian H, Yazdani N, Hosseiny M, Kooraki S, Pirouzi P, et al. Differentiation between benign and malignant thyroid nodules using diffusion-weighted imaging, a 3-T MRI study. Indian Journal of Radiology and Imaging. 2018 Oct;28(04):460-4.
8. Sohu DM, Sohail S, Shaikh R. Diagnostic accuracy of diffusion weighted MRI in differentiating benign and malignant meningiomas. Pak J Med Sci. 2019;35(3):726-730.
9. Kong W, Yue X, Ren J, Tao X. A comparative analysis of diffusion-weighted imaging and ultrasound in thyroid nodules. BMC Med Imaging. 2019 Nov 21;19(1):92.
10. Mostafa Th Hussen MD, Mohammad HE, Marwa IA, Reham SS, Seifeldein S. Efficacy of diffusion-weighted MRI in thyroid nodules. The Medical Journal of Cairo University. 2019 Dec 1;87(December):5283-91.
11. Davies L, Welch HG. Increasing incidence of thyroid cancer in the United States, 1973-2002. Jama. 2006 May 10;295(18):2164-7.
12. Koh DM, Collins DJ. Diffusion-weighted MRI in the body: applications and challenges in oncology. American Journal of Roentgenology. 2007 Jun;188(6):1622-35.
13. BHARGAVA K, NARULA H, MITTAL A, SHARMA D, GOEL K, NIJHAWAN D. Role of Diffusion-Weighted Magnetic Resonance Imaging in Differentiating Benign From Malignant Thyroid Lesions: A Prospective Study. Journal of Clinical & Diagnostic Research. 2020 Apr 1;14(4):TC06–TC10.
14. Elshafey R, Elattar A, Mlees M, Esheba N. Role of quantitative diffusion-weighted MRI and 1H MR spectroscopy in distinguishing between benign and malignant thyroid nodules. The Egyptian Journal of Radiology and Nuclear Medicine. 2014 Mar 1;45(1):89-96.
15. Shi HF, Feng Q, Qiang JW, Li RK, Wang L, Yu JP. Utility of diffusion-weighted imaging in differentiating malignant from benign thyroid nodules with magnetic resonance imaging and pathologic correlation. Journal of computer assisted tomography. 2013 Jul 1;37(4):505-10.
16. Khizer AT, Raza S. Diffusion-weighted MR imaging and ADC mapping in differentiating benign from malignant thyroid nodules. Journal of the College of Physicians and Surgeons Pakistan. 2015 Nov 1;25(11):785-9.
17. Razek AA, Sadek AG, Kombar OR, Elmahdy TE, Nada N. Role of apparent diffusion coefficient values in differentiation between malignant and benign solitary thyroid nodules. American journal of neuroradiology. 2008 Mar 1;29(3):563-8.
18. Özer BM, Pabuşçu Y, Tarhan S, Ovalı GY, Aydede H, Demireli P, Karadeniz T. Effectiveness of diffusion-weighted magnetic resonance imaging (DW-MRI) in the differentiation of thyroid nodules. Thyroid Research. 2024 Nov 18;17(1):24.