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Research Article

DIAGNOSTIC ACCURACY OF DIFFUSION WEIGHTED IMAGING IN DIFFERENTIATING BENIGN AND MALIGNANT THYROID NODULES: A CROSS SECTIONAL STUDY

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A R T I C L E I N F O

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Apparent diffusion coefficient; Histopathology; thyroid nodules

A B S T R A C T

Aim: To evaluate the role of diffusion weighted MRI in differentiating benign from malignant thyroid nodules and correlating them with fine needle aspiration cytology (FNAC)/Histopathological examination.

Materials and Methods: The study was conducted after getting approval from our institution ethical committee and after obtaining written informed consent from the patients in the Department of Radiology, SRM Medical College hospital and Research center, Kattankulathur, Chengalpattu district. It is a cross sectional study done on fifty patients who were diagnosed to have thyroid nodules by B-mode ultrasound or by palpation or incidental detection. Patients who refused to undergo FNAC, purely cystic nodules were excluded from the study. MRI was done using SIEMENS 1.5T essenza using b-values of 50, 500, 800 and apparent diffusion coefficient (ADC) maps were generated.

Results: Among the 50 cases, MRI ADC value had a sensitivity of 87.5%, specificity of 88% and an accuracy of 88% in differentiating benign and malignant thyroid nodules. The cut off ADC value for differentiating benign from malignant thyroid nodules was 0.859.

Conclusion: ADC values can help in differentiating benign and malignant thyroid nodules with better accuracy and specificity. This study lead us to believe that the incorporation of ADC values in MRI could avoid surgery in patients with thyroid nodules and comorbidities for whom potential risk of surgery outweighs the survival benefit.

INTRODUCTION

The thyroid gland, the biggest endocrine gland, is the first gland to form throughout foetal life. It is located superficially which helps in physical examination, easy visualization and anatomical evaluation using real time high resolution grey scale ultrasound for detecting any pathological conditions.[1]Being non-invasive, USG helps to diagnosis the thyroid pathologies and manage accordingly. Real time high resolution grey scale ultrasound and color doppler can aid in demonstrating normal thyroid and pathologies with remarkable quality.[2]In USG, thyroid nodules are examined for size, echotexture, location, margins, calcification, presence of halo, vascularity and cervical lymphadenopathy to differentiate between malignant and benign nodule.[3] In spite of all these advantages, in few cases, ultrasound cannot distinguish between malignant and benign masses. It needs to be correlated with FNAC to confirm definitive diagnosis.

Fine needle aspiration cytology (FNAC) gives most specific information regarding thyroid swellings. It helps to reduce thyroidectomies required, by approximately 50%. FNAC is a specific, sensitive, and accurate technique for evaluation of thyroid swellings[4]. FNAC has an overall high sensitivity ranging from 90-100%, for detection of malignancy in both cystic and solid masses. [5-8] Combination of USG and FNAC permits higher diagnostic accuracy and adequate sampling of nodules and thus lessen false negative reports.[9-14] However FNAC is an invasive procedure and cannot be done in all patients. Magnetic resonance imaging (MRI) can also be used in the evaluation of thyroid nodules. One of the functional MRI methods used is DWI, that assess net diffusion of water molecules in any lesion quantitatively. Increased cellularity in thyroid carcinomas restricts the diffusion which results in low apparent diffusion coefficient (ADC) values that helps to differentiate between malignant and benign thyroid swelling.[15]

In this present study, we seek to establish the diffusion weighted MR Imaging diagnostic performance with ADC values in distinguishing malignant and benign thyroid nodules by correlating with FNAC (Fine Needle Aspiration Cytology)/HPE (Histopathological Examination). If proved useful ADC values can help in avoiding FNAC in thyroid nodules by categorizing them as benign or malignant.

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MATERIALS AND METHODS

The study was conducted after getting approval from our institution ethical committee (Ethics clearance number – 2395/IEC/2021) and after obtaining written informed consent from the patients during the period from January 2021 to June 2022 in the Department of Radiology, SRM Medical College hospital and Research center, Kattankulathur, Chengalpattu district. It is a cross sectional study done on fifty patients who were diagnosed to have thyroid nodules by B-mode ultrasound or by palpation.

Inclusion Criteria

- Patients who were diagnosed to have thyroid nodules by B-mode ultrasound or by palpation or incidental detection
- Patient of any age group and both sex

Exclusion Criteria

- Patient refusal for FNAC
- Purely cystic nodules
- TIRADS 6

Sample Size:[4]

Using the formula, Sample size (n) = $4pq/d^2$
Where, p = prevalence, q = 1 – prevalence, d = precision is 10
p=4%q=100-4=96%d=6%n=4pqL2=4*4*96/6*6=43 cases
Total number of cases done was 50.

METHODOLOGY

Patients who fulfilled the inclusion criteria were undertaken for the study. Detailed history and reports of thyroid function tests were collected from these patients. Following ultrasound evaluation of thyroid nodules, the patients were then subjected to MRI examination.MR scanning was performed with 1.5-T Siemens Essenzamachine with the help of standard head and neck coil. Localizer images was obtained followed by Diffusion weighted MR images obtained in AXIAL using b-values of 50, 500, 800 and ADC maps was generated and quantitatively measured (Table/Fig-1).

FNAC of Thyroid

After USG and MRI examinations, all patients with thyroid nodules underwent FNAC. Few of these patients also underwent surgery. Follicular neoplasm and follicular adenoma could not be differentiated by FNAC. So in those cases, histopathological report was obtained from the surgical specimen.

Statistical Analysis

Numerical variables like Age, ADC value etc., are represented in mean, SD, median, and mode. Categorical variables are characterised in frequencies and percentages. For test of significance, fisher's exact test and chi-square test were used as appropriate. For identifying ADC value cut-offs of malignant nature ROC curve was plotted. Sensitivity, Specificity, Positive and Negative predictive values was used a measure of accuracy. P-values lesser than 0.05 level were considered statistically significant. Data was entered in MS excel sheet and analysed using SPSS software version 16.

RESULTS

In the study done with 50 patients diagnosed with thyroid nodules, most of them were females between 21-30 years (16%). Most with benign lesions were between the age of 41 to 50 (28.5%)and those with malignant lesions were among 21 to 30 years age group (75%)(Table-1).Most of the malignant lesions were detected in female patients (Table-1). Majority presented with neck swelling followed by swelling associated with pain and incidentally detected nodules. Most of the cases were Euthyroid and most of the patients had duration of symptoms more than 6 months for both benign and malignant nodules. Majority of the patients had multiple nodules (52%) as compared to solitary nodule. On correlation with HPE diagnosis, 57.1% benign cases had multiple nodule and 75% malignant cases had solitary thyroid nodule (Table-2). Adenomatoid or colloid nodule (74%) was the most common benign lesion that was diagnosed in our study (Figure 2). Papillary carcinoma (10%) was the most common malignant neoplasm detected in our study (Figure-3). Other lesions were focal asymmetrical thyroiditis (8%), follicular adenoma (2%) and carcinoma (6%) (Table -3).

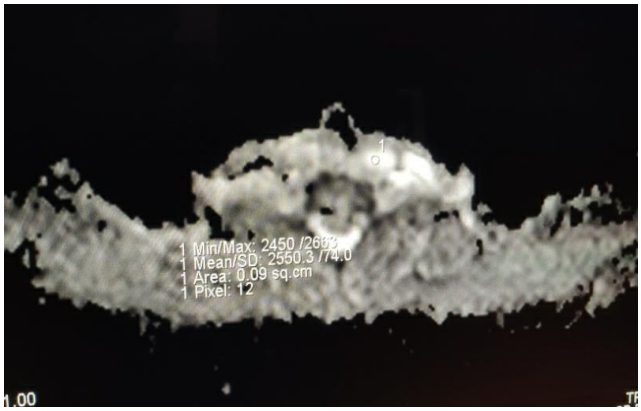

Figure 1 ADC image of a thyroid nodule showing ADC value of $2.5x10^{-3}$ mm^2/s

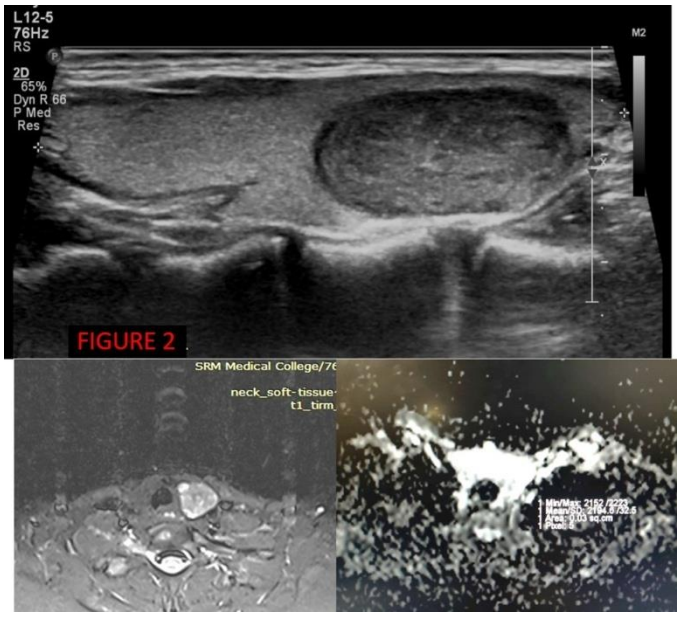

Fig 2 Ultrasound showing a well defined solid iso to hyperechoic wider than taller nodule in left lobe of thyroid MRI STIR axial and ADC image of the corresponding thyroid nodule in left lobe showing ADC value of 2.1 $x10^{-3}mm^2/s$ – Suggestive of benign lesion. FNAC revealed colloid nodule.

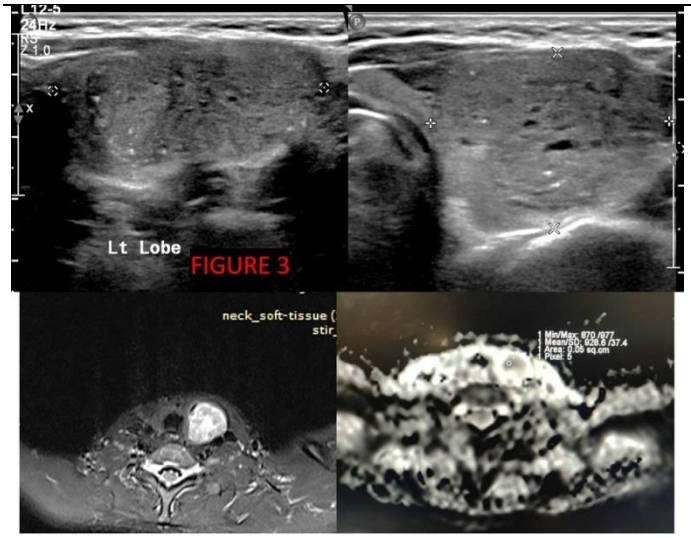

Fig 3 Ultrasound showing a relatively well defined lobulated solid cystic isoechoic wider than taller lesion showing micro calcifications in left lobe of thyroid. MRI STIR axial and ADC image of the corresponding thyroid nodule in left lobe showing ADC value of 0.9 x$10^{-3}$$mm^2$/s – Suggestive of malignant lesion. Histopathology revealed papillary thyroid carcinoma.

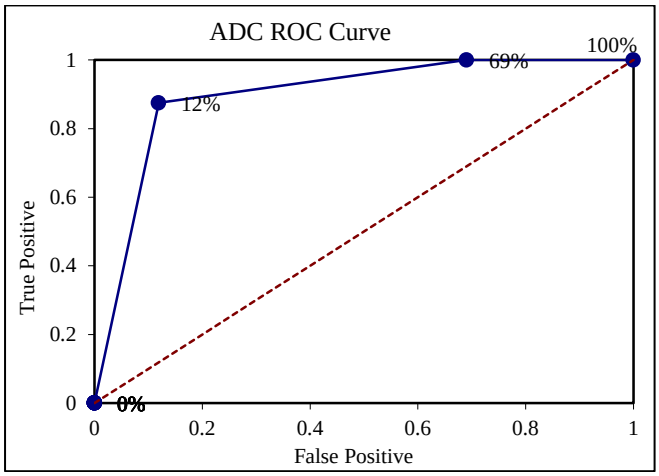

Figure 4 ROC Curve for ADC score

"In our study we found that ADC score of 0.859 is the value to differentiate between benign and malignant lesions on diffusion weighted MRI."

The mean ADC score among the patients with benign thyroid lesions on Histopathological examination was 1.62+/- 0.7 and in patients with malignant lesions was 0.96 +/- 0.3 (Table-4).ADC cut off value of 0.899 was found in our study according to ROC curve for differentiating benign and malignant thyroid nodules (Figure-4). The sensitivity, specificity, positive predictive value, negative predictive value and accuracy were 87.5%, 88%, 58.3%,97.3% and 88% (Table-5).

Table 1 Age and sex distribution among study patients

GROUP	Frequency	Percent
21-30	16	32%
31-40	10	20%
41-50	12	24%
51-60	7	14%
>60	5	10%
Total	50	100%

AGE	Benign		Malignant	
	Number	Percent	Number	Percent
21-30	10	23.8%	6	75%
31-40	8	19.04%	2	25%
41-50	12	28.5%	-	-
51-60	7	16.66%	-	-
>60	5	11.9%	-	-

SEX	Benign		Malignant		TOTAL
	Number	Percent	Number	Percent	
Male	3	7.1%	-	-	3(6%)
Female	39	92.8%	8	100%	47(94%)

Table 2 Correlation of number of nodules with HPE diagnosis

Number of nodules	Benign		Malignant		Total
	Number	Percent	Number	Percent	
Single	18	42.8%	6	75%	24(48%)
Multiple	24	57.1%	2	25%	26(52%)
Total	42	100%	8	100%	50

Table 3 Histopathological diagnosis distribution among study patients

HPE Results	Frequency	Percent
Adenomatoid /colloid nodule	37	74%
Focal asymmetrical thyroiditis	4	8%
Papillary carcinoma	5	10%
Follicular adenoma	1	2%
Follicular carcinoma	3	6%
Total	50	100%

Table 4 Mean ADC scores among the study patients

	Mean	SD	Range
Benign	1.62	0.7	0.4 - 3.5
Malignant	0.96	0.3	0.4 - 1.3

Table 5 Specificity, Sensitivity, positive, negative predictive value and accuracy of ADC values

	ADC score
Sensitivity	87.5%
Specificity	88%
Positive predictive value	58.33%
Negative predictive value	97.33%
Accuracy	88%

DISCUSSION

This was a cross sectional study based on MRI in 50 cases with thyroid nodules identified by palpation/ incidentally during other investigations.

In this study, there was a 94% female preponderance, which is clearly visible. The results were consistent with a study by Palaniappan V *et al*. that found that females are more likely than males to experience thyroid disorders.[16] The incidence of malignant thyroid nodules were significantly more in younger age group of 21-30 years in this study. The results were consistent with study conducted by Palaniappan V *et al* at a tertiary care hospital which showed that most of the malignant thyroid nodules were detected in younger population. [16]

In a case study done by Bamanikar, *et al* in a tertiary care hospital showed that common presenting complaint was neck swelling and most cases were of euthyroid.[17] These results were similar to our study which showed the common presenting complaint was swelling in the neck and with 88% of the patients being euthyroid.

Out of 50 patients, 24(48%) of thyroid lesions were solitary nodule and 26(52%) were multiple nodules. These findings were consistent with the study conducted by Palaniappan MK *et al* showing that majority of the thyroid nodules were multiple.[4]

Most common lesion that was diagnosed on HPE in our study was adenomatoid nodule (70%). Other lesions detected include colloid nodule (4%), focal asymmetrical thyroiditis (8%), papillary carcinoma (10%), follicular adenoma (2%),

follicular neoplasm (6%). Our results were identical to studies conducted by Patel Nr *et al*, in a study group of 100 cases showing benign colloid goitre as the most commonly detected lesion[6]. Similar research done by Mallikarjunappa *et al* also showed colloid goitre as the most predominant lesion. [8]

The sensitivity, specificity, positive predictive value, negative predictive value and accuracy of ADC score in our study was 87.5%, 88%, 58.3%,97.3% and 88% using b value of 50, 500 and 800 s/mm^2. The cut-off value of ADC for predicting benign and malignant nodules in our study was 0.85 x 10^{-3} mm^2/s.

One of the study by Razek *et al* in 2008 with a sample size of 67 using b values of 0, 250 and 500 s/mm^2 showed a sensitivity of 98% and specificity of 92 %. [18]In this study, the cut off value of ADC for predicting benign and malignant nodules was 0.98 x 10^{-3} mm^2/s which is comparable to our study.

In study done by Nakahira M *et al*, the cut-off point for differentiating benign and malignant thyroid nodules by ADC value was 1.60 with sensitivity, the specificity and the accuracy of 94.73%; 82.60%; 88.09%, respectively. [19] Although the sensitivity, specificity and accuracy values were similar to our study, the ADC cut off value was different. The b value used in that study was 0 and 1000 s/mm2.

In another study conducted by Shi *et al* in 2013 in111cases, when the b factor was 500 s/mm, an ADC value of 1.704 × 10 mm/s was used as a threshold for differentiating malignant from benign nodules, with 92% sensitivity, 88% specificity, and 87% accuracy. [20] The sensitivity, specificity and accuracy of this study is comparable to our study but ADC cut off value was different.

In a study by Aghaghazvini L *et al* with 41 thyroid nodules, ADC value cutoff of 1 × 10-3 mm2/s yielded an accuracy, sensitivity, and specificity of 93%, 87%, and 96% to differentiate benign and malignant nodules. The machine used was 3tesla MRI and b values used were 50, 500 and 1000 s/mm2.[21]

Although the ADC cut off value is different in each studies, the sensitivity, specificity and accuracy is high, thereby proving ADC score is valuable method to distinguish benign from malignant thyroid nodules[Table 6]. The different ADC values may be because of different MRI machine and different b values used.[21]

Table 6 Comparison of our study with previously published papers showing the sensitivity and specificity of MRI ADC value

Studies	Sensitivity (%)	Specificity (%)
Razek *et al*[18], 2008	98	92
Shi *et al*[19], 2013	92	88
Nakahira *et al*[20] 2012	94	83
Aghaghazvini L*et al*[21]2018	87	96
Our study	**87.5%**	**88%**

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