Can ARFI elastography be used to differentiate parathyroid from thyroid lesions?

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Purpose

"The only localization study needed in a patient with hyperparathyroidism is to localize an experienced parathyroid surgeon" is an old saying by Doppman.(1) However, in the era of minimally invasive surgeries which have far less morbidity and equal success rate, accurate pre-operative localization of the parathyroid lesion has become extremely important.(2,3)

Ultrasound and Tc99m Sestamibi scinitigraphy are the imaging modalities of choice for pre-operative localization of the parathyroid lesion. (1,2,4) But these modalities are fraught with significant false positive and false negative rates upto 30%. Concomitant thyroid nodules and inability to differentiate thyroid and parathyroid nodules are the most common reasons for the same. (3,5-10)

There is only one previous study on the use of stain elastography in the evaluation of parathyroid lesions. (11) However, there has been no previous study looking at the usefulness of shear wave elastography in differentiating parathyroid and thyroid lesions.

For the first time, we aimed to assess the usefulness of ARFI elastography in differentiating parathyroid and thyroid lesions.

Methods and materials

This is an IRB approved prospective study. Consecutive patients with primary hyperparathyroidism planned for parathyroid surgery and patients with solid thyroid nodules planned for thyroidectomy were recruited into the study after informed consent.

After B-mode ultrasound and colour Doppler, ARFI elastography was performed on the solid or mixed solid and cystic parathyroid lesions and predominantly solid thyroid nodules. Thyroid and parathyroid nodules with extensive calcification and predominantly cystic lesions were excluded.

Shear wave elastography using ARFI technology was performed using 9 MHz linear probe of Seimens S2000 ultrasound equipment. Shear wave velocity (SWV) was measured in meters/ second using virtual touch quantification (VTQ) soft ware. A 6 x 5 mm sized region of interest (ROI) is placed in the parathyroid or thyroid lesion and five successful readings were recorded. Figure 1 shows the ROI in the parathyroid lesion. Definitive SWV was documented as the mean of these five readings. Reading were

obtained in quiet breathing unless patient was anxious and breathing related movement interfered with the test. Interference from carotid pulsations was minimized by tilting the probe in a direction away from the carotids. Values were obtained only from the solid portion of the lesion carefully avoiding cystic or calcified components of the nodules, capsule of the lesion and the surrounding tissues. In small parathyroid lesions the probe was tilted to obtain oblique images of the lesion which would fit the ROI within the lesion.

Values XXX m/s were considered incorrect: probably due to movement artifact, compression, too low or too high values in very soft or hard portions of the nodule beyond the range detectable by the soft ware. Range of detectable SWV values consisted of 0.3 - 8.4 m/s.

Elasticity index (EI) was obtained using Asteria four point scale using virtual touch imaging (VTI) software. (12) Stiffness of the lesion is displayed as shades of grey with light shade denoting a soft lesion and dark shade denoting a hard lesion. EI of one was given to a lesion that is entirely soft; EI of two was given to nodules which were partly soft and same in size as the b-mode ultrasound image; EI of three was given to lesions which were partly hard and same in size as B-mode ultrasound; EI of four was given to lesions which were entirely hard and larger in size compared to its B-mode ultrasound image. Apart from the EI the appearance of parathyroid and thyroid lesions on VTI was also noted.

Only patients with surgical histopathology were included for final analysis. Appearance of the lesion on VTI, SWV and EI of parathyroid and thyroid nodules were compared.

Statistical analysis:

IBM SPSS Analytics 16.0 software (Chicago, Ill., USA) was used for statistical analysis. Continuous variables like age and mean SWV (m/s) of thyroid and parathyroid lesions were compared using Wisconsin rank sum test and categorical variables like elasticity index, VTI appearance were compared using Chi square test. ROC curve analysis was performed to assess the diagnostic performance of ARFI elastography in differentiating parathyroid and thyroid lesions and the best cut off value of SWV (m/s) which differentiates parathyroid and thyroid lesions was obtained. Sensitivity, specificity, positive predictive value, negative predictive value and accuracy of VTI appearance, EI and SWV in were calculated.

Images for this section:

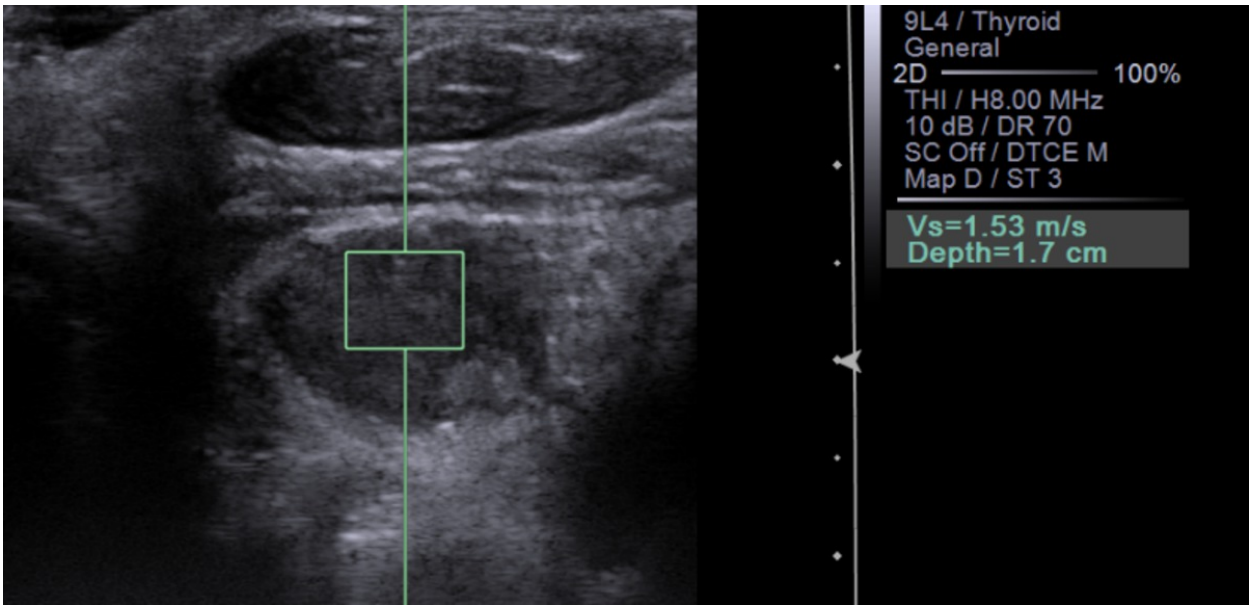

Fig. 1: Display shear wave velocity in meters/second with the ROI placed in the parathyroid lesion.

Results

There were 39 solitary adenomas, 2 double adenomas, 3 parathyroid hyperplasias in 43 patients (20 male, 23 females) with age of 41.7 +/- 11.6 years; serum corrected calcium and PTH was 11.12 +/- 1.02 mg/dL and 417.7 +/- 444.1 ng/L respectively; size and weight was 20 +/- 9.74 mm (range of 11 - 48 mm) and 198.9 +/- 255.8 mg (range of 47-1032 mg) respectively.

ARFI elastography was performed on 102 thyroid nodules and surgical histopathology was available for 93 of them (23 males and 70 females). Out of them 38 were benign thyroid nodules (BTN) and 55 were malignant thyroid nodules (MTN). The size of the thyroid nodule was 36 +/- 15.8 mm (range of 11-72 mm).

Surgical histopathology of lesions included in the study.

Parathyroid lesions		Benign thyroid nodules		Malignant thyroid nodules	
Solitary adenomas	39	Adenomatous or nodular hyperplasia	31	Papillary carcinoma of thyroid	41
Double adenomas	2	Hurthle cell adenoma	4	Follicular variant of papillary carcinoma (FVPTC	12
Parathyroid hyperplasias	3	Hashimoto's thyroditis	2		
		Follicular adenoma	1	Medullary carcinoma of thyroid	2

ARFI elastography:

Shear wave velocity measurements:

The mean SWV of parathyroid lesion was 1.6 +/-0.78 m/s (range of 0.61 to 4.8 m/s). The mean SWV of benign and malignant thyroid nodules was 2.11 +/- 0.8 m/s (range of 0.8 to 4.8 m/s) and 4.3 +/- 2.71 m/s (1.05 to 8.4 m/s) respectively. This difference was statistically significant, $p < 0.05$. Figure 2 shows the box plot comparing the SWV (m/s) of parathyroid and thyroid nodules.

Elasticity index:

Majority (n = 36, 78.3%) of parathyroid lesions had an elasticity index of 2, 8 lesions had an EI of one and two lesions had an EI of three. None of them showed an elasticity index of four. Majority (89.1%) of malignant nodules had elasticity score of 3 (n = 36) and 4 (n=13). But majority (79%) of BTN had an EI of one (n = 18) or two (n = 12). Eight BTN showed an EI of three. There was significant difference in the EI of parathyroid and thyroid lesions (chi square = 51.6, p<0.000).

VTI appearance:

There was a characteristic speckled pattern on VTI in most (n=41, 91.1%) of the parathyroid lesions. Figure 3 and 4 shows an example of the speckled appearance of parathyroid lesions in two different patients with right inferior parathyroid adenomas. However this appearance was seen in only few (n=9, 9.1%) thyroid nodules. This difference was quiet significant, Chi square = 87.04, p<0.001. The nine thyroid lesions which had this appearance in part of the lesion was due to artifacts caused by foci of cystic degeneration (n=6) and micro calcification (n=3).

ROC analysis showed an area under the curve (95% CI) of 0.901 (0.848-0.967) (Figure 5), 0.797 (0.72-0.875) and 0.724 (0.641 - 0.808) respectively for speckled appearance on VTI, VTQ and elasticity score respectively to differentiate parathyroid and thyroid lesion. The sensitivity, specificity, PPV, NPV and accuracy of speckled appearance of parathyroid lesions as a sign to differentiate parathyroid and thyroid lesions was 91.1 %, 90.3%, 82%, 95.45% and 90.5% respectively. The SWV cut off which offers the best diagnostic performance for parathyroid is 1.72 m/s with a sensitivity of 75.3% and specificity of 71.1%.

Tc99m Sestamibi scintigraphy:

Tc99m Sestamibi scitigraphy and SPECT was discordant with the surgical findings in 11/43 (25.5%) patients. Among these, ultrasound correctly localized the parathyroid lesion in 9/11 patients. Ultrasound was discordant with the surgical findings in 2 patients (4.6 %), one due to missed double adenoma and other due to concomitant thyroid nodule, the later was false positive on Tc99m sestamibi scintigraphy as well. (Figure 6-8)

Images for this section:

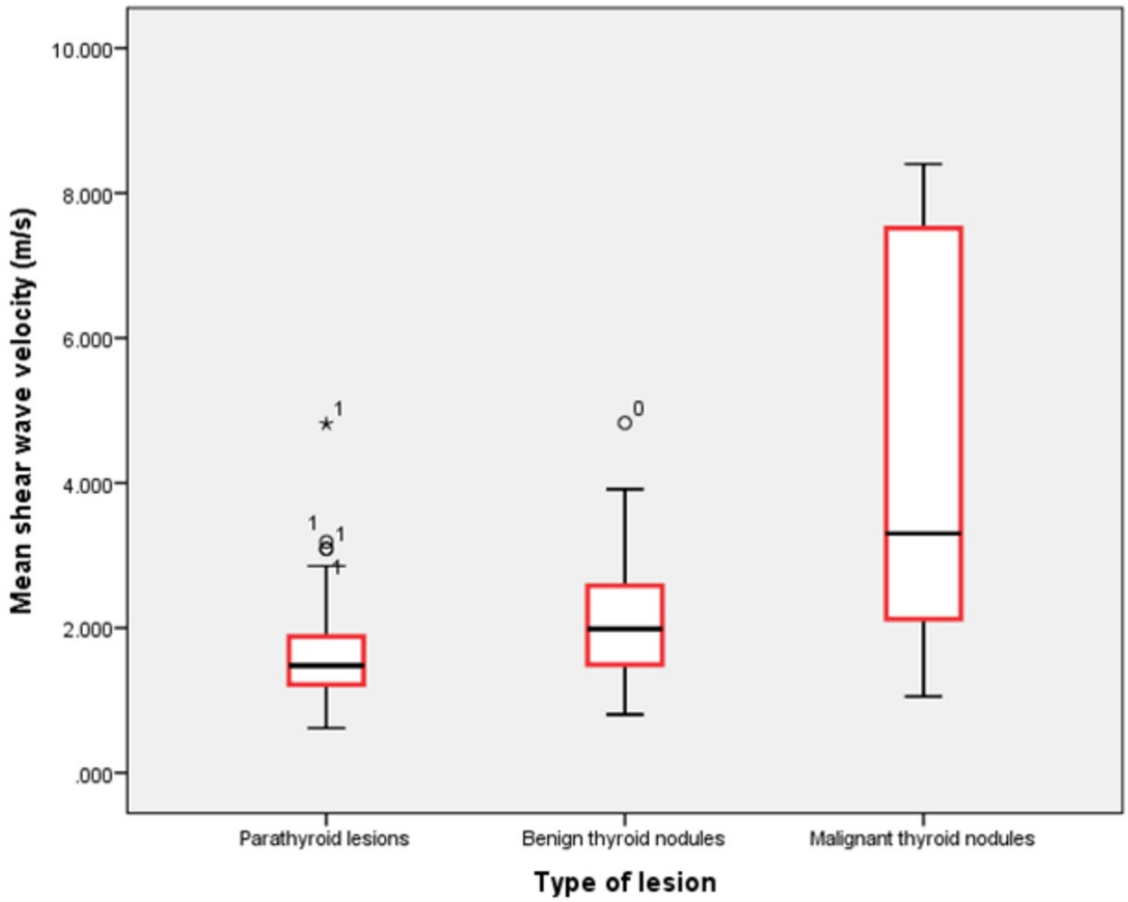

Fig. 2: Box plot of comparing the SWV (m/s) of parathyroid lesion, benign thyroid nodule and malignant thyroid nodules.

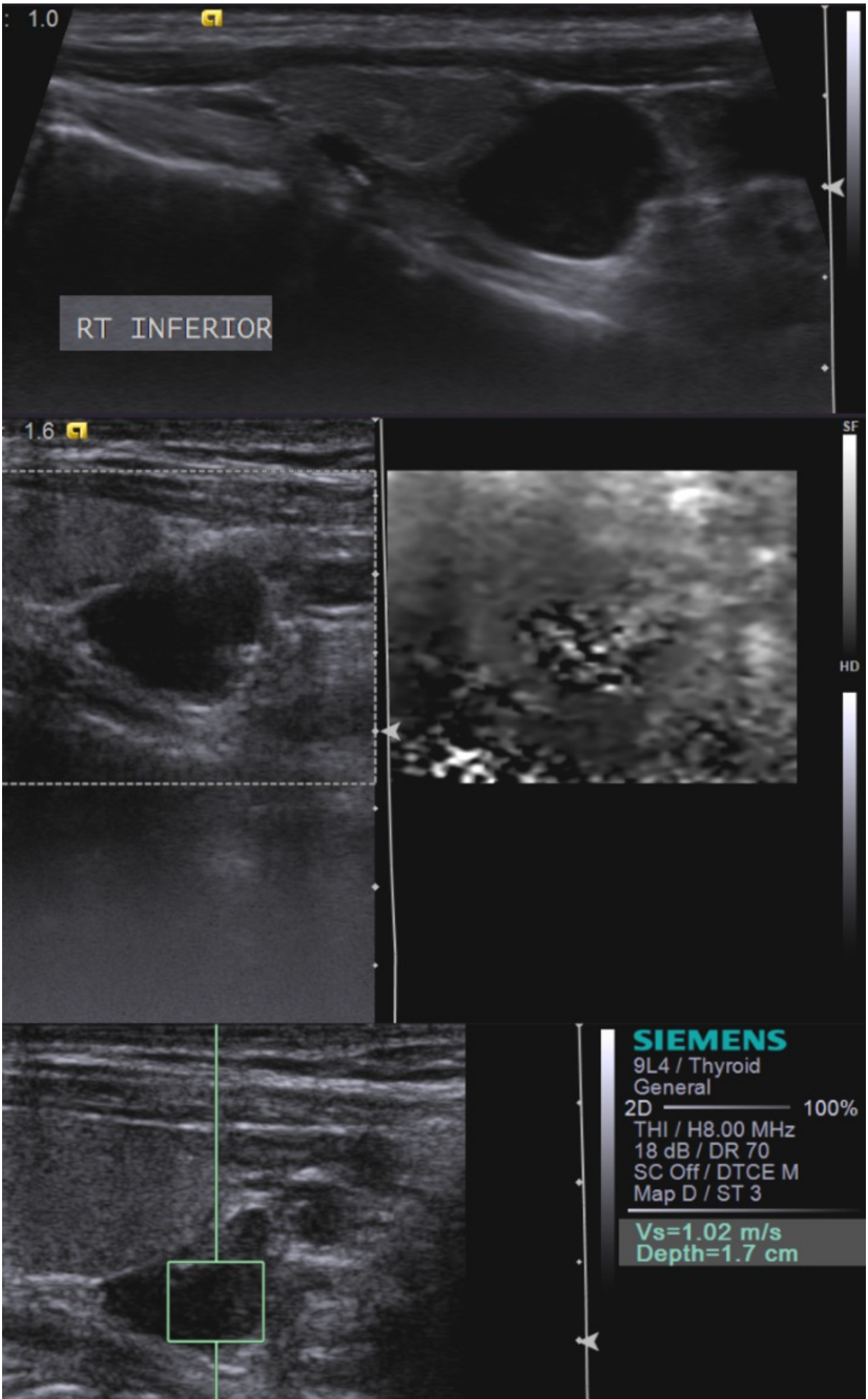
1.0
RT INFERIOR
1.6
SF
HD
SIEMENS
9L4 / Thyroid
General
2D
100%
THI / H8.00 MHz
18 dB / DR 70
SC Off / DTCE M
Map D / ST 3
Vs=1.02 m/s
Depth=1.7 cm

Fig. 3: ARFI elastography of right inferior parathyroid adenomas in two different patients with primary hyperparathyroidism showing a speckled appearance of parathyroid lesion on virtual touch imaging.

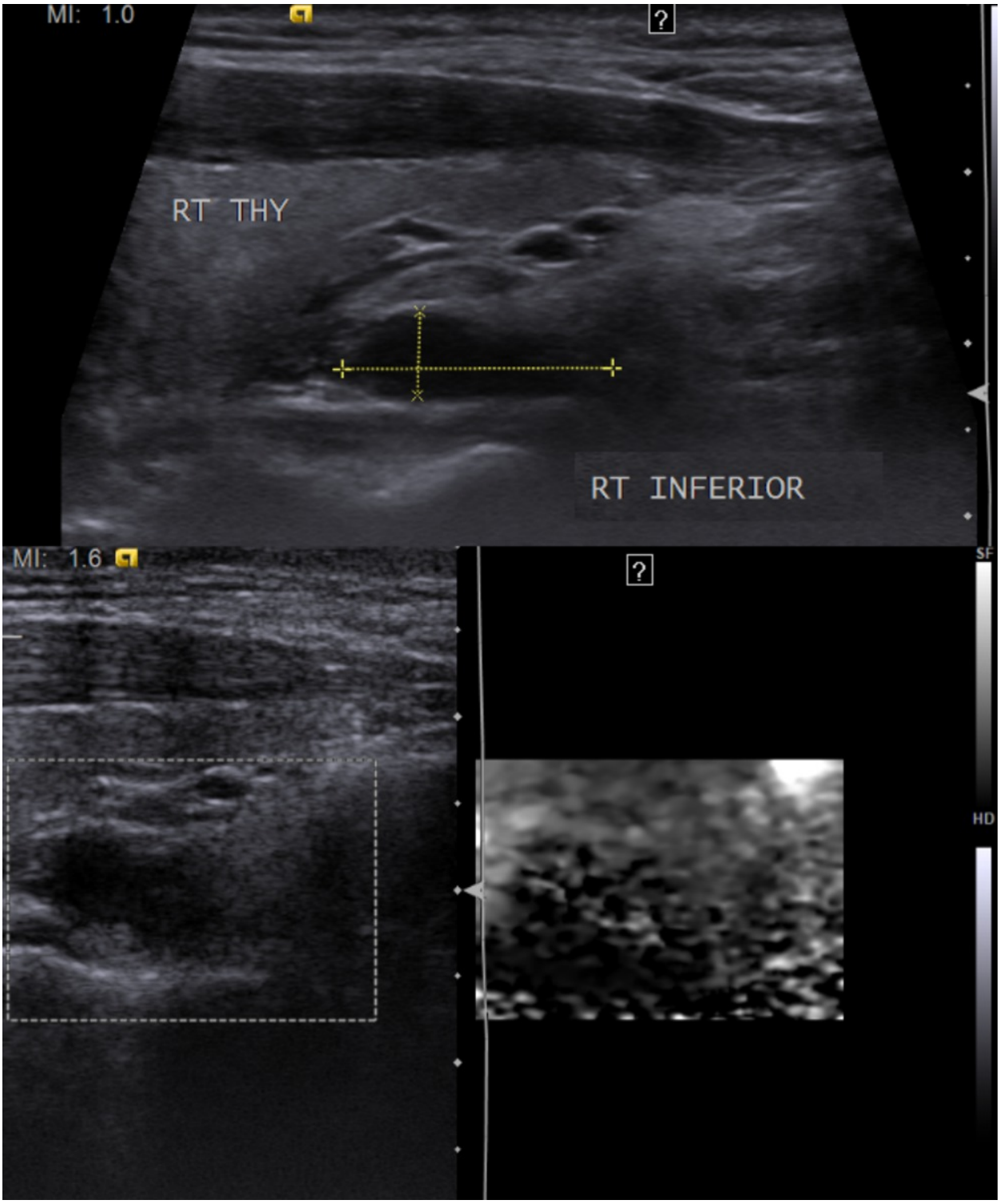

Fig. 4: ARFI elastography of right inferior parathyroid adenomas in two different patients with primary hyperparathyroidism showing a speckled appearance of parathyroid lesion on virtual touch imaging.

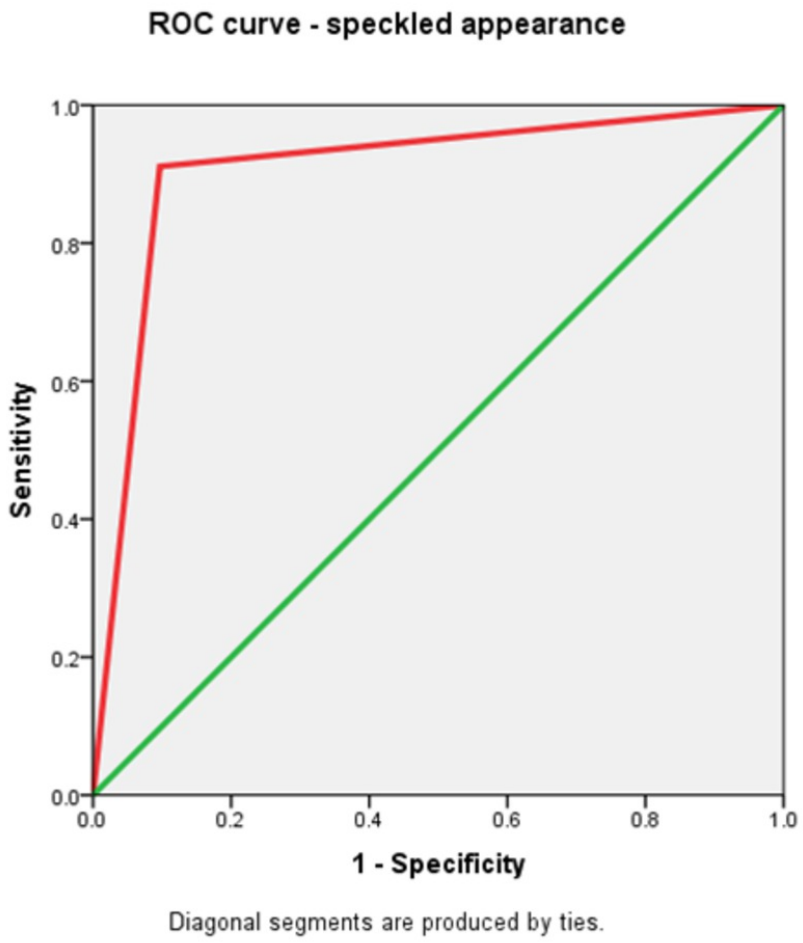

Fig. 5: ROC curve showing the diagnostic performance of speckled appearance of parathyroid lesions as a sign to differentiate parathyroid and thyroid lesions.

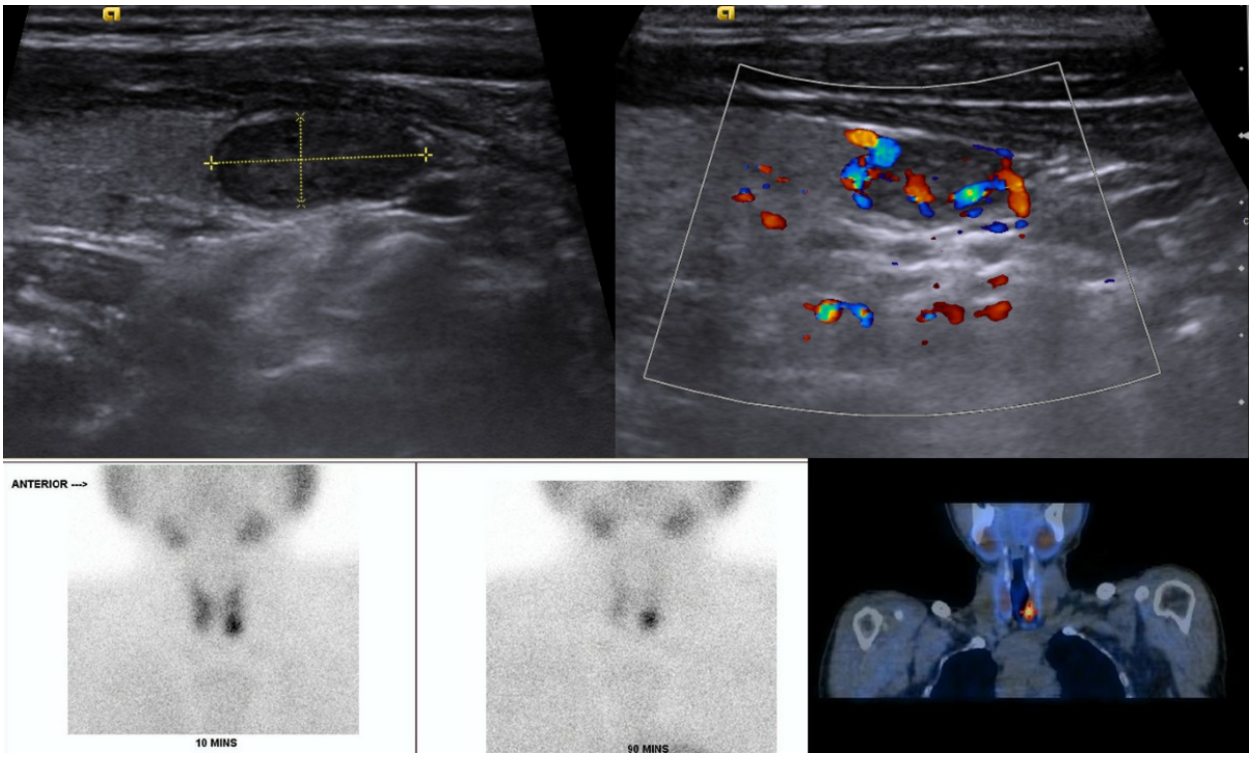

Fig. 6: False positive Tc99m sestamibi and ultrasound in a patient primary hyperparathyroidism and concomitant thyroid nodule. Ultrasound and scintigraphy images of the thyroid nodule mistaken for parathyroid.

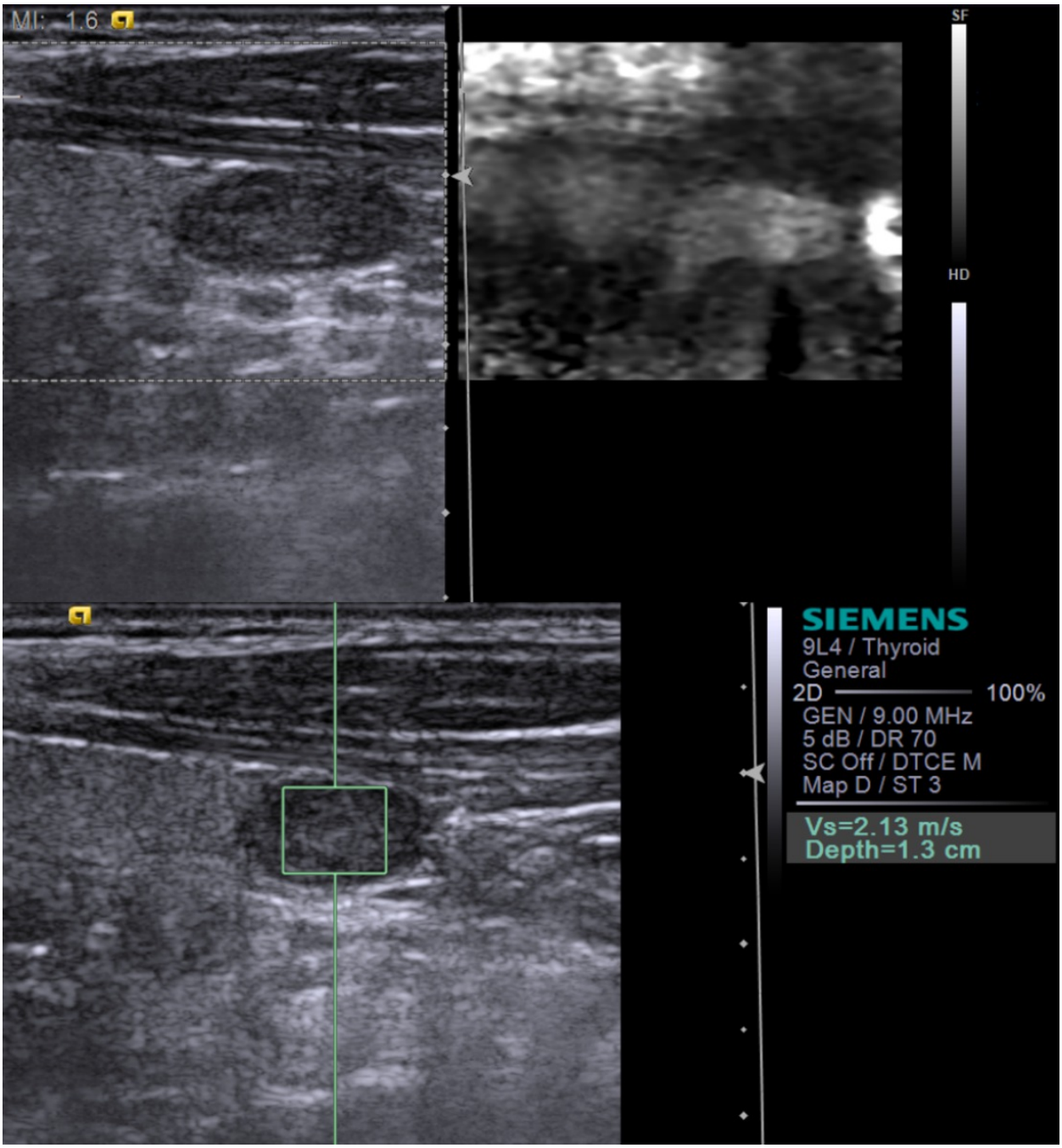

Fig. 7: False positive Tc99m sestamibi and ultrasound in a patient primary hyperparathyroidism and concomitant thyroid nodule. ARFI elastography of the same lesion. Note that the nodule lacks speckled appearance and SWV is similar to benign thyroid nodules.

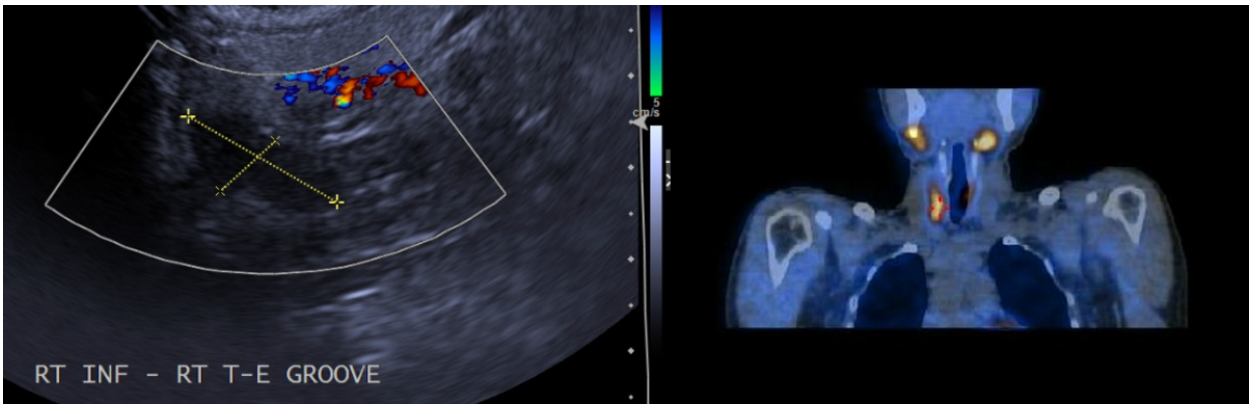

Fig. 8: False positive Tc99m sestamibi and ultrasound in a patient primary hyperparathyroidism and concomitant thyroid nodule. Right inferior parathyroid adenoma correctly identified during the evaluation performed 3 months after failed initial focused parathyroidectomy.

Conclusion

1. Our study shows low shear wave velocity in parathyroid lesions compared to thyroid and majority (> 95%) of parathyroid lesions shows elasticity score of 1 or 2. This is in contrast to previous workers who have used strain elastography. (11)

2. Speckled appearance characteristically seen in parathyroid lesions can be used as a sign to differentiate parathyroid and thyroid lesions with high degree of accuracy.

3. ARFI elastography can be used as an additional tool to increase the accuaracy of ultrasound localisation of parathyroid lesions.

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