Shear Wave Elastography in the Diagnosis of Thyroid Nodules with Coexistent Chronic Autoimmune Hashimoto’s Thyroiditis

Baoxian Liu, MD, PhD1*, Jinyu Liang, MD, PhD1*, Luyao Zhou, MD1, Ying Lu, MD1, Yanling Zheng, MD, PhD1, Wenshuo Tian, MD, PhD1, and Xiaoyan Xie, MD, PhD1

No sponsorships or competing interests have been disclosed for this article.

Abstract

Objective. To evaluate the diagnostic performance of shear wave elastography (SWE) in the differentiation of malignant and benign thyroid nodules with coexistent Hashimoto’s thyroiditis (HT).

Study Design. Case series with chart review.

Setting. Tertiary general hospital.

Subjects and Methods. From September 2012 to January 2014, conventional ultrasound and SWE were performed on 243 patients with 286 thyroid nodules with histologic results. The HT group consisted of 93 patients with 117 nodules. The non-HT group consisted of 140 patients with 169 nodules.

Results. In the benign and malignant nodules, there were no significant differences of the mean, minimum, or maximum SWE values between HT and non-HT groups (P = .158-.945). However, SWE values of extranodular tissue were significantly higher in the HT group (P = .000-.011). In the HT group, the maximum SWE value showed the highest area under the receiver operating characteristic curve (0.817; 95% confidence interval, .735-.900), and there were no significant differences when compared with other SWE parameters (P = .669-.848). In the multivariate analysis, hypoechogenicity (odds ratio = 9.855, P = .002), microcalcification (odds ratio = 3.977, P = .046), and maximum SWE value (odds ratio = 40.712, P < .001) were independent predictors of thyroid malignancy.

Conclusions. SWE could be performed to obtain a differential diagnosis between malignant and benign thyroid nodules, including nodules with coexistent HT. Although all the SWE parameters within a 2-mm region of interest that was placed on the stiffest region could be applied, we suggest that the maximum value of nodules harbored within a Hashimoto’s gland be used.

Keywords

shear wave elastography, Thyroid nodule, Hashimoto’s thyroiditis, malignancy

Received March 24, 2015; revised June 25, 2015; accepted July 22, 2015.
Moreover, this technique is not reliable in nodules with coexistent HT, because the estimation of elasticity may be altered by the stiffness of surrounding tissue.9

Shear wave elastography (SWE) is a new real-time elastography technique that provides a map of the elasticity within a region and allows quantitative analysis of stiffness. It is based on a combination of (1) the radiation force that is induced in tissue by a US beam and (2) an ultrafast imaging sequence capable of capturing the propagation of the resulting shear waves; the wave propagation is thus affected by local viscoelastic properties of tissue, and it can be used to estimate tissue stiffness, expressed as Young’s modulus (kPa).3 Most previous studies have evaluated SWE for the differentiation of thyroid nodules in a general population, with promising results.2,3,13 Moreover, SWE can overcome some of the limitations of strain elastography with high reproducibility and quantitative elasticity measurement.14

Therefore, the aim of this study was to evaluate whether SWE should be applied to detect malignancy in thyroid nodules associated with chronic autoimmune HT.

Materials and Methods

This retrospective study was performed according to the guidelines of the Helsinki Declaration. It was registered and approved by the ethics committee at The First Affiliated Hospital of Sun Yat-sen University. All patients gave written informed consent before treatment.

Patients

Between September 2012 and January 2014, 233 patients were consecutively enrolled in this study who had been scheduled for thyroid surgery and together possessed 286 nodules (mean size: 2.1 ± 1.4 cm; size range: 0.3-8.9 cm). There were 57 male patients and 176 female patients (mean age: 45.8 ± 13.5 years; age range: 11-83 years). The patients’ inclusion criteria were as follows: (1) presence of ≥1 thyroid nodules and surgery performed within 3 months after US examination, (2) no previous treatment performed for thyroid nodules and no history of radiotherapy of head and neck regions, and (3) preoperative positive thyroglobulin antibody (Tg-Ab) and thyroid peroxidase antibody (TPO-Ab) results. Up to 2 nodules in each patient were included. Exclusion criteria were as follows: (1) completely liquid cystic nodules and (2) insufficient thyroid parenchyma surrounding a nodule.

Each enrolled patient was placed into either an HT group (patients with HT who were harboring ≥1 thyroid nodules) or a non-HT group. A diagnosis of HT was made in the presence of a positive test result for Tg-Ab and/or TPO-Ab and a hypoechoic pattern of the thyroid in conventional US. Serum concentrations of Tg-Ab (reference, <4.1 IU/mL) and TPO-Ab (reference, <5.6 IU/mL) were measured with chemiluminescent immunometric assays via commercial kits (Beckman Coulter, Pasadena, California). Finally, the HT group consisted of 117 nodules from 93 patients; the non-HT group, 169 nodules from 140 patients.

US Examination

Conventional US and SWE examinations were performed with an Aixplorer device (SuperSonic Imagine, Aix en Provence, France) equipped with a 4- to 15-MHz broadband linear transducer. All patients were examined by the same operator (B.L., with 5 years of experience in thyroid US and 3 years in US elastography), who was blinded to the results from serum examination and histology.

Conventional US. The patients were positioned in a supine position with dorsal flexion of the head. A US pattern of the thyroid parenchyma and the volume of the gland (elliptical shape volume formula = π/6 × length × width × thickness) were recorded for each patient. All thyroid nodules were evaluated for the following parameters: volume (elliptical shape volume formula), echogenicity (ie, hyperechoic, isoechoic, or hypoechoic vs normal thyroid parenchyma), nodular margin (ie, well or poor), nodular shape (ie, regular or irregular), presence or absence of halo sign, aspect ratio (ie, ≥1 or <1), and presence or absence of microcalcification (hyperechoic spots <2 mm without acoustic shadowing). After B-mode US examination, color Doppler flow imaging was performed to record vascular pattern. The vascular patterns were classified into 1 the following 4 types: type I, absence of blood flow; type II, peripheral vascularization; type III, peri- and intranodular vascularization; type IV, markedly increased vascularization.15

Shear Wave Elastography. After identification of a target lesion, the transducer was kept in a stable position without pressure, and the SWE mode was implemented over the B-mode image. A color signal box of an appropriate size was displayed as a colored area, where softer was presented as blue and harder as red. A 2-mm region of interest (ROI; Q-box, SuperSonic Imagine) was used for elastographic quantitative measurement and was placed over the stiffest region, avoiding any cystic components, visible calcifications, and artifacts. The mean, minimum, and maximum values within the 2-mm ROI were recorded (Emean, Emin, and Emax). To repeat the process, at least 3 successive measurements were carried out for each nodule. In addition, 5 successful measurements per thyroid lobe were performed, with suitable ROI placement in the thyroid parenchyma away from any thyroid nodules at the same depth of 1.5 and 2.0 cm. We calculated the mean values of successful measurements of thyroid nodules and surrounding parenchyma.

Statistical Analysis

All collected variables were expressed as frequency tables for categorical data or mean values ± standard deviations for continuous data. Between-group comparisons were performed with a Student’s t test or a Mann-Whitney test for quantitative data and a chi-square test or Fisher’s exact test for qualitative data. The diagnostic performance of SWE was assessed by receiver operating characteristic analysis, which included calculations of corresponding sensitivity, specificity, accuracy, positive predictive value (PPV), and
negative predictive value (NPV). Areas under the receiver operating characteristic curve (AUCs) were calculated and compared with a \( z \) test. Correlations were assessed by Spearman’s correlation coefficient. Logistic regression analysis was applied to determine which factors have a predictive effect of malignancy. All statistical analyses were carried out using SPSS 16.0 (Chicago, Illinois) and MedCalc 10.3.0.0 (MedCalc Software, Mariakerke, Belgium). A 2-tailed \( P \) value \(< .05 \) was considered statistically significant.

**Results**

All of the 233 included patients underwent thyroid surgery at our hospital. After surgery, histologic results confirmed 193 benign and 93 malignant nodules. Of 93 malignant lesions, 92 were confirmed as papillary thyroid carcinomas; the remaining lesion was medullar carcinoma. The majority of benign nodules were nodular hyperplasia (\( n = 185 \)), except for 3 that were confirmed as adenoma and 5 as focal thyroiditis. In the HT group, there were 72 benign and 45 malignant nodules; in the non-HT group, 121 benign and 48 malignant. The malignant rate was 38.5% in the HT group and 28.4% in the non-HT group, without significant difference (\( P = .074 \)).

**Conventional US**

The thyroid volumes were 23.9 ± 20.4 mL in the HT group and 24.0 ± 26.9 mL in the non-HT group (\( P = .628 \)). There were no significant differences in volumes between the HT group and the non-HT group in benign nodules (5.4 ± 14.6 mL vs 6.3 ± 11.3 mL, \( P = .611 \)) or in malignant nodules (1.7 ± 2.8 mL vs 7.8 ± 28.4 mL, \( P = .135 \)). US features indicating malignancy—such as hypoechogenicity, poor margin, irregular shape, absence of halo sign, aspect ratio \( \geq 1 \), microcalcification, and type III or IV vascularization—were equally distributed in the HT and non-HT groups (\( P = .206-.852 \); Table 1).

**Shear Wave Elastography**

**Diagnostic Performance of SWE in All Nodules.** In all nodules, the Emean, Emin, and Emax of the malignant nodules were significantly higher than those of benign nodules (\( P < .001 \); Table 2).

The AUCs of Emean, Emin, and Emax in differentiating malignant from benign thyroid nodules were 0.816, 0.815, and 0.812, respectively (\( P = .514-.954 \); Figure 1). The optimal cutoff value of Emean was 39.2 kPa, yielding a sensitivity of 68.8% (95% confidence interval [CI], 58.9%-77.6%), a specificity of 86.0% (95% CI, 80.6%-90.4%), and an accuracy of 80.4% (95% CI, 75.5%-84.7%; Table 3).

**HT Group versus Non-HT Group.** There were no significant differences of SWE values between the HT and non-HT groups, regardless of benign or malignant nodules (\( P = .158-.945 \); Table 2, Figure 2). However, the Emean, Emin, and Emax values of extranodular tissue were significantly higher in the HT group (\( P = .000-.111 \); Table 2). Moreover, there were significant positive relationships between the SWE values of extranodular tissue and the serum titer of TPO-Ab (correlation coefficients: Emean, 0.225, \( P < .001 \); Emin, 0.222, \( P = .001 \); Emax, 0.314, \( P < .001 \)).

**Predictive Factors for Malignancy in the HT Group**

In the HT group, the sensitivity, specificity, accuracy, PPV, NPV, and AUC corresponding to conventional US features are presented in Table 4. The highest diagnostic performance of US features was poor margin, followed by irregular shape and

| Table 1. Basic Characteristics and Ultrasound Features of Patients and Nodules with and without Coexistent HT. |
|----------------------|----------------------|----------------------|
|                      | HT Group            | Non-HT               |
| Patients, n          | 93                  | 140                  |
| Sex, male:female, n  | 21:82               | 36:94                |
| Age, y               | 45.2 ± 13.1         | 46.1 ± 13.8          |
| TPO-Ab, IU/mL        | 244.1 ± 476.9       | 0.9 ± 5.6            |
| Tg-Ab, IU/mL         | 377.8 ± 933.7       | 2.9 ± 9.9            |
| Thyroid volume, mL   | 23.9 ± 20.4         | 24.0 ± 26.9          |
| Nodules, n           | 117                 | 169                  |
| Nodule volume, mL    | 3.9 ± 11.7          | 6.7 ± 17.4           |
| Nodule location, left:right:isthmus, n | 56:56:5 | 86:79:4 |
| Histology result, benign:malignant, n | 72:45 | 121:48 |
| Hypoechogenicity, %  | 49.6                | 42.0                 |
| Poor margin, %       | 41.9                | 34.9                 |
| Irregular shape, %   | 37.6                | 33.1                 |
| Absence of halo sign, % | 73.5          | 77.5                 |
| Aspect ratio \( \geq 1 \), % | 8.5            | 5.3                  |
| Microcalcification, % | 25.6            | 26.6                 |
| Type III-IV vascularization, % | 27.4          | 22.5                 |

Abbreviations: HT, Hashimoto’s thyroiditis; Tg-Ab, thyroglobulin antibody; TPO-Ab, thyroid peroxidase antibody.
microcalcification. Absence of halo sign had high sensitivity (86.7%) but poor specificity (34.7%); aspect ratio/C21 was high specificity (94.4%) but poor sensitivity (13.3%).

Among the SWE parameters, Emax showed the highest AUC in the HT group (0.817; 95% CI, 0.735-0.900) and no significant difference when compared with other SWE parameters (P = .669-.848; Figure 3). The optimal cutoff values were 43.0, 35.9, and 49.8 kPa for Emean, Emin, and Emax, respectively, in the HT group. The sensitivity, specificity, accuracy, PPV, and NPV for each SWE parameter in detecting malignant thyroid nodules with coexistent HT are listed in Table 5. The most accurate cutoff value in the HT group, 49.8 kPa for Emax, achieved a sensitivity of 68.9% (95% CI, 54.3%-81.1%), a specificity of 91.7% (95% CI, 83.5%-96.6%), and an accuracy of 82.9% (95% CI, 75.3%-88.9%).

On univariate logistic regression analysis, the majority of suspicious US features and each cutoff value of the SWE parameters were statistically significant predictive factors of thyroid malignancy, including hypoechogenicity (odds ratio [OR] = 3.143, P = .003), poor margin (OR = 5.579, P < .001), irregular shape (OR = 5.765, P < .001), absence of halo sign (OR = 3.457, P = .014), microcalcification (OR = 6.125, P < .001), Emean (OR = 22.000, P < .001), Emin (OR = 20.287, P < .001), and Emax (OR = 29.671, P < .001).

On multivariate analysis, hypoechogenicity (OR = 9.855, P = .002), microcalcification (OR = 3.977, P = .046), and Emax (OR = 40.712, P < .001) were independent predictive factors of thyroid malignant nodules harbored in Hashimoto’s parenchyma.

Discussion

In the present study, SWE values displayed no significant differences between the HT and non-HT groups, which indicated that SWE could be performed regardless of the coexistence of HT. In the HT group, the AUCs of the SWE parameters were higher than any of the conventional US features. SWE had the best diagnostic performance for thyroid nodules with coexistent HT, and maximum SWE value was an independent predictor of thyroid malignancy. Moreover, it was suggested that the optimal cutoff values of SWE parameters in the differentiation of malignant thyroid nodules harbored within glands of patients with HT could be higher than those of nodules in the general population.

It is well known that HT is the most common autoimmune inflammatory disease. Thyroid cancer is more
frequently found in HT patients than in non-HT patients.\textsuperscript{16-18} Furthermore, a higher prevalence of suspicious or indeterminate fine-needle aspiration (FNA) results was reported when a target nodule was harbored within a Hashimoto’s gland. Therefore, it is important to select suspicious nodules for further management in HT patients.\textsuperscript{19} In 2012, Magri et al\textsuperscript{19} compared SWE values between nodules with and without coexistent HT and declared that SWE could correctly define the elasticity of thyroid nodules regardless of the coexistence of HT. However, they did not evaluate the diagnostic performance of SWE for thyroid nodules. Several studies\textsuperscript{4,20} have recently used acoustic radiation force impulse (ARFI), another type of quantitative elastography technique, to differentiate thyroid nodules in HT patients. ARFI elastography, including virtual touch tissue imaging\textsuperscript{20} and virtual touch tissue quantification,\textsuperscript{4,20} could be performed for the differential diagnosis of malignant thyroid nodules and benign thyroid nodules independently from the coexistence of chronic autoimmune thyroiditis, with promising diagnostic accuracy. Additionally, the diagnostic performance of ARFI was better than that of elasticity imaging.\textsuperscript{20} To the best of our knowledge, this study is the first to investigate the diagnostic performance of SWE with respect to thyroid nodules in HT patients and to compare it with conventional US features.

In nodules with coexistent HT, the sensitivities of conventional US features in our study ranged from 13.3\% to 86.7\%, and their specificities ranged from 34.7\% to 94.4\%. The majority of the US features were significantly different between malignant and benign nodules in the HT group. However, no US features exhibited good sensitivity and specificity simultaneously. The SWE technique provides mean, minimum, and maximum SWE values to evaluate tissue stiffness. Using the maximum SWE value within a 2-mm ROI placed over the stiffest region showed the best diagnostic performance in the HT group, and no significant differences were found when the mean and minimum values were compared. Moreover, Emax was an independent predictor of thyroid malignancy. However, Emean showed better diagnostic performance than Emax in all nodules. On the basis of these results, we deem that all 3 SWE parameters can be applied to distinguish malignant thyroid nodules from benign ones. The maximum value within a 2-mm ROI should be measured on nodules that are harbored within a Hashimoto’s gland.

There were no significant differences in SWE values between nodules with and without coexistent HT, which was similar to previous studies.\textsuperscript{19,21} However, the optimal cutoff values of the 3 SWE parameters in the HT group were higher than those in a general population, suggesting that the cutoff values of SWE parameters for the differentiation of malignant thyroid nodules harbored within a Hashimoto’s gland could be raised.

### Table 3. Diagnostic Performance of Shear Wave Elastography Parameters in Each Nodule.\textsuperscript{a}

<table>
<thead>
<tr>
<th>Parameter</th>
<th>AUC</th>
<th>OCV, kPa</th>
<th>Sensitivity, %</th>
<th>Specificity, %</th>
<th>Accuracy, %</th>
<th>PPV, %</th>
<th>NPV, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emean</td>
<td>0.816</td>
<td>&gt;39.2</td>
<td>68.8 (58.9-77.6)</td>
<td>86.0 (80.6-90.4)</td>
<td>80.4 (75.5-84.7)</td>
<td>70.3 (60.4-79.0)</td>
<td>85.1 (79.6-89.6)</td>
</tr>
<tr>
<td>Emin</td>
<td>0.815</td>
<td>&gt;25.8</td>
<td>72.0 (62.3-80.4)</td>
<td>79.3 (73.1-84.6)</td>
<td>76.9 (71.8-81.5)</td>
<td>62.6 (53.2-71.4)</td>
<td>85.5 (79.7-90.1)</td>
</tr>
<tr>
<td>Emax</td>
<td>0.812</td>
<td>&gt;48.7</td>
<td>66.7 (56.6-75.7)</td>
<td>85.0 (79.4-89.5)</td>
<td>79.0 (74.0-83.5)</td>
<td>68.1 (58.1-77.1)</td>
<td>84.1 (78.5-88.7)</td>
</tr>
</tbody>
</table>

Abbreviations: AUC, area under the receiver operating characteristic curve; NPV, negative predictive value; OCV, optimal cutoff value; PPV, positive predictive value.

\textsuperscript{a}Elastographic quantitative measurement: mean, minimum, maximum (Emean, Emin, Emax, respectively). In parentheses, 95\% confidence intervals.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{swe_values.png}
\caption{Mean ± SD shear wave elastography (SWE) values of nodules in the Hashimoto’s thyroiditis (HT) and non-HT groups: (a) benign and (b) malignant. Elastographic quantitative measurement: mean, minimum, maximum (Emean, Emin, Emax, respectively).}
\end{figure}
Currently, conventional US and FNA are the technologies that are most frequently used to assess thyroid nodules. FNA is recommended as the most accurate method of distinguishing benign thyroid nodules from those at risk of malignancy. When FNA results reveal a diagnosis of nondiagnostic (10%-15%) or indeterminate (10%-20%), repeated FNA should be considered. By comparison, US elastography can be performed as an add-on to conventional US, which remains the standard preoperative imaging modality used for initial thyroid nodule evaluation and FNA. Furthermore, SWE can provide qualitative stiffness measurements for thyroid nodules. Perhaps US elastography, especially SWE, could be used to complement conventional US. Thus, we recommend that SWE be integrated into routine imaging protocols for thyroid nodules, regardless of whether nodules exhibit the coexistence of HT parenchyma.

Our data show that the SWE values corresponding to extranodular thyroid tissue in the HT group were higher than those in the non-HT group, with significant difference. Additionally, a significant positive direct relation could be found between SWE values of extranodular thyroid tissue and TPO-Ab titers, similar to results of Magri et al. Recently, several elastography techniques—including strain elastography, ARFI, and SWE—have been developed and applied in the evaluation of tissue stiffness. It was declared that thyroid parenchyma in HT patients was stiffer than in healthy patients. With an optimal cutoff value for strain ratio, strain elastography showed a sensitivity of 72.2% to 96% and a specificity of 67% to 70% in the differentiation of Hashimoto’s parenchyma. It is well known that healthy thyroid parenchyma consists of follicles filled with colloid and includes abundant capillaries surrounding the follicles in interstitial tissue. Extranodular thyroid tissue in HT patients, characterized by lymphocytic infiltration and fibrosis, changes thyroid structures and results in a stiffer gland. Therefore, SWE is also useful in the diagnosis of Hashimoto’s parenchyma.

### Table 4. Diagnostic Performance of Conventional Ultrasound Features in the Hashimoto’s Thyroiditis Group (n = 117).

<table>
<thead>
<tr>
<th>Feature</th>
<th>AUC</th>
<th>Sensitivity, %</th>
<th>Specificity, %</th>
<th>Accuracy, %</th>
<th>PPV, %</th>
<th>NPV, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypoechoigenicity</td>
<td>0.639</td>
<td>66.7 (52.0-79.2)</td>
<td>61.1 (49.5-71.8)</td>
<td>63.3 (54.2-71.6)</td>
<td>51.7 (38.9-64.3)</td>
<td>74.6 (62.4-84.4)</td>
</tr>
<tr>
<td>Poor margin</td>
<td>0.701</td>
<td>66.7 (52.0-79.2)</td>
<td>73.6 (62.6-82.8)</td>
<td>70.9 (62.2-78.6)</td>
<td>61.2 (47.1-74.0)</td>
<td>77.9 (67.0-86.6)</td>
</tr>
<tr>
<td>Irregular shape</td>
<td>0.700</td>
<td>62.2 (47.5-75.4)</td>
<td>77.8 (67.1-86.3)</td>
<td>71.8 (63.1-79.4)</td>
<td>63.3 (48.8-76.8)</td>
<td>76.7 (66.0-85.3)</td>
</tr>
<tr>
<td>Absence of halo sign</td>
<td>0.607</td>
<td>86.7 (74.3-94.4)</td>
<td>34.7 (24.4-46.2)</td>
<td>54.7 (45.6-63.6)</td>
<td>45.4 (35.1-55.9)</td>
<td>80.7 (64.0-91.8)</td>
</tr>
<tr>
<td>Aspect ratio ≥1</td>
<td>0.539</td>
<td>13.3 (5.6-25.7)</td>
<td>94.4 (87.1-98.2)</td>
<td>63.3 (54.2-71.6)</td>
<td>60.0 (29.1-85.8)</td>
<td>63.6 (54.1-72.3)</td>
</tr>
<tr>
<td>Microcalcification</td>
<td>0.671</td>
<td>46.7 (32.5-61.2)</td>
<td>87.5 (78.3-93.7)</td>
<td>71.8 (63.1-79.4)</td>
<td>70.0 (52.0-84.3)</td>
<td>72.4 (62.3-81.0)</td>
</tr>
<tr>
<td>Type III-IV vascularization</td>
<td>0.494</td>
<td>26.7 (15.3-40.9)</td>
<td>72.2 (61.1-81.6)</td>
<td>54.7 (45.6-63.6)</td>
<td>37.5 (22.2-55.0)</td>
<td>61.2 (50.5-71.1)</td>
</tr>
</tbody>
</table>

Abbreviations: AUC, area under the receiver operating characteristic curve; NPV, negative predictive value; PPV, positive predictive value.

### Table 5. Diagnostic Performance of Shear Wave Elastography Parameters in the Hashimoto’s Thyroiditis Group (n = 117).

<table>
<thead>
<tr>
<th>Feature</th>
<th>AUC</th>
<th>OCV, kPa</th>
<th>Sensitivity, %</th>
<th>Specificity, %</th>
<th>Accuracy, %</th>
<th>PPV, %</th>
<th>NPV, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emean</td>
<td>0.815</td>
<td>&gt;43.0</td>
<td>66.7 (52.0-79.2)</td>
<td>91.7 (83.5-96.6)</td>
<td>82.1 (74.3-88.2)</td>
<td>79.0 (63.9-89.7)</td>
<td>81.5 (71.9-88.8)</td>
</tr>
<tr>
<td>Emin</td>
<td>0.810</td>
<td>&gt;35.9</td>
<td>55.6 (40.9-69.5)</td>
<td>90.3 (81.7-95.7)</td>
<td>76.9 (68.7-83.9)</td>
<td>78.1 (61.5-89.9)</td>
<td>76.5 (66.6-84.6)</td>
</tr>
<tr>
<td>Emax</td>
<td>0.817</td>
<td>&gt;49.8</td>
<td>68.9 (54.3-81.1)</td>
<td>91.7 (83.5-96.6)</td>
<td>82.9 (75.3-88.9)</td>
<td>83.8 (69.3-93.2)</td>
<td>82.5 (73.0-89.7)</td>
</tr>
</tbody>
</table>

Abbreviations: AUC, area under the receiver operating characteristic curve; OCV, optimal cutoff value; NPV, negative predictive value.

Elastographic quantitative measurement: mean, minimum, maximum (Emean, Emin, Emax, respectively). In parentheses, 95% confidence intervals.
There were several limitations in the present study. First, only pathologically proven nodules were analyzed. Thus, selection bias may be present, and the results should be carefully interpreted. Second, it was a single-center study. Further prospective multicenter studies with larger numbers of HT patients are necessary.

In conclusion, SWE proved to be a valuable tool in differentiating between benign and malignant thyroid nodules, including nodules with coexistent HT. Although all the SWE parameters could be applied, we suggest using the maximum value within a 2-mm ROI when nodules are harbored within a Hashimoto’s gland.

**Author Contributions**

Baoxian Liu, data analysis, drafting, final approval, accountability for all aspects of the work; Jinyu Liang, data analysis, drafting, final approval, accountability for all aspects of the work; Luyao Zhou, data analysis, drafting, final approval, accountability for all aspects of the work; Ying Lu, data analysis, drafting, final approval, accountability for all aspects of the work; Yanling Zheng, data analysis, drafting, final approval, accountability for all aspects of the work; Wenshuo Tian, data analysis, drafting, final approval, accountability for all aspects of the work; Xiaoyan Xie, data analysis, drafting, final approval, accountability for all aspects of the work.

**Disclosures**

**Competing interests:** None.

**Sponsorships:** None.

**Funding source:** None.

**References**