Elastography: Novel Development in Ultrasound for the Differential Diagnosis of Thyroid Nodules

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Abstract
Our aim was to compare the effectiveness of conventional ultrasonography and ultrasound elasto-graphy in differential diagnosis of thyroid nodular diseases, using Accuvix V20. The examination results were compared against pathological findings obtained by fine-needle aspiration biopsy. Clear high-quality elastograms were obtained and proved useful in the characterization of thyroid nodules, greatly improving the diagnostic rate of thyroid nodular diseases. Thus, elastography can be a useful adjunct tool for traditional ultrasound diagnosis.

Introduction
Thyroid nodules are not uncommon. Their prevalence is dramatically increased in iodine-deficient areas. The great majority of nodules are benign, less than 5% of them being malignant\(^{1-3}\). Several studies have been performed to establish the ability of thyroid ultrasonography (US) to differentiate benign from malignant lesions\(^{4-8}\). Indeed, as compared with fine needle aspiration (FNA), thyroid US has the advantage of being a noninvasive procedure and giving immediate information. Among several US patterns, hypoechogenicity of the nodule, spot microcalcifications, and the absence of halo sign have been useful for predicting thyroid malignancy\(^{9-11}\).

On the other hand, conventional US and color-flow Doppler become highly predictive of malignancy only when multiple patterns are simultaneously present in a thyroid nodule\(^{12-14}\). Elastography is a newly developed US dynamic technique to provide an estimation of tissue stiffness by measuring the degree of distortion under the application of an external force. We present 30 cases with thyroid nodule, examined by real-time US elastography, so as to differentiate if it is malignant or benign. The standard used for reference is based on histological results.

Methods
Our patients were euthyroid. FNA was performed under US guidance using a 23-gauge needle attached to a 10-ml syringe. All patients underwent surgery. The indication for surgery was size of the nodules or suspected carcinoma. Conventional Thyroid US and US elastography: Thyroid US and US elastography were performed using a real-time Accuvix V20 system (Samsung Medison, South Korea). A 5-13 MHz linear transducer was used and the average section thickness of the elastogram acquired was about 5 mm. US elastography was performed during the US
examination, using the same real-time instrument and probe. The probe was placed on the patient’s neck, with a large amount of US gel placed to create a stand-off pad. After a 5-second light tissue compression with the probe, multiple scans (two transverse and two longitudinal) were acquired. In such circumstances, reliable elastographic images of the thyroid gland could be obtained and the images were deemed reliable when the coloring was constant over the entire nodule for more than 5 seconds. This technique was easy to perform and required no more than 3-5 min of additional examination time. All examinations were performed by the same operator, who was not aware of the results of cytology.

**Image analysis:** Careful evaluation of the following ultrasound parameters was performed: shape; margin (well circumscribed, microlobulated, or irregular); echogenicity (hyperechoic, isoechoic, hypoechoic, or markedly hypoechoic with respect to normal thyroid parenchyma); composition (solid, cystic, or mixed cystic-solid); and calcification (negative [no calcifications], microcalcifications, macrocalcifications, or mixed-type calcifications). Colors of the elasticity images were assigned depending on the color-map of elasticity and ranged from blue for high elasticity to red with central black-patches for low elasticity, with green for moderate elasticity.

The following measures were considered in our analysis:

1. Elasticity at the peripheral part of the nodule
2. Elasticity at the central part of the nodule
3. Elasticity at both peripheral and central parts of the nodule

**Results**

Real-time ultrasound characteristics and clear color-map definition in US elastography analysis allowed correct diagnoses in all patients with benign thyroid nodules, whom we suspected of having thyroid cancer (Table 1).

**Figure 1:** Longitudinal and transverse scan obtained in 60-year-old woman with a nodule in right thyroid lobe. (a & b): There is a solitary nodule (N) involving the right thyroid lobe, with speckles of calcification (arrows), irregular outline and absence of complete halo sign. On the elastogram, the nodule shows overriding red color with central black patches, suggesting low elasticity of the nodule (Outlined).

**Figure 2:** Transverse B-mode sonogram and real-time elastogram obtained in 31-year-old man

### Table 1. BI-RADS classification system

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Real-time Ultrasound*</th>
<th>Real-time Elastography*</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thyroid cysts (n = 6)</td>
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<td></td>
<td></td>
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<tr>
<td>Margin regularity score</td>
<td>2.48 ± 0.53</td>
<td>2.39 ± 0.87</td>
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<tr>
<td>Margin definition score</td>
<td>2.72 ± 0.91</td>
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<td>Tumor area ratio</td>
<td>0.81 ± 0.22</td>
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<tr>
<td>Solid benign nodules (n = 15)</td>
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<tr>
<td>Margin regularity score</td>
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<td>Margin definition score</td>
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<tr>
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<td>Malignant lesions (n = 9)</td>
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<td>Tumor area ratio</td>
<td>0.91 ± 0.21</td>
<td>1.23 ± 0.15</td>
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</table>

* Data are mean values ± standard deviations.
show a cyst (N) in the central part of the left lobe of the thyroid gland. The cyst is clearly visible as a very blue lesion with a mildly irregular margin (Outlined) due to excessive movements of cyst content under compression.

**Figure 3:** Transverse B-mode sonogram and real-time elastogram obtained in 54-year-old woman with a solid benign hyper-echoic thyroid gland tumor (N) mostly of the thyroid isthmus and to a lesser extent of the left thyroid gland lobe. The tumor displays a red-blue (Outlined) mixed color, in contrast with the surrounding normal thyroid gland tissue, and has an irregular margin.

**Discussion**

US elastography was developed to determine tissue stiffness information noninvasively\(^{11-14}\). A thyroid lesion may have different levels of stiffness within it, depending on the cellularity and composition of the nodule. Information from elastograms helps assess the relative stiffness of the lesion compared with its surrounding tissues and within itself.

We used the free-hand external compression for any region of the thyroid, including a tumor and ensuring that there is some normal thyroid tissue outside the tumor\(^4,^{11}\). Such validation may not always be appropriate because thyroid tumors can occupy the whole thyroid lobe, which will not be accurate in assessing strain-images. Furthermore, the tissue outside the tumor may not be normal.

Hence, the clear definition in US elastography depending on color-map analysis of Accuvix V20 machine allowed correct diagnoses in the present study. Our results, confirmed by cytologic reports, go beyond merely optimistic expectations, suggesting that US elastography—using definite colors representing grades of stiffness as compared to corresponding histopathological results—could be the best available noninvasive tool for the evaluation of thyroid nodules. This may also imply that real-time elastography via clear color definition can be implemented on commercial ultrasound systems for use during routine ultrasound examinations. In the present study, the color-guide of thyroid carcinoma was significantly different from those of the other lesions.
However, there was a significant difference in thyroid color-guide among benign nodular or cystic lesion, and malignant nodule. The color guide revealed that thyroid nodule carcinoma is stiffer than other lesions, and such result is consistent with the findings of two previous studies\cite{9,10}. In addition, sensitivity of the thyroid stiffness color-guide obviously varies depending on the color of thyroid stiffness that is overriding. According to our data, patients with mixed colors shown on thyroid would require FNA to allow distinction between benign and malignant lesions.

In conclusion, the color-scale available on the machine we used is excellent, because it displays clear-cut colors on elasticity images in different planes conjoined with conventional images. However, we must highlight the importance of maintaining light pressure on the probe for 5 seconds during such US elastography of the thyroid, because strong pressure may lead to misdiagnosis.

References


10. Seiberling KA, Dutra JC, Grant T, Bajramovic S. Role of intrathyroidal calcifications detected on ultrasound as a marker of malignancy. Laryngoscope 2004; 114:1753-1757


