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EVALUATING THE DIAGNOSTIC EFFICIENCY OF ULTRASOUND AND THYROID PROFILE IN HASHIMOTO'S THYROIDITIS

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Vol. 5 No. 1 (2026)

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Abstract

Introduction: Hashimoto's thyroiditis (HT) is the most common autoimmune thyroid disorder and is frequently associated with thyroid nodules, which may complicate malignancy risk assessment. Differentiating benign from malignant nodules in the background of HT remains clinically challenging due to diffuse inflammatory changes that affect ultrasound interpretation.

Objective: This systematic literature review aimed to evaluate the diagnostic efficiency of ultrasound modalities and thyroid profile parameters in detecting and differentiating thyroid nodules in patients with Hashimoto's thyroiditis.

Methodology: A systematic literature review was conducted following PRISMA guidelines. Electronic databases including PubMed, Google Scholar, and Scopus were searched for relevant studies published after 2015. Eighteen eligible studies were selected based on predefined inclusion and exclusion criteria. Data were extracted and categorized into conventional ultrasound systems, advanced imaging techniques, artificial intelligence models, and laboratory biomarkers.

Results: Conventional TI-RADS systems showed high sensitivity but moderate specificity. Advanced techniques such as contrast-enhanced ultrasound and elastography improved diagnostic accuracy. Radiomics and deep learning models demonstrated the highest predictive performance, with AUC values exceeding 0.90 in several studies. Serum thyroid antibodies supported diagnosis but had limited independent sensitivity.

Conclusion: A multimodal diagnostic approach integrating advanced ultrasound and AI-based models provides improved accuracy in evaluating thyroid nodules in HT.

Vol. 5 No. 1 (2026)

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1. INTRODUCTION

The thyroid gland is a small butterfly shaped organ located in the front of the neck. It controls metabolism through the release of thyroid hormones (Khan & Farhana, 2019). These hormones regulate energy production, temperature control, heart rate, and brain function. When the thyroid works normally, the body remains balanced. When it fails, many systems are affected. Disorders of the thyroid are among the most common endocrine problems worldwide (Al-Suhaimi & Khan, 2022). The thyroiditis that is caused by Hashimoto is one of the most significant causes of dysfunction in the thyroid. It is a progressive disease that over time destroys the thyroid, modifies its structure and functioning (Pace and Colagrande, 2024).

The thyroiditis was initially reported in 1912 by the Japanese doctor Hakaru Hashimoto in Hashimoto. He indicated four incidences of women with an enlarged thyroid gland and lymphocytic infiltration on histology (Li et al., 2024). This disease was then referred to as struma lymphomatosa. Subsequent studies proved that it was an autoimmune disease. In 1956 research discovered thyroid autoantibodies which justified the immune assault of the thyroid tissue. The thyroiditis of Hashimoto has since been identified to be the most prevalent cause of hypothyroidism in iodine sufficient areas. It impacts on women more than men. It has a prevalence of between 5 and 10 percent in adult females the world over (Mahmoud, Azeem, Sayed, and Ali, 2022).

With the increase in the knowledge of the disease, clinicians started to note the gradual development of symptoms. Early stages may be silent. Stages of late are usually characterised by the feeling of fatigue, weight gain, dry skin, cold intolerance. There are patients who develop a visible goiter (Delgadillo & Agrawal, 2026). In 2017, Kapali et al. have described clinical cases of progressive lymphocytic destruction of the gland that causes permanent hypothyroidism. Their result was confirmatory of the fact that hormonal degradation is associated with structural damage. This association between tissue alteration with dysfunctional loss established the necessity of superior diagnostic assessment. Doctors required good resources to be able to spot the illness at an early stage (Kapali et al., 2017).

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In the past, thyroid profile testing was used to diagnose the conditions. Thyroid stimulating hormone, free T4, free T3 and thyroid autoantibodies including anti-TPO and anti-thyroglobulin are measured by blood tests. Positive antibodies with a raised TSH are a good indication of a positive view of Hashimoto thyroiditis. But the structural changes do not necessarily mean changes in the laboratory values. Other patients are positive in antibodies but normal in hormone levels (Eftekharian et al., 2024). Ralli et al. (2014) reported a clinical case series, where patients with ultrasound changes despite biochemical hypothyroidism and antibody positivity were reported prior to the onset of biochemical deficiency in 2014. This observation implied that imaging could potentially diagnose the illness earlier as compared to blood tests alone. Thus, the focus was shifted to the combination of laboratory and imaging tools (Ceylan et al., 2014).

Ultrasound was chosen as one of the most significant diagnostic techniques as it is safe, non-invasive, and ubiquitous. It demonstrates the size of glands, echogenicity and texture. Thyroiditis in Hashimoto is usually hypoechoic and heterogeneous in the gland (Couto et al., 2024). A multicenter European study found that even before abnormalities of hormones developing, diffuse hypoechogenicity on ultrasound was strongly associated with autoimmune thyroiditis. This strengthened the use of imaging. Nevertheless, interpretation of ultrasound requires the skills of the operator. It is also not able to directly quantify hormone imbalance (Tan et al., 2025). Consequently, questions still exist concerning the method that is more correct or the combination of both methods enhances detection.

Vol. 5 No. 1 (2026)

Pakistan Journal of Medical & Cardiological Review
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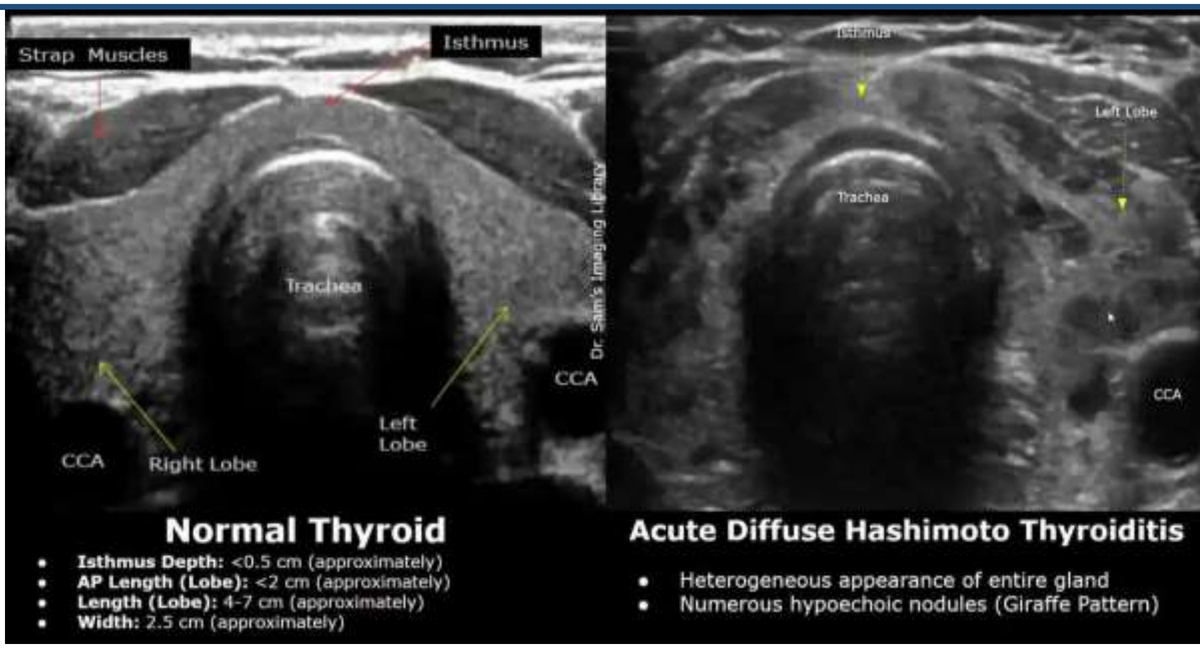

Figure 1: Ultrasound Appearance of Normal Thyroid and Diffuse Hashimoto's Thyroiditis: The image compares a normal thyroid gland with acute diffuse Hashimoto's thyroiditis. The affected gland shows heterogeneous echotexture and multiple hypoechoic areas, characteristic of autoimmune inflammatory changes.

As cases continued to be reported in the world, researchers started to compare against each other in terms of diagnostic performance. Indicatively, a 2021 study (South Korea) studied newly diagnosed patients with suspected autoimmune thyroid disease. The researchers had compared the ultrasound grading scores with the antibody levels (Koprowski et al., 2012). They discovered moderate correlation and not absolute overlap. There were patients who possessed definite ultrasound alterations and borderline antibody levels. There were those with a high antibodies but mild imaging. These variations also caused an issue regarding the adoption of a single approach. It indicated that the diagnostic efficiency is a complex and multi dimensional approach (Staii, 2010).

This results in a critical clinical problem. Long-term complications like cardiovascular risk, infertility and neurocognitive decline can be prevented through early diagnosis. Silent progression can

Vol. 5 No. 1 (2026)

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Online ISSN 3007-2387 Print ISSN 3007-2379

Tariq et al - 2026

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manifest itself due to delayed diagnosis (Angelopoulos, 2023). Meanwhile, over diagnosis will cause needless treatment. Hence, there is a need to assess the diagnostic efficiency. Diagnostic efficiency is the sensitivity, specificity, predictive value, and general accuracy. It is the extent to which a test is true disease detecting and false positive (Kenarlı, 2024). This assessment is particularly critical in the case of autoimmune thyroid disease since the structural and biochemical alterations are not invariably parallel.

Though, individual studies have studied and evaluated ultrasound or thyroid profile individually, the results were inconclusive. Other studies prefer antibody testing as being the gold standard. Some mention the predictive nature of ultrasound texture grading (Li et al., 2024). It is not so much agreed on whether the combination of both is effective in improving early detection. Moreover, there is a difference among populations and health care institutions. This leaves a loophole in evidence synthesis. Systematic review has the potential of bringing clarity since it allows an analysis of available data in a structured way that is transparent.

Consequently, this research examines the diagnostic accuracy of ultrasound and thyroid profile in Hashimoto thyroiditis. Having synthesised recent findings, it aims to clarify which method is more useful or integrated assessment is more accurate. This knowledge may help the clinicians make diagnostics. It can also lead to better patient outcomes by ensuring that the right intervention is done in time.

2. Methodology

2.1 Research Design

This study adopted a Systematic Literature Review (SLR) design to evaluate the diagnostic efficiency of ultrasound and thyroid profile in Hashimoto's thyroiditis. A systematic review was chosen since the research question is on diagnostic performance but not on single patient outcomes. This method is an alternative to gathering primary clinical information, enabling the systematic pooling of existing evidence in a number of studies. The sample size, population traits, and clinical environments of

Vol. 5 No. 1 (2026)

Pakistan Journal of Medical & Cardiological Review

https://pakjmcr.com/index.php/1/about

Online ISSN 3007-2387 Print ISSN 3007-2379

Tariq et al - 2026

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diagnostic accuracy are frequently different in diagnostic accuracy studies. Hence, systematic approach is needed to find, compare, and critically analyze the results in an open manner. To reduce bias and enhance reproducibility the SLR approach adheres to inclusion and exclusion criteria that are set in advance. It also allows evaluation of sensitivity, specificity, predictive value, and diagnostic reliability found in the literature. The research design is suitable as it incorporates the evidence available worldwide to identify the best mode that offers the best diagnostic performance; ultrasound, thyroid profile testing, or the combination of both in the diagnosis of Hashimoto thyroiditis. The study has a methodological rigour and evidence-based conclusions; this is achieved by conducting structured screening and quality appraisal procedures.

2.2 Search Strategy

A comprehensive literature search was conducted using several major electronic databases, including such as PubMed, Scopus, Web of Science, Google Scholar, and ScienceDirect. The reason why PubMed was chosen is that it covers a lot of biomedical and clinical research especially in endocrinology and autoimmune diseases. Scopus and Web of Science were used as they are multidisciplinary indexing and citation tracking tools that enable finding highly-cited and influential studies. Capturing of the grey literature and recent publications that might be under indexing in the traditional databases was done through the use of Google Scholar which provided access to full-text articles in radiology and diagnostic imaging journals through ScienceDirect.

The search strategy has used definite keywords and Boolean operators to make sure it has narrowed down to to-the-point retrieval of the relevant literature. Such terms as Hashimoto thyroiditis AND ultrasound were used to find the studies that analyze imaging assessment, whereas Autoimmune thyroiditis AND diagnostic accuracy were used to search the studies that address the performance of diagnostic instruments. Serological assessment studies were included in the search results that included the key words such as Thyroid profile AND sensitivity and specificity; TSH AND anti-TPO antibodies AND diagnosis. To pursue the imaging features as well as the overall diagnostic

Vol. 5 No. 1 (2026)

Pakistan Journal of Medical & Cardiological Review

https://pakjmcr.com/index.php/1/about

Online ISSN 3007-2387 Print ISSN 3007-2379

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performance, the following keywords were used: Ultrasound echogenicity AND Hashimoto AND Diagnostic efficiency AND thyroiditis. This mixture made sure that there was a complete and applicable body of research that covered both lab and imaging tests in Hashimoto thyroiditis.

2.3 Inclusion and Exclusion Criteria.

Table 1: Inclusion and Exclusion Criteria for the study

Criteria Type	Inclusion Criteria	Exclusion Criteria
Study Design	Diagnostic accuracy studies, cohort studies, case-control studies, cross-sectional studies, systematic reviews	Case reports without diagnostic comparison, editorials, opinion articles
Population	Human patients diagnosed or suspected with Hashimoto's thyroiditis	Animal studies
Diagnostic Tools	Studies evaluating ultrasound, thyroid profile, or both	Studies evaluating only treatment outcomes
Outcomes	Sensitivity, specificity, predictive value, diagnostic reliability	Studies without measurable diagnostic outcomes
Language	English	Non-English publications
Publication Date	2014–2024	Published before 2014
Publication Type	Peer-reviewed journals	Conference abstracts without full text

2.4 Study Selection Process

PRISMA (Preferred Reporting Items to Systematic Reviews and Meta-Analyses) guidelines were followed in such a way that the review process of the research was rigorous and transparent. The design of the methodology was developed under four consecutive steps including namely,

Vol. 5 No. 1 (2026)
Pakistan Journal of Medical & Cardiological Review
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Online ISSN 3007-2387 Print ISSN 3007-2379
Tariq et al - 2026
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identification, screening, eligibility, and inclusion. In the identification, all records discovered in the sampled electronic databases were imported to the reference management software where the duplicates were carefully eliminated to avoid repetition and ensure that the next screening was accurate. The titles and abstracts of the rest of the articles were examined thoroughly during the screening process to determine the initial relevance, therefore, to sort out the obviously irrelevant studies.

Next, the eligibility phase consisted of the analysis of the whole text of the potentially useful articles on the answer to the particular objectives and questions of the research or not. Articles that were not qualitatively fit were summarily rejected and the reasons to reject them were appropriately documented to promote clarity and transparency. Finally, the reviewed research that satisfies all the requirements were counted as a part of the study, and both data extraction and synthesis were made on this basis. The PRISMA flow diagram was developed to visually represent all the stages of the process with the number of studies, where the location, screening, and eligibility, and incorporation took place. This methodology offered methodological soundness, repeatability or transparency when it came to the systematic review process.

2.5 Quality Assessment

Critical appraisal of the selected studies was conducted to enhance the quality of the methodology through CASP (Critical Appraisal Skills Programme) checklist. Validity, the appropriateness of the study design, risk of bias evaluation, clarity of the results, and applicability of findings were evaluated using the CASP diagnostic study checklist. The studies were rated using structured questions which covered internal validity, diagnostic measure precision and the relevance of the study to clinical practice. The methodological weaknesses in the studies were avoided or handled with care on synthesis.

Vol. 5 No. 1 (2026)

Pakistan Journal of Medical & Cardiological Review

https://pakjmcr.com/index.php/1/about

Online ISSN 3007-2387 Print ISSN 3007-2379

Tariq et al - 2026

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2.6 Data Extraction and Synthesis

A structured data extraction form was used to extract the data. Some of the variables that were extracted were: author name, year of publication, country, study design, sample size, diagnostic method evaluated, sensitivity, specificity, positive predictive value and some of the key findings. The Microsoft Excel was used to organise data in a tabular format. The methodology used in the comparison of the results of an ultrasound and thyroid profile between different studies was a narrative synthesis method. Where needed diagnostic accuracy measures were summarised and compared to find out which method proved more reliable. Synthesis was centered on the determination of patterns of consistency, differences among populations and the evidence of the combined diagnostic methods.

Results

Predefined keywords on the topic of Hashimoto thyroiditis, ultrasound, thyroid profile, diagnostic accuracy, CEUS, elastography, and radiomics were used to search through PubMed, Scopus, Web of Science, ScienceDirect, and Google Scholar. The preliminary database search gave a 701 records identification. Following the exportation of all references to EndNote and elimination of duplicates, 458 unique articles were left. These articles were screened on the basis of a title and abstract where the inclusion and exclusion criteria were established. At this phase, 109 records were eliminated as they were not related to diagnostic performance, were solely concerned with the outcome of treatment, or did not concern the issue of Hashimoto thyroiditis.

After the screening phase, 242 full-text articles were evaluated to check their eligibility. Full-text assessment saw the elimination of 224 studies because they did not have any measures of diagnostic outcomes, they had no sensitivity or specificity figures, were not human or the methodology was not very clear. Others were also eliminated due to the fact that they have evaluated thyroid nodules without particular evaluation in the presence of the thyroiditis of Hashimoto. To ensure transparency and methodological rigor, all exclusions were recorded.

Pakistan Journal of Medical & Cardiological Review
https://pakjmcr.com/index.php/1/about
Online ISSN 3007-2387
Print ISSN 3007-2379
Tariq et al - 2026
DOI: http://doi.org/10.5281/zenodo.19567715

Following the last eligibility check, 18 studies were selected according to all the inclusion criteria, and were eligible to be incorporated into the qualitative synthesis. These research studies included cross-sectional research studies, retrospective and prospective cohort research studies, systematic research studies and superior imaging model development research studies. The selection resulted in the final sample that represented both the equal representation of serum biomarkers, traditional ultrasound scoring systems, and more sophisticated imaging and artificial intelligence-based diagnostic methods with a final sample of 18 studies.

Vol. 5 No. 1 (2026)

Pakistan Journal of Medical & Cardiological Review

https://pakjmcr.com/index.php/1/about

Online ISSN 3007-2387

Print ISSN 3007-2379

Tariq et al - 2026

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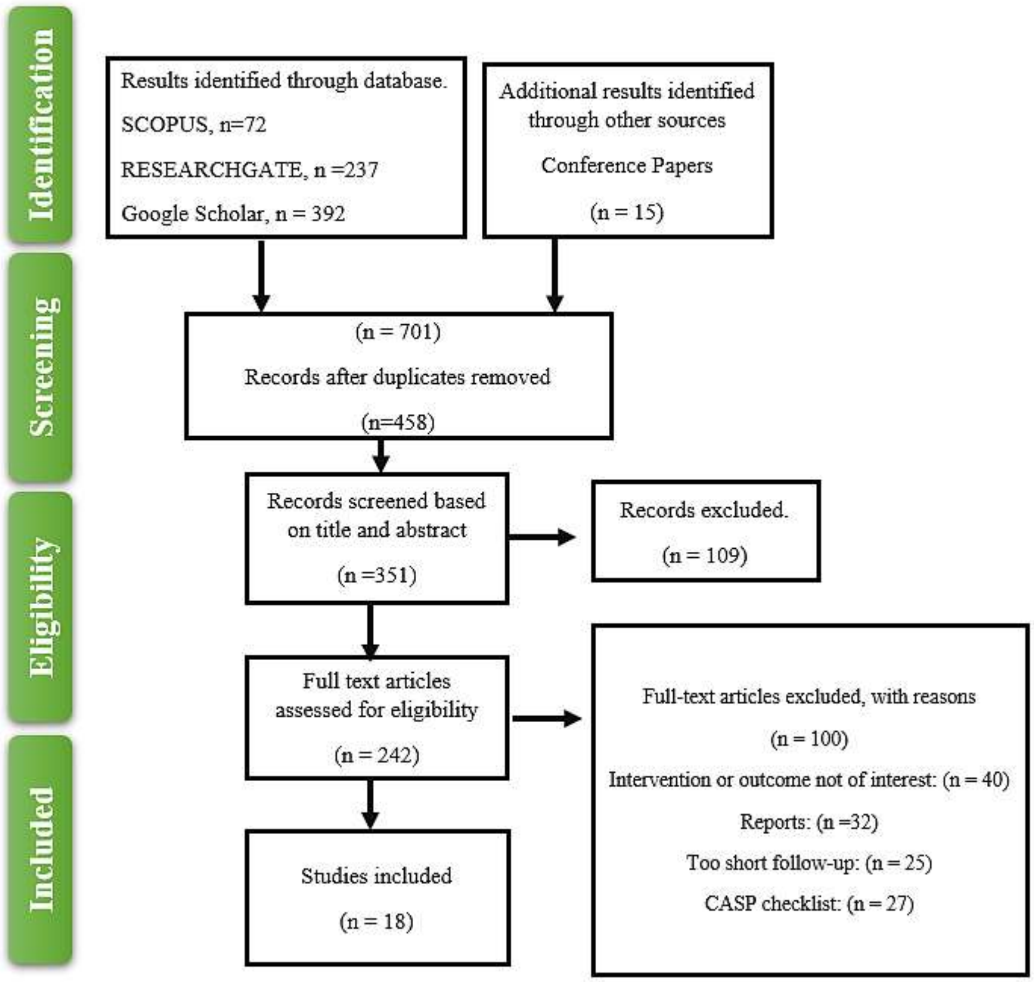

Figure 2: PRISMA flowchart of study selection process: Out of 701 records identified, 18 studies met the eligibility and quality criteria and were included in the final review

Vol. 5 No. 1 (2026)
Pakistan Journal of Medical & Cardiological Review
https://pakjmcr.com/index.php/1/about
Online ISSN 3007-2387 Print ISSN 3007-2379

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Table 2: Summary of Included Studies Categorised by Diagnostic Approach: This table presents the extracted results from the 18 included studies, organised into three major categories: conventional ultrasound risk stratification systems, advanced imaging techniques including elastography and contrast-enhanced ultrasound, and artificial intelligence with radiomics-based models. The categorisation highlights differences in study design, sample size, diagnostic performance metrics, and key clinical findings across diagnostic approaches in Hashimoto's thyroiditis.

Reference	Study Type	Population	Diagnostic Method	Key Diagnostic Performance	Main Contribution
Serum Biomarkers and Laboratory-Based Diagnostic Studies					
Tan et al., 2025	Cross-sectional	24,014 participants (6,195 HT)	Serum autoantibodies + Ultrasound	High specificity (≈90%) but low sensitivity (≈30%)	Lab markers correlate with HT risk but weak standalone sensitivity
Nishihara et al., 2017	Comparative immunoassay study	HT n=70 + other thyroid diseases	TgAb vs TPOAb (5 kits)	TgAb positivity higher than TPOAb in most kits	TgAb may be superior screening tool depending on assay
Zhao et al., 2024	Cohort ML study	272 HT patients	IgG4 TgAb & TPOAb + ML models	RF AUC 0.87–0.92	ML improves identification of high-risk IgG4 HT
Conventional Ultrasound and Risk Stratification Systems (TI-RADS / ATA)					

Online ISSN 3007-2387
Print ISSN 3007-2379
Tariq et al - 2026
DOI: http://doi.org/10.5281/zenodo.19567715

Chatti et al., 2023	Retrospective	198 nodules	EU vs ACR TI-RADS	AUC 0.81–0.82	Comparable performance
Torshizian et al., 2023	Prospective	571 nodules	ACR TI-RADS vs ATA	ACR AUC 0.776	ACR more sensitive, ATA more specific
Chen et al., 2022	Retrospective + reliability	749 nodules	Simplified TI-RADS	Sensitivity 94%	sTI-RADS improved consistency
Li et al., 2021	Meta-analysis	21,882 nodules	ACR TI-RADS	Pooled sensitivity 0.89	Strong evidence base for ACR system
Li et al. (C-TIRADS study)	Retrospective	204 nodules	C-TIRADS vs ACR	C-TIRADS AUC 0.941	C-TIRADS higher sensitivity in HT context
Khan et al., 2024	Cross-sectional	224 nodules	ACR TI-RADS	Sensitivity 87.5%, specificity 31.6%	High sensitivity but poor specificity in local population
Advanced Imaging, CEUS, Elastography, Radiomics and AI-Based Models					
Yang et al., 2024	Retrospective	242 HT patients	CEUS quantitative TIC	AUC 0.947 (PTL vs NHT)	CEUS strong differentiation tool
Wang et al., 2023	Diagnostic study	133 nodules in HT	CEUS + SWE	Combined sensitivity 94%	Combined imaging improves accuracy

Vol. 5 No. 1 (2026)

Pakistan Journal of Medical & Cardiological Review

https://pakjmcr.com/index.php/1/about

Online ISSN 3007-2387

Print ISSN 3007-2379

Tariq et al - 2026

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Fang et al., 2023	Radiomics modelling	227 HT patients	Ultrasound radiomics (TN+TG)	AUC improved to 0.94	Whole-gland radiomics improves prediction
Hu et al., 2021	CAD evaluation	148 patients	Ultrasound CAD	Sensitivity 89.8%	CAD improves junior radiologist performance
Durmaz et al., 2019	Case-control	80 HT vs 107 controls	SMI vascular index	Sensitivity 86.3%	Quantitative vascular marker for HT
Wu et al., 2025	Multicentre AI study	1,585 HT patients	DL + Radiomics model	AUC 0.917 validation	AI comparable to FNA
Jin et al.	Radiomics nomogram	235 PTC with HT	Clinical + radiomics	AUC 0.845	Improves CLNM prediction
Peng et al., 2019	Observational	69 HT patients	US + ARFI + CEUS	Significant malignant indicators	Multiparameter imaging improves differentiation

Serum Biomarkers and Laboratory-Based Diagnostic Approaches

Three articles were primarily concerned with serum biomarkers and laboratory-based diagnostic assessment in Hashimoto thyroiditis. Tan et al. (2025) presented huge cross-sectional research that involved over 24,000 individuals in order to evaluate the diagnostic advantages of serum thyroid autoantibodies and ultrasound relative to histopathology, which was used as a reference criterion. They stated that thyroid autoantibodies were highly specific and had high negative predictive value yet the sensitivity was very low. Sensitivity did not increase significantly even with the use of ultrasound as well. This implies that the presence of antibodies is a strong sign that a person is

Vol. 5 No. 1 (2026)

Pakistan Journal of Medical & Cardiological Review

https://pakjmcr.com/index.php/1/about

Online ISSN 3007-2387

Print ISSN 3007-2379

Tariq et al - 2026

DOI: http://doi.org/10.5281/zenodo.19567715

diseased, but that a substantial portion of the actual cases will be missed when using biochemical testing alone.

Conversely, Nishihara et al. (2017) determined the comparison of thyroglobulin antibodies (TgAb) and thyroid peroxidase antibodies (TPOAb) with five immunoassay kits. Their results indicated that TgAb positivity was common than TPOAb in patients of Hashimoto thyroiditis when the majority of kits were applied. This implies that diagnostic interpretation can be affected by the assay variability. It further points out that TgAb cannot be undermined as a screening marker, especially in certain groups of people. The research contributes to the supposition that TPOAb is invariably the best.

Based on the biomarker analysis, Zhao et al. (2024) used machine learning models to forecast the high-risk IgG4-related Hashimoto thyroiditis with antibody subtypes. They discovered that the model of Random Forest shows good diagnostic performances with high sensitivity and reasonable specificity. Interestingly, there was no significant difference in the ultrasound features in the case of the groups with IgG4 and non-IgG4 groups, which indicates that laboratory markers with computational modelling can identify subtypes that would otherwise be unidentified by imaging alone. Collectively, these research findings suggest that even though conventional serum markers are highly specific, incorporation of sophisticated models of analysis could yield improved diagnostic accuracy.

Traditional Ultrasound and Risk Stratification System.

Conventional Ultrasound and Risk Stratification Systems

- **Diagnostic Performance of ACR TI-RADS and EU TI-RADS Systems**

Some of the studies compared the effectiveness of structured ultrasound scoring systems in the assessment of thyroid malignancy in the context of Hashimoto thyroiditis. Chatti et al. (2023) provided a retrospective study involving 198 nodules and compared EU TI-RADS and ACS TI-RADS with a gold standard of histopathology. They have discovered that there were similar overall diagnostic performance within the two systems and the similar areas under the ROC curve.

Online ISSN 3007-2387
Print ISSN 3007-2379

DOI: http://doi.org/10.5281/zenodo.19567715

Nonetheless, ACR TI-RADS proved to have a greater specificity in category 5 nodules, whereas the EU TI-RADS had a high sensitivity in category 4 + 5 nodules. This implies that the two systems are applicable though they might differ slightly based on risk levels.

In the same vein, Torshizian et al. (2023) have conducted a prospective study that worked on 571 thyroid nodules to compare ACR TI-RADS with ATA guidelines. In their results, ACS TI-RADS was demonstrated to have a greater sensitivity and lower unnecessary biopsies than ATA. Nevertheless, ATA was more specific in some of the thresholds. It implies that there is a trade-off between the minimization of missed malignancies and the reduction of over-biopsy rates.

In line with these findings, Li et al. (2021) have performed a meta-analysis of over 21,000 nodules. They indicated pooled sensitivity of 0.89 and moderate specificity of 0.70 of ACR TI-RADS. Their findings validated that ACS TI-RADS is effective in the sensitivity of malignancy risk stratification but can be affected by lack of specificity in certain circumstances. Altogether, such studies imply that standard TI-RADS systems offer structured and credible models, yet diagnostic balance is conditioned on selected cut-off categories.

- **Comparison Between ACR TI-RADS, C-TIRADS, and Population-Based Validation Studies**

Chen et al. (2022) made additional comparative assessment and introduced a simplified TI-RADS scoring system to compare it with the 2017 ACR and 2020 C-TIRADS systems. In their retrospective study of 749 nodules, they found that the simplified TI-RADS had a higher sensitivity and a high inter-observer consistency. The suggested scoring system was simpler to risk stratify and also had high diagnostic performance. This points to the fact that development of ultrasound scoring systems can enhance systematicness in clinical practice.

The given case of 204 pathologically confirmed nodules of thyroiditis in Li et al. (C-TIRADS study) was evaluated and compared ACR TI-RADS with C-TIRADS. They established that C-TIRADS was larger in sensitivity, and AUC significantly higher than ACS TI-RADS. Moreover, C-TIRADS also

Vol. 5 No. 1 (2026)
Pakistan Journal of Medical & Cardiological Review
https://pakjmcr.com/index.php/1/about
Online ISSN 3007-2387
Print ISSN 3007-2379
Tariq et al - 2026
DOI: http://doi.org/10.5281/zenodo.19567715

reduced the unnecessarily high number of fine-needle aspiration. This means that local changes of TI-RADS may be handy in the better diagnostic accuracy of autoimmune thyroid cases.

In their validation study regionally, Khan et al. (2024) compared ACR TI-RADS and Bethesda cytology on 224 patients. Sensitivity was excellent but specificity was very low that gave moderate accuracy. It implies that the performance of TI-RADS may not be universal among individuals and health care facilities. All of these studies indicate that structured ultrasound systems are useful, yet the diagnostic efficiency should be based on the changes in scoring and the demographic setting..

Table 3: Conventional risk stratification systems maintain strong sensitivity in Hashimoto's thyroiditis. However, specificity varies across systems. Modified or regional adaptations such as C-TIRADS show higher diagnostic precision in inflammatory thyroid backgrounds

Study	Scoring System / Modality	Reference Standard	Sensitivity (%)	Specificity (%)	AUC	Clinical Implication in HT Context
Li et al. (2019)	ACR TI-RADS (Meta-analysis)	FNAB / Histopathology	89	70	0.86	High sensitivity but moderate specificity; reduces unnecessary biopsies
Chatti et al. (2023)	EU TI-RADS vs ACR TI-RADS	Histology	89 (EU 4+5)	82 (EU 5)	0.81–0.82	Comparable performance; risk stratification remains

Vol. 5 No. 1 (2026)

Pakistan Journal of Medical & Cardiological Review

https://pakjmcr.com/index.php/1/about

Online ISSN 3007-2387 Print ISSN 3007-2379

Tariq et al - 2026

DOI: http://doi.org/10.5281/zenodo.19567715

						reliable in inflammatory background
Torshizian et al. (2023)	ACR TI-RADS vs ATA	FNAC / Histology	72.3 (ACR)	79.2 (ACR)	0.776	ACR reduces unnecessary FNAs but may miss low-risk malignancies
Khan et al. (2024)	ACR TI-RADS	Bethesda FNAC	87.5	31.6	—	Excellent sensitivity; poor specificity in Pakistani population
Chen et al. (2022)	Simplified TI-RADS (sTI-RADS)	Histology	94.0	67.4	—	Improved specificity and interobserver consistency
Li Chaoxi et al. (2021)	C-TIRADS vs ACR	Surgical pathology	91.7 (C-TIRADS)	98.3 (C-TIRADS)	0.941	Superior performance of C-TIRADS in HT-associated nodules

Vol. 5 No. 1 (2026)

Pakistan Journal of Medical & Cardiological Review

https://pakjmcr.com/index.php/1/about

Online ISSN 3007-2387

Print ISSN 3007-2379

Tariq et al - 2026

DOI: http://doi.org/10.5281/zenodo.19567715

Advanced Imaging Modalities and Artificial Intelligence-Based Models

- **Contrast-Enhanced Ultrasound (CEUS) in Hashimoto's Thyroiditis**

High-level imaging has also been actively investigated, including contrast-enhanced ultrasound (CEUS), to enhance the diagnostic capabilities of Hashimotos thyroiditis. Yang et al. (2024) used a retrospective cohort study in 242 patients with thyroid nodules and having a concomitant diagnosis of Hashimoto thyroiditis. On the basis of time-intensity curve analysis, they showed that parameters of the CEUS like peak intensity, and time to peak were significantly differentiating primary thyroid lymphoma and nodular Hashimoto thyroiditis. The summative quantitative CEUS indicators obtained an area under the curve of 0.947 which is a great indicator of diagnostic performance. This implies that, CEUS is able to give supplementary microvascular data that cannot be captured by the conventional ultrasound.

On the same note, Yang et al. (PTL vs NHT study) tested the features of CEUS in 60 patients with heterogeneous background having Hashimoto thyroiditis. They claimed that the quantitative CEUS parameters including the peak intensity ratio and the area under the curve ratio have a significant improvement in the differentiation between the nodular disease and lymphoma. The integrated CEUS model had the highest sensitivity and specificity of AUC of 0.92. The results suggest that CEUS is especially useful when diffuse inflammatory processes disfigure conventional ultrasound images.

Collectively, these studies indicate the fact that CEUS has the capability of improving the characterization of lesions by evaluation of vascular patterns and dynamic perfusion data. In thyroiditis of Hashimoto, where the heterogeneity of parenchyma in the background may decrease diagnostic specificity, CEUS seems to be a better discrimination of malignant and benign pathology.

- **Shear Wave Elastography and Microvascular Imaging Techniques**

Elastography and microvascular imaging also have demonstrated capability of enhancing diagnosis examination. Wang et al. (2023) evaluated the added value of CEUS + shear wave elastography (SWE) in distinguishing between benign and malignant nodules of TI-RADS 4 and 5 that are co-

Online ISSN 3007-2387 Print ISSN 3007-2379

Tariq et al - 2026

DOI: http://doi.org/10.5281/zenodo.19567715

existing with Hashimoto thyroiditis. According to them, SWE was the only one that was highly specific and CEUS was highly sensitive. Notably the combined method far enhanced the general diagnostic accuracy and high sensitivity than the two methods used individually. It implies that a merge between vascular analysis and assessment of tissue stiffness will give complementary diagnostic data.

The study of vascularization was conducted by Durmaz et al. (2019) on children with Hashimoto thyroiditis through superb microvascular imaging analysis of vascularization index. Their case-control study showed that the values of the vascularization index were quite higher in the HT patients than in the healthy controls. Sensitivity was 86.3%, and specificity was 82.2. In addition, the vascularization index had a positive correlation to thyroid-stimulating hormone and antibody. It means that the quantitative vascular assessment is indicative of the inflammatory activity.

Also, multiparameter ultrasound assessment including acoustic radiation force impulse imaging and CEUS proved that the characteristics of microcalcifications, indistinct margins, and low index of peak intensity were autonomous prognosticators of malignancy in the presence of Hashimoto thyroiditis. The results indicate that combined stiffness and vascular characteristics promote the differentiation of malignant nodules in inflammatory glands.

- **Radiomics and Artificial Intelligence-Based Diagnostic Models**

The development of radiomics and artificial intelligence (AI) algorithms is another step toward accurate diagnosis. Fang et al. (2023) proposed a radiomics model of thyroid nodule using ultrasound images and features of the entire glands in 227 patients with Hashimoto thyroiditis. They proved the inclusion of gland-level radiomics features greatly enhanced the diagnostic performance with the AUC increasing to 0.94. It is important to note that the analysis of the entire gland is important and not just its nodules.

Hu et al. (2021) assessed a computer-aided diagnosis (CAD) system in thyroid nodules in patients with simultaneous Hashimoto thyroiditis. Although the CAD system was similar in sensitivity with the experienced radiologists, it had lower specificity. Nevertheless, in the case of helping less

Pakistan Journal of Medical & Cardiological Review
https://pakjmcr.com/index.php/1/about
Online ISSN 3007-2387
Print ISSN 3007-2379
Tariq et al - 2026
DOI: http://doi.org/10.5281/zenodo.19567715

experienced radiologists, diagnostic sensitivity and the general accuracy increased significantly. It means that AI support systems could increase diagnostic consistency.

This method was further enhanced by Wu et al. (2025) who created a deep learning radiomics (DLR) model based on 1,585 patients in various centres. The model had excellent AUC value and similar performance with the fine-needle aspiration and genetic testing. In addition, it enhanced the performance of clinicians in reader studies. The findings indicate the possibility of AI-based models in decreasing the number of unnecessary biopsies and ensuring high diagnostic sensitivity in Hashimoto thyroiditis.

Table 4: Advanced imaging modalities provide microvascular and stiffness information not visible on conventional ultrasound. CEUS particularly improves differentiation in diffuse HT parenchyma, where structural heterogeneity reduces traditional accuracy

Study	Imaging Technique	Target Differentiation	Sensitivity (%)	Specificity (%)	AUC	Added Diagnostic Value
Wang et al. (2023)	CEUS + SWE	Benign vs Malignant nodules	94.0 (combined)	66.0	0.80	Combination improves sensitivity and accuracy
Yang et al. (2024)	CEUS quantitative TIC	PTL vs Nodular HT	—	—	0.947	Excellent discrimination in complex inflammatory background

Vol. 5 No. 1 (2026)

Pakistan Journal of Medical & Cardiological Review

https://pakjmcr.com/index.php/1/about

Online ISSN 3007-2387

Print ISSN 3007-2379

Tariq et al - 2026

DOI: http://doi.org/10.5281/zenodo.19567715

Yang et al. (PTL vs NHT study)	CEUS imaging + ratios	PTL vs NHT	83.9	87.9	0.92	Conjoint CEUS features significantly outperform conventional US
Durmaz et al. (2019)	SMI Vascularization Index	HT vs Healthy controls	86.3	82.2	—	Objective quantification of inflammation severity
Multiparameter US Study	CEUS + ARFI-VTIQ	Benign vs PTC in HT	—	—	—	Peak intensity index <1 and stiffness improve malignancy prediction

Discussion

This systematic literature review evaluated the diagnostic efficiency of ultrasound modalities and thyroid profile parameters in Hashimoto's thyroiditis (HT). The results of the eighteen chosen studies indicate that despite the high sensitivity of traditional ultrasound scoring tools like ACR TI-RADS and EU TI-RADS, all of them have moderate specificity and unreliable in the inflammatory background of HT. Li et al. meta-analysis revealed that ACR TI-RADS has a pooled sensitivity of 89

Online ISSN 3007-2387
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and a specificity of 70 meaning that the test is effective in eliminating malignancy but might give false alarms. Likewise, Torshizian et al. found more sensitive ACR TI-RADS than ATA guidelines, at the expense of losing some low-risk malignancies. This evidence indicates that even though traditional systems are beneficial, inflammatory events in HT make them less accurate in diagnosis (Mahmoud, 2022).

The outcomes also underscore the increased significance of advanced imaging modalities. The comparison of the studies on contrast-enhanced ultrasound (CEUS), shear wave elastography (SWE) and microvascular imaging revealed a better ability to differentiate between benign and malignant nodules in patients with HT. Wang et al. showed that the sensitivity was higher with the combination of CEUS and SWE to 94% and this enhances the overall diagnostic accuracy. Similarly, the quantitative CEUS parameters of distinguishing between primary thyroid lymphoma and nodular Hashimoto thyroiditis reported by Yang et al. had an AUC of 0.947. These results suggest that microvascular parameters of perfusion and stiffness have supplementary objective data that traditional grayscale ultrasound cannot attain. This additional vascular and elasticity data is of clinical importance in the environment of diffuse parenchymal heterogeneity (Li et al., 2024).

The other discussion aspect that is important to mention is the issue of artificial intelligence and radiomics-based models. The radiomics literature by Fang et al. and Wu et al. demonstrated that their AUC values were 0.94 and 0.917 respectively, and these are comparable to invasive diagnostic techniques like the fine needle aspiration (FNA). Wu et al. used a deep learning radiomics (DLR) model that showed similar diagnostic results when compared with FNA with genetic mutation analysis. These outcomes imply that AI-aided ultrasound analysis can be a non-invasive alternative tool or an adjunct in the clinical practice in the future. Moreover, other researchers like Hu et al. established that computer-aided diagnosis systems were observed to play an important role in enhancing the performance of less experienced radiologists, thus lowering the variability in interpretation (Delgadillo & Agrawal, 2026).

Pakistan Journal of Medical & Cardiological Review
https://pakjmcr.com/index.php/1/about
Online ISSN 3007-2387
Print ISSN 3007-2379
Tariq et al - 2026
DOI: http://doi.org/10.5281/zenodo.19567715

In the comparison of the imaging and thyroid autoantibody tests, the findings reveal that serum markers (TgAb and TPOAb) are closely linked with HT but the low independent power to detect malignancy. In Tan et al., there was high specificity and low sensitivity with either the use of autoantibodies or ultrasound alone or a combination of the two. This strengthens the notion that biochemical tests will aid in the diagnosis of autoimmune activity but not structural imaging in risk stratifying malignancy.

In general, the results show a development of diagnosis. Traditional TI-RADS offer the base of risk evaluation. Elaborate ultrasound technologies enhance selectivity of complicated inflammatory environment. Radiomics models derived by AIs demonstrate the best predictive ability and can potentially decrease unnecessary biopsies in future. Nevertheless, specificity and heterogeneity variability across study populations indicate the necessity to use standardized protocols and require multicenter validation. All these findings are indicative of a multimodal diagnosis. A combination of clinical information, thyroid profile, superior ultrasound and artificial intelligence seems to provide the most promising direction in assessing nodules among patients with Hashimoto thyroiditis.

Vol. 5 No. 1 (2026)
Pakistan Journal of Medical & Cardiological Review
https://pakjmcr.com/index.php/1/about
Online ISSN 3007-2387
Print ISSN 3007-2379
Tariq et al - 2026
DOI: http://doi.org/10.5281/zenodo.19567715

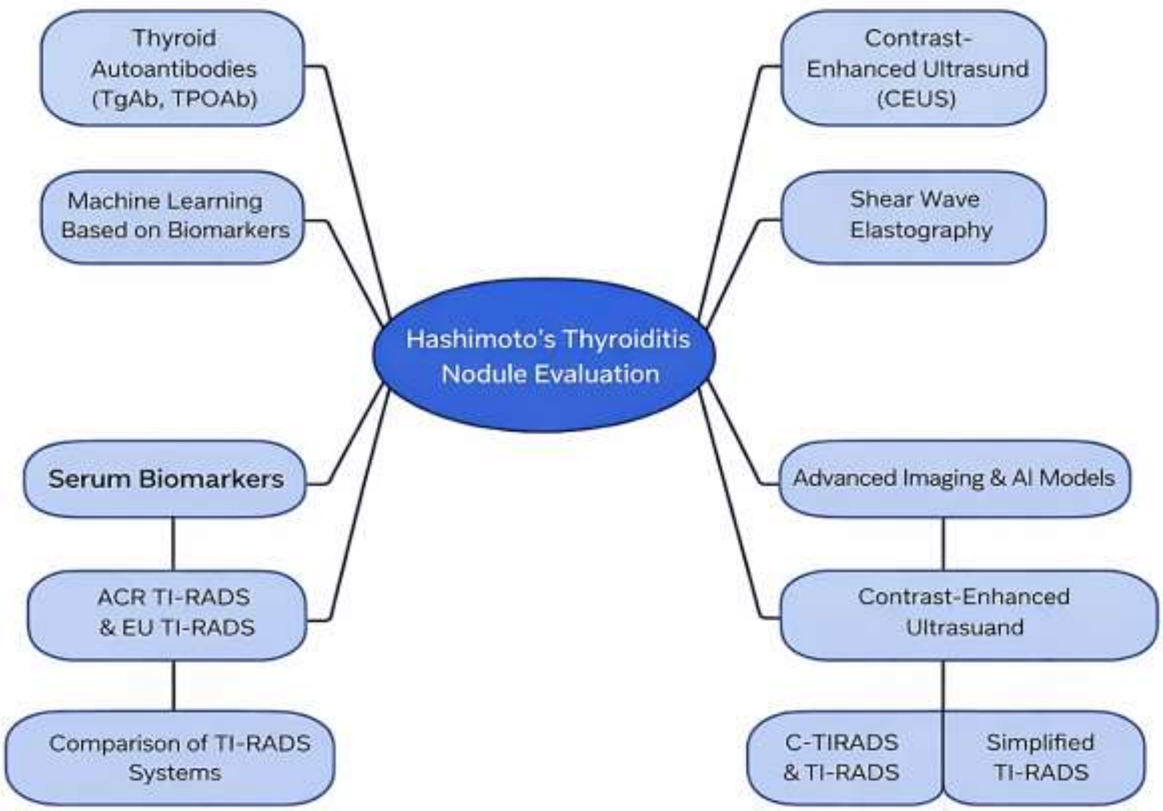

Figure 3: Concept Map of Diagnostic Approaches in Hashimoto's Thyroiditis Nodule Evaluation: This concept map illustrates the key diagnostic pathways explored in the study, including serum biomarkers, conventional ultrasound risk stratification systems, and advanced imaging with artificial intelligence models. It visually represents the relationships between traditional laboratory testing and emerging imaging technologies used to improve diagnostic accuracy in Hashimoto's thyroiditis (Source: NVivo).

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Conclusion

This study conducted a systematic literature review that assessed the diagnostic effectiveness of ultrasound modalities and thyroid profile parameters in patients with the Hashimoto thyroiditis. The results indicate that the common ultrasound scoring systems like ACR TI-RADS have excellent

Pakistan Journal of Medical & Cardiological Review
https://pakjmcr.com/index.php/1/about
Online ISSN 3007-2387 Print ISSN 3007-2379
Tariq et al - 2026
DOI: http://doi.org/10.5281/zenodo.19567715

sensitivity and poor specificity in the inflammatory background of HT. One of the latest methods such as contrast-enhance ultrasound, shear wave elastography, and microvascular images have enhanced the diagnostic accuracy due to the availability of quantitative vascular and stiffness information. Artificial intelligence and radiomics based models showed the best diagnostic accuracy, and its performance was similar to invasive measures in a number of studies. Nonetheless, serum thyroid antibodies are supportive and not confirmatory diagnostic tools that can identify the risk of malignancy. On the whole, there are indications that no single modality is adequate in itself. The synthesis of clinical manifestation, laboratory signs, high-quality ultrasound, and AI-assisted analysis could be the most effective and safe method of examining thyroid nodules in Hashimoto thyroiditis. More multicenter validation is suggested.

References

Al-Suhaimi, E. A., & Khan, F. A. (2022). Thyroid glands: Physiology and structure. In *Emerging concepts in endocrine structure and functions* (pp. 133-160). Singapore: Springer Nature Singapore.

Angelopoulos, N., Goulis, D. G., Chrisogonidis, I., Giannoula, E., & Iakovou, I. (2023). Ultrasound characteristics of Hashimoto's thyroiditis in the subclinical stages of the disease. *WFUMB Ultrasound Open*, *1*(2), 100022.

Can, T.S., Özdemir, S., İkizceli, T., Yılmaz, B.K., Sarı, M.A., Türkay, R. and Doğan, Ö. (2025) 'Vascularity assessment in Hashimoto's thyroiditis: a prospective comparative study with power Doppler and superb microvascular imaging', *Diagnostic and Interventional Radiology*, online ahead of print (27 Aug). https://doi.org/10.4274/dir.2025.253311

Ceylan, I., Yener, S., Bayraktar, F., & Secil, M. (2014). Roles of ultrasound and power Doppler ultrasound for diagnosis of Hashimoto thyroiditis in anti-thyroid marker-positive euthyroid subjects. *Quantitative imaging in medicine and surgery*, *4*(4), 232.

Online ISSN 3007-2387 Print ISSN 3007-2379

DOI: http://doi.org/10.5281/zenodo.19567715

Chatti, H.-A., Oueslati, I., Azaiez, A., Marrakchi, J., Boukriba, S., Mizouni, H., Haouet, S., Besbes, G., Yazidi, M. and Chihaoui, M. (2023) 'Diagnostic performance of the EU TI-RADS and ACR TI-RADS scoring systems in predicting thyroid malignancy', *Endocrinology, Diabetes & Metabolism*, 6(4), e434. https://doi.org/10.1002/edm2.434

Chen, Z., Du, Y., Cheng, L. *et al.* (2022) 'Diagnostic performance of simplified TI-RADS for malignant thyroid nodules: comparison with 2017 ACR-TI-RADS and 2020 C-TI-RADS', *Cancer Imaging*, 22, 41. https://doi.org/10.1186/s40644-022-00478-y

Couto, B., Neves, C., Neves, J. S., & Delgado, L. (2024). Thyroid function, autoimmunity, thyroid volume, and metabolic profile in people with Hashimoto thyroiditis. *BMC Endocrine Disorders*, *24*(1), 281.

Delgadillo, F., & Agrawal, D. K. (2026). Immunopathogenesis, Diagnosis, and Treatment of Hashimoto's Thyroiditis. *Archives of Internal Medicine Research*, *9*, 01-13.

Durmaz, M.S., Akyürek, N., Kara, T., Ateş, F., Özbakir, B., Gökgöz Durmaz, F., Soğukpinar Karaağaç, S. and Öztürk, M. (2019) 'Quantitative assessment of thyroid gland vascularization with vascularization index using color superb microvascular imaging in pediatric patients with Hashimoto thyroiditis', *Ultrasound Quarterly*, 35(3), pp. 281–289. https://doi.org/10.1097/RUQ.0000000000000430

Eftekharian, F., Omrani, G. R., Dabbaghmanesh, M. H., Sahraei, R., Behnam, M. A., Bakhshayeshkaram, M., & Dabbaghmanesh, M. M. (2024). Comparison of Thyroid Gland Sonography Index with Serum Antithyroid Peroxidase, Antithyroglobulin, and Thyroid Function Tests in Patients with Hashimoto Thyroiditis. *Galen Medical Journal*, *13*, e3309.

Fang, M., Lei, M., Chen, X., Cao, H., Duan, X., Yuan, H. and Guo, L. (2023) 'Radiomics-based ultrasound models for thyroid nodule differentiation in Hashimoto's thyroiditis', *Frontiers in Endocrinology*, 14, 1267886. https://doi.org/10.3389/fendo.2023.1267886

Hu, M., Zong, S., Xu, N., Li, J., Xia, C., Yu, F., Zhu, Q. and Zhao, H. (2022) 'The value of thyroid ultrasound computer-aided diagnosis system in the evaluation of thyroid nodules with concurrent Hashimoto's thyroiditis', *Journal of Ultrasound in Medicine*, 41(5), pp. 1117–1124. https://doi.org/10.1002/jum.15801

Jin, P., Chen, J., Dong, Y. *et al.* (2022) 'Ultrasound-based radiomics nomogram combined with clinical features for prediction of central lymph node metastasis in papillary thyroid carcinoma patients with Hashimoto's thyroiditis', *Frontiers in Endocrinology*, 13, 993564. https://doi.org/10.3389/fendo.2022.993564

Kapali, A., Beerappa, J., Raghuram, P., & Bangar, R. (2017). Diagnostic accuracy of ultrasound imaging in Hashimoto's thyroiditis. *Thyroid Research and Practice*, *14*(1), 28-31.

Kenarlı, K., Bahçecioğlu, A. B., Aksu, Ö. B., & Güllü, S. (2024). Are sonographic characteristics of Hashimoto's thyroiditis related with immunologic parameters? A cross-sectional study. *Journal of Endocrinological Investigation*, *47*(7), 1701-1709.

Khan, T.B., Shaikh, T.A., Akram, S., Ali, R., Zia, W., Khan, T. and Maqbool, S. (2025) 'Determination of diagnostic accuracy of ACR-TI-RADS in detecting malignancy in thyroid nodules on ultrasonography, keeping Bethesda cytological score at FNAC as gold standard', *Pakistan Journal of Health Sciences*, 6(3), pp. 291–295. https://doi.org/10.54393/pjhs.v6i3.2685

Khan, Y. S., & Farhana, A. (2019). Histology, thyroid gland.

Koprowski, R., Korzyńska, A., Wróbel, Z., Zieleźnik, W., Witkowska, A., Małyszek, J. and Wójcik, W., 2012. Influence of the measurement method of features in ultrasound images of the thyroid in the diagnosis of Hashimoto's disease. *Biomedical engineering online*, *11*(1), p.91.

Li, C., Wen, D., Lu, H., Chen, Y. and Liu, X. (2022) 'The value of ACR-TI-RADS and C-TI-RADS in the diagnosis of nodular Hashimoto thyroiditis and papillary thyroid carcinoma with Hashimoto thyroiditis', *Journal of Clinical Otorhinolaryngology Head and Neck Surgery*, 36(6), pp. 447–452. https://doi.org/10.13201/j.issn.2096-7993.2022.06.008

Pakistan Journal of Medical & Cardiological Review
https://pakjmcr.com/index.php/1/about
Online ISSN 3007-2387
Print ISSN 3007-2379
Tariq et al - 2026
DOI: http://doi.org/10.5281/zenodo.19567715

Li, J., Huang, Q., Sun, S., Zhou, K., Wang, X., Pan, K., ... & Li, D. (2024). Thyroid antibodies in Hashimoto's thyroiditis patients are positively associated with inflammation and multiple symptoms. *Scientific Reports*, *14*(1), 27902.

Li, W., Wang, Y., Wen, J., Zhang, L. and Sun, Y. (2021) 'Diagnostic performance of American College of Radiology TI-RADS: a systematic review and meta-analysis', *American Journal of Roentgenology*, 216(1), pp. 38–47. https://doi.org/10.2214/AJR.19.22691

Mahmoud, R., Azeem, K. M., Sayed, A. S. A., & Ali, F. M. (2022). Role of ultrasound and Doppler findings as a predictor of thyroid hormonal levels in cases of Hashimoto thyroiditis. *Beni-Suef University Journal of Basic and Applied Sciences*, *11*(1), 28.

Nishihara, E., Amino, N., Kudo, T., Ito, M., Fukata, S., Nishikawa, M., Nakamura, H. and Miyauchi, A. (2017) 'Comparison of thyroglobulin and thyroid peroxidase antibodies measured by five different kits in autoimmune thyroid diseases', *Endocrine Journal*, 64(10), pp. 955–961. https://doi.org/10.1507/endocrj.EJ17-0164

Pace, D., & Colagrande, E. (2024). *Thyroid: The Butterfly of Metabolism*.

Peng, Q., Niu, C., Zhang, M., Peng, Q. and Chen, S. (2019) 'Sonographic characteristics of papillary thyroid carcinoma with coexistent Hashimoto's thyroiditis: conventional ultrasound, ARFI imaging and contrast-enhanced ultrasound', *Ultrasound in Medicine & Biology*, 45(2), pp. 471–480. https://doi.org/10.1016/j.ultrasmedbio.2018.10.020

Staii, A., Mirocha, S., Todorova-Koteva, K., Glinberg, S., & Jaume, J. C. (2010). Hashimoto thyroiditis is more frequent than expected when diagnosed by cytology which uncovers a pre-clinical state. *Thyroid research*, *3*(1), 11.

Tan, H. L., Ge, H., Qin, Z. E., Jiang, Y. L., Chang, S., & Tang, N. (2025). Evaluating the diagnostic efficiency of ultrasound and serum autoantibodies in Hashimoto's thyroiditis: a cross-sectional study. *Scientific Reports*, *15*(1), 12674.

Vol. 5 No. 1 (2026)

Pakistan Journal of Medical & Cardiological Review

https://pakjmcr.com/index.php/1/about

Online ISSN 3007-2387

Print ISSN 3007-2379

Tariq et al - 2026

DOI: http://doi.org/10.5281/zenodo.19567715

Torshizian, A., Hashemi, F., Khoshhal, N., Ghodsi, A., Rastegar, H., Mousavi, Z., Dadgar Moghadam, M. and Mohebbi, M. (2023) 'Diagnostic performance of ACR TI-RADS and ATA guidelines in the prediction of thyroid malignancy: a prospective study and literature review', *Diagnostics*, 13(18), 2972. https://doi.org/10.3390/diagnostics13182972

Wang, B., Ou, X., Yang, J., Zhang, H., Cui, X.-W., Dietrich, C.F. and Yi, A.-J. (2023) 'Contrast-enhanced ultrasound and shear wave elastography in the diagnosis of ACR TI-RADS 4 and 5 thyroid nodules coexisting with Hashimoto's thyroiditis', *Frontiers in Oncology*, 12, 1022305. https://doi.org/10.3389/fonc.2022.1022305

Wu, F., Pan, T., Huang, X., Huang, K., Shi, J., Mao, L., Ni, Y., Luo, D. and Zhang, Y. (2025) 'Revolutionizing thyroid nodule diagnosis in Hashimoto's thyroiditis: AI-driven radiomics and deep learning model', *[Journal details in PubMed record]*. https://doi.org/10.1097/JS9.0000000000004546

Yang, L., Zhao, H., He, Y., Zhu, X., Yue, C., Luo, Y. and Ma, B. (2021) 'Contrast-enhanced ultrasound in the differential diagnosis of primary thyroid lymphoma and nodular Hashimoto's thyroiditis', *Frontiers in Oncology*, 10, 597975. https://doi.org/10.3389/fonc.2020.597975

Yang, W., Zhou, J., Yue, C., He, Y., Lei, J., Chen, Y. and Ma, B. (2024) 'Clinical value of contrast-enhanced ultrasound quantitative analysis for differentiating thyroid lesions in Hashimoto's thyroiditis patients', *Quantitative Imaging in Medicine and Surgery*, 14(1), pp. 944–957. https://doi.org/10.21037/qims-23-601

Zhao, C., Sun, Z., Yu, Y., Lou, Y., Liu, L., Li, G., Liu, J., Chen, L., Zhu, S., Huang, Y., Zhang, Y. and Gao, Y. (2024) 'A machine learning-based diagnosis modeling of IgG4 Hashimoto's thyroiditis', *Endocrine*, 86(2), pp. 672–681. https://doi.org/10.1007/s12020-024-03889-y