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The utility of strain elastography in differentiation between healthy thyroid parenchyma and residual/recurrent thyroid parenchyma disorders

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ABSTRACT

Objectives: This study is designed to evaluate the utility of strain elastography in the differentiation between healtly thyroid parenchyma and residual/recurrent thyroid parenchyma after partial thyroidectomy.

Methods: Gray-scale ultrasonography (B-mode US) and strain elastography were performed in patients who had undergone partial thyroidectomy due to benign thyroid diseases and volunteers as a control group without any throid disease. The elasticity scores and strain rate values of thyroid parenchyma were obtained in two groups and compared. The strain elastography of the patient and control groups were analyzed with the Pearson Chi-Square test. Strain rates for both groups were compared with the Manny-Whitney U test. Ethical approval and permissions were obtained from legally authorized representatives and patients.

Results: There were 94 cases in total, 47 cases (4 male, 43 female; mean age: 51 ± 12.9 years, ranging between 25-79) in the patient group and 47 cases (11 male, 36 female; mean age: 36.8 ± 11.5 years, ranging between 19-71) in the control group. The strain rate of the right (2.22 ± 1.9) and left thyroid lobe (1.9 ± 1.9) were significantly higher than control group (1.05 ± 0.6 and 0.8 ± 0.5, respectively; $p = 0.002$ and $p = 0.043$).

Conclusions: The elasticity of thyroid parenchyma after partial thyroidectomy differs from healthy thyroid tissue, which may be helpful in differentiation between residual parenchymal changes in thyroid from malignant lesions with strain elastography.

Keywords: Thyroidectomy, strain elastography, residual, recurrence

Thyroid diseases are fairly common in the population. Diffuse (simple) and nodular goiter may be encountered [1]. The first imaging method of choice in the diagnosis of thyroid diseases is thyroid ultrasonography (US) [2]. The US identifies the location, volume, parenchymal structure, presence, and the number of nodules and may be helpful in differentiation between the cystic-solid nodule and benign-malignant thyroid nodules [3]. Thyroid US is also the mainstay imaging technique in the evaluation of residual or recurrent thyroid disorders.

Despite all the benefits, B-mode US is not specific and sensitive enough to evaluate thyroid disorders. Therefore, an increasing number of studies have been conducted on the use of strain elastography (SE) in evaluating thyroid parenchyma and its pathologies [4]. SE is a method based on measuring the stiffness and elasticity of tissue. In strain elastography, tissue stiff-

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ness is measured by applying external force (compression) [4, 5] while tissue elasticity is measured by qualitative (color coding-elasticity score- ES) and semi-quantitative (strain rate measurement) methods. Diagnostic utility of SE in the assessment of thyroid parenchymal diseases and differentiation between benign and malignant in thyroid nodules was found comparable with fine-needle aspiration biopsy (FNAB) [5].

The recurrence rate of thyroid nodules and the rate of incidental malignancy in thyroid parenchyma after subtotal and total thyroidectomies are not infrequent [6]. The second surgery to be performed is quite risky in terms of the recurrent nerve injury and development of hypoparathyroidism [7]. The B-mode US may be insufficient in the evaluation of residual/recurrent tissue and the differentiation of malignant-benign lesions in the area where thyroidectomy is performed. Thus, it is essential to know if there exists a difference between US-E examination findings in an operated and non-operated thyroid parenchyma. In addition, US-E may be useful in examining the area where post-surgical fibrous tissue development is expected. No studies regarding the utility of US-E in patients who underwent thyroid surgery have been found in the literature. A better understanding of the elasticity changes in the area of thyroidectomy, and revealing masses or visual differences may help to prevent invasive procedures such as FNAB or surgery.

Therefore, this study aims to compare the US-E findings of residual changes and recurrent diseases in postoperative thyroid parenchyma with normal thyroid parenchyma.

METHODS

Study Design and Study Population

Ethical approval of this study was obtained from the Fırat University Medical Faculty "Non-Interventional Clinical Research Ethics Board" of the authorized ethics committee (Number of decision: 2020/06-29). The study was conducted in accordance with the Helsinki declaration and, with informed consent was obtained from the participants. A total of 47 patients aged between 18-70 years who had thyroidectomy (lobectomy, subtotal thyroidectomy, near-total thyroidectomy, total thyroidectomy) due to benign thyroid disease and scheduled for sonographic evaluation of thyroid parenchyma as of January 2020 were included in this study. These were the inclusion criteria; patients with no malignancy as a result of pathology after thyroidectomy, no radioactive iodine treatment and radiation to the neck, no other surgery in the neck, no other malignancy, no collagen tissue disease, no rheumatic disease in the body, with or without thyroid hormone replacement, with thyroid functions of any level (hypothyroid, euthyroid, hyperthyroid). The ones who did not volunteer and were not followed-up were excluded from the study.

The control group of the study consisted of 47 healthy individuals aged between 19-71 years whose thyroid function tests (TSH, free T3 (FT3), free T4 (FT4), thyroid autoantibodies and thyroid the US were normal, who had no chronic and systemic disease (diabetes mellitus, hypertension, coronary heart disease, malignancy, collagen tissue disease, rheumatic disease), and did not use any substance or hormonal drugs.

Whether the control group consisting of individuals who had been examined by the general surgery specialist received any thyroid replacement or suppression treatment was recorded. The patients were directed to the laboratory to evaluate thyroid function tests. The information about the performed operations was obtained and reported from the epicrisis notes and pathology reports available in the hospital records. The results were evaluated by the clinician.

Sonographic Examinations

The procedure was performed using the US equipment (Philips EPIQ 7G) with eL18-4 MHz linear probe while the patient and control groups were in the supine position and the patient head was moderately hyperextended. To prevent interobserver differences, thyroid US and US-E were evaluated by only a single experienced radiologist.

The size (length × width × thickness × 0.52 = volume, mm3, for each lobe), echogenicity (hypoechoic, heterogeneous, isoechoic), vascularity (hypovascular, middle and hypervascular) of residual or recurrent thyroid parenchyma, presence and structure of nodule were interpreted with B-mode and color flow Doppler US.

US-E examination was conducted with freehand compression and decompression technique. The amount of compression and homogeneity were standardized using a color pressure scale. The assessment was performed after a safe measurement interval of over 50% was achieved on the pressure scale. The tissue elasticity distribution was calculated in real-time, and the results were represented in a color map placed on the B-mode image. The color spectrum ranged from blue (soft-elastic) to red (hard-inelastic) and represented the relative stiffness of the tissue [5]. Elasticity (color) scoring was performed in the residual/recurrent thyroid parenchyma:

Score 1 - Elastic parenchymal structure, almost coded in blue (over 75%).

Score 2 - Predominantly elastic parenchyma (over 50-55%), containing yellow and red coded areas scattered on a blue-green coded ground.

Score 3 - Predominantly inelastic parenchyma (over 50-55%), containing green and yellow coded areas scattered on a red coded ground.

Score 4 - Inelastic parenchyma, almost coded red (over 75%).

In addition, the imaging area was adjusted to include residual/recurrent tissue and surrounding strep muscles in B-mode and elastography examination. After the elastograms were obtained, the residual/recurrent tissue and the strain values of the adjacent strep muscles were measured numerically and proportioned automatically by the device on the static elastogram image with the region of interest (ROI) (mean 4-6 mm^2). The ratio of strain values of strep muscles and residual/recurrent tissues was expressed as strain index (SR, SI). SI was calculated and recorded for residual/recurrent tissue in the left and right lobe separately.

Statistical Analysis

Statistical analysis was performed using the SPSS 22.00 package program. In comparing the measured parameters for the patients in the study, the normality of the data obtained from the patients was evaluated with the Kolmogorov-Smirnov test. Student-T test and Mann-Whitney U-test were used for comparison between groups. chi-square test and Fisher's Exact test were used to evaluate qualitative data. The correlation analysis between variables was performed with Pearson and Spearman methods. P values less than 0.05 were considered statistically significant.

RESULTS

A total of 94 cases were evaluated (47 in the study group and 47 in the control group). The mean age of the patient group was 51 ± 12.9 (range: 25-79) years, and 43 (91.5%) were females. The mean age of the control group was 36.8 ± 11.5 (range: 19-71) years, and 36 (76.6%) were females. There was a statistically significant difference between the two groups in terms of age ($p < 0.001$). In the study group, US-E was performed in recurrent tissue of 5 (11.2%) patients with total thyroidectomy, residual tissue of 38 (81%) patients with subtotal thyroidectomy, thyroid lobe of 3 (5.6%) patients with unilateral lobectomy, and residual tissue of 1 (2.2%) patient with near-total thyroidectomy. The mean time between the time of surgery and participation of the study was 17.6 ± 7.6 years, ranging from 2 to 30 years. Two patients were operated twice; one was 10 and 5 years ago, and the other was 20 and 10 years ago.

The mean volume of the right lobe and left lobe, and isthmus were measured as 8.72 ± 10.4 (range: 0.17-43.6) mm³ and 7.5 ± 11 (range: 0.32-55) mm³,

Table 1. The elasticity scores of residual/recurrent thyroid tissue and healthy thyroid parenchyma in the control group

	Right lobe		Left lobe	
Elasticity Scores	**Patient group**	**Control group**	**Patient group**	**Control group**
1	4	3	5	3
2	17	36	17	40
3	11	8	12	4
4	6	0	5	0
***p* value**	**0.003**		**0.001**	

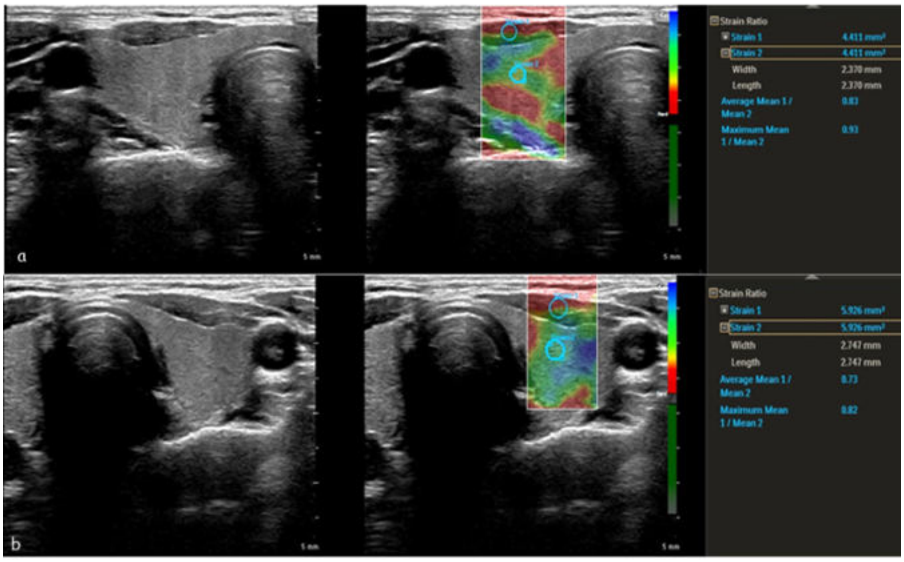

Fig. 1. Elastographic measurement of healthy thyroid parenchyma. (a) Right lobe (ES score 2, mean SR 0.73). (b) Left lobe (ES score 1, mean SR 0.83).
The left side of the windows is a color-coded elastography image; the right side is a gray scale image. The circles show the regions of interest where we measure the SRs. One is in the belt muscle and the other is in the normal thyroid parenchyma. The color scale on the upper left is used to evaluate the ES relatively, and the green color scale on the lower left is used to evaluate the amount of compression and homogeneity. ES = Elasticity Score, SR = Strain Ratio.

and 0.94 ± 0.6 (range: 0.12-2.02) mm³, respectively. Thyroid nodules were detected in 14 (29.8%) of the patients with a mean diameter of 13.8 (range: 2-40) mm.

The echogenicity of the residual/recurrent thyroid tissue was assessed with respect to the echogenicity of the normal thyroid parenchyma. Residual / recurrent thyroid tissue was found hypoechoic in 17 (36.2%) patients, heterogeneous echogenicity in 14 (29.8%), and isoechoic in 16 (34%) patients. Assessment of vascularity in residual/recurrent thyroid tissue yielded hypervascularity in 10 (21.3%) patients, hypovascularity in 24 (51%), and moderate vascularity in 13 (27.7%) patients.

The elasticity scores of residual/recurrent thyroid tissue in patients and healthy thyroid parenchyma in the control group are summarized in Table 1. Elasticity score and Strain ratio measurements in normal thyroid tissue one control subject and one operated patient were showed (Fig. 1 and 2). Most frequently encoun-

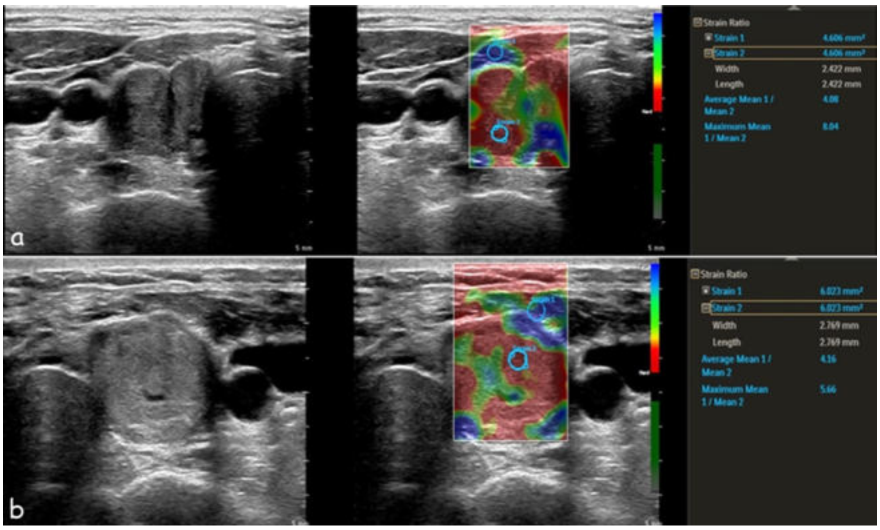

Fig. 2. Images show measurement of ES and SR in residual or recurrent thyroid tissue. (a) Right thyroid lob (ES score 3, mean SR 4.06). (b) Left thyroid lobe (ES score 4, mean SR 4.16). ES = Elasticity Score, SR = Strain Ratio.

Table 2. The mean SR of left and right thyroid lobes in the patient and control groups and comparison the SR between control and patient groups

Strain Ratio (SR)	Patient group	Control group	*p* value
Right lobe	2.22 ± 1.9	1.05 ± 0.6	**0.002**
Left Lobe	1.9 ± 1.9	0.8 ± 0.5	**0.043**

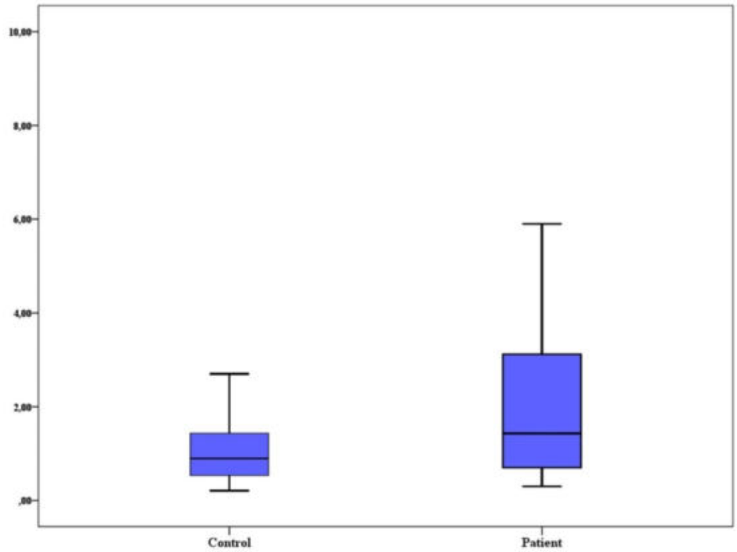

Fig. 3. Histogram graphic shows SR distribution for the right lobe in the patient and control groups. SR = Strain Ratio.

tered ES in the left and right lobe of the patient and control group was score 2.

The elasticity scores were significantly different between the right lobe and left lobe of thyroid parenchyma in patients ($p = 0.003$) and control ($p = 0.001$) groups. In the patient group, both score 3 and score 4 were found higher for the right and left lobes. The mean SR of left and right thyroid lobes in the patient and control groups and comparison the SR between control and patient groups are presented in Table 2. Mean SR of right and left lobes were significantly higher in the patient group than the control group. There was a correlation between the elasticity scores and strain rates (SRs) for both groups ($p < 0.01$). This result was statistically significant and higher in the patient group (Fig. 3 and 4).

Patients who were operated twice were found to have higher SR. (The mean SR was 3.12 and ES was

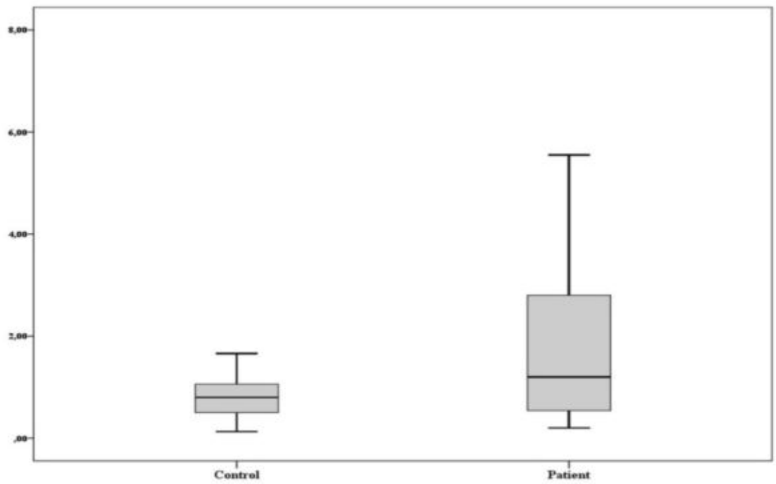

Fig. 4. Histogram graphic shows SR distribution for the left lobe in the patient and control groups. SR = Strain Ratio.

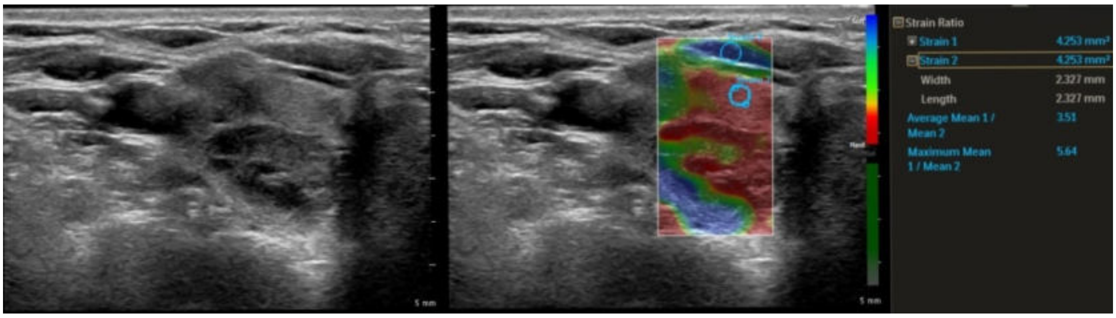

Fig. 5. Images show measurement of ES and SR in residual or recurrent thyroid tissue. (a) Right thyroid lob (ES score 3, mean SR 4.06). (b) Left thyroid lobe (ES score 4, mean SR 4.16). ES = Elasticity Score, SR = Strain Ratio.

4 for right lobe in the first patient, while the mean SR was 2 and ES was 3 for the right lobe, the mean SR was 3.51 and ES was 4 for the left lobe in the second patient) (Fig. 5).

DISCUSSION

The elasticity of recurrent/residual thyroid tissue was found significantly different from healthy thyroid parenchyma. This result implies the importance of elasticity changes in postoperative thyroid tissue. The elasticity of postoperative thyroid tissue differs from healthy thyroid tissue, which should be kept in mind in comparison to elasticity between postoperative thyroid tissue and focal or diffuse thyroid diseases.

Anatomical and morphological changes occur in the neck region after thyroidectomy compared to the preoperative findings. Identifying changes in the thyroidectomy area and distinguishing these changes from malignancy with noninvasive imaging methods is important. Postoperative tissue changes are permanent in some patients. It is more accurate to diagnose if the US technician is aware of the surgical procedure applied to the thyroid in cases where there is residual thyroid tissue after lobectomy or subtotal thyroidectomy. However, in cases with antithyroid drug treatment or thyroiditis or previous radioactive ablation therapy, residual thyroid tissue may not be recognized. The fibrous scar in the surgical area may not be distinguished from a tumor. In such cases, the patient can be evaluated by repeated US follow-ups. The size and shape of the fibrous tissue often remain stable or become smaller [9, 10]. Although these findings have been described in the B-mode US in previous studies, there is no study on US-E evaluating tissue fibrosis and its elasticity in the literature. In this study, residual/recurrent tissue was primarily evaluated with B-mode US and US-E.

In this study, the mean age of the patient group was higher as the incidence of thyroid nodules increases, and the indication for surgery is more common at advanced ages. Therefore, our control group consisted of younger cases. On the other hand, whether there is any elasticity difference in adults that may arise from age difference should be investigated in the future with studies involving patients with similar age groups.

Thyroid diseases are more common in females, which is consistent with our data. In multinodular goiter and benign thyroid diseases, total thyroidectomy has become common in the last decade while subtotal and near-total thyroidectomy were preferred in younger ages [6]. The average time after surgery in the study group was 17.6 years, which explains the high rate of subtotal thyroidectomy. Although the rate of subtotal thyroidectomy was high, the rate of recurrence nodules was 29.8%. As expected from an operated tissue, thyroid tissue was hypovascular in 51% of the patients and moderate vascular in 13% of the patients. When the US-E findings were examined, there was a statistically significant difference between the strain rates of the patient and control groups. The rates of the patient group were higher in both the right and left lobes compared to the control group. It can be understood from this situation that the elasticity of the thyroid tissue decreased in postoperative thyroid parenchyma. In previous US-E studies evaluating the normal thyroid tissue, the thyroid tissue was found to present with high and homogeneous elasticity manifesting as green color code and the elasticity scores of 1 and 2. However, it was also reported that elasticity might increase towards green/red/yellow direction in cases with parenchymal diseases such as parenchymal hyperplasia. In healthy subjects, the mean SR of thyroid parenchyma was found as 0.76 ± 0.55 [11-13]. Yang *et al*. [14] revealed that the thyroid tissue SR of 43 control group patients without any thyroid disease was found between 0.66-2.70, and the mean was 1.76 ± 0.54. Yurttutan *et al*. [15] found that the mean SR of thyroid tissue was 0.54 ± 0.38 in children without a thyroid disease between the ages of 3-16. However, they did not find any difference between the SR value with age, gender, and body mass index.

In our study, the mean SR values of right and left thyroid lobes in healthy subjects were consistent with the literature. On the other hand, mean SR values of postoperative thyroid parenchyma were found significantly higher than normal parenchyma in both right and left lobes. Elastography scores of the patient and control groups were found statistically significant and the score 3 and score 4 were higher for both lobes in the patient group. While measuring the SR elasticity semi-quantitatively, the elastography score consisting of the color scale is a qualitative measurement method. In our study, as in SR, ES of the patient group was found higher than the control group. These results reveal that the elasticity decreases in tissues that have undergone operation and fibrosis. Although there are no studies in the literature that have performed elastographic measurements in operated thyroid cases, Gode *et al*. [16] measured the elasticity score of preoperative tissue and postoperative fibrous tissue for inferior turbinate process in the lateral nasal cavity, and they found the elasticity score of the postoperative fibrous tissue significantly higher. Korkusuz *et al*. [17] noted decreased tissue elasticity after the procedure in their elastography measurements before and after microwave ablation applied to thyroid nodules. In our study, we found a decrease in postoperative residual/recurrent thyroid tissue elasticity in accordance with the literature.

Studies have shown that the elastographic value of the thyroid parenchyma changes according to the histological state of the tissue. Similarly, it was revealed in our study that the elasticity decreased, and the strain increased in patients who had undergone thyroid operation, changing the histology of the parenchymal structure. The results of the comparison between the elasticity values of diffuse and focal thyroid abnormalities with uninvolved healthy or postoperative thyroid parenchyma are expected to be different due to the results of our study, which reveal the elasticity changes in postoperative thyroid parenchyma.

Limitations

The limitation of this study might be the low number of patients, the age difference between the study and control groups, the difference between the type of surgery and the preoperative diagnosis of the study group.

CONCLUSION

In operated thyroid cases, the US-E values and elasticity of thyroid tissue may be decreased compared to healthy thyroid tissue. Familiarizing with this situation may contribute to minimally invasive intervention as well as being useful in the differential diagnosis of recurrent or residual tissues.

Authors' Contribution

Study Conception: YG, GK; Study Design: YG, ZÖ; Supervision: YG, ZÖ; Funding: GK, ZÖ; Materials: GK, ZÖ; Data Collection and/or Processing: YG, MB; Statistical Analysis and/or Data Interpretation: YG, MB; Literature Review: ZÖ, MB; Manuscript Preparation: YG, ZÖ and Critical Review: YG, GK.

Conflict of interest

The authors disclosed no conflict of interest during the preparation or publication of this manuscript.

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REFERENCES

1. Durgun Z, Yazıcı C, Inan AO. [Thyroid hormones and diseases]. Akdeniz Spor Bilimleri Dergisi 2019;2:28-40. [Article in Turkish]

2. Thyroid Study Group, Society of Endocrinology and Metabolism of Turkey. Guideline of Throid Diseases and Treatment. Turkey Clinics Publication, 4. Edition, April 2019. Ankara – Turkey.

3. Cetin M. [Ultrasonographic diagnosis in throid diseases]. SDU Tıp Fakültesi Dergisi. 2009;7:26-9. [Article in Turkish]
4. Dudea SM, Botar-Jid C. Ultrasound elastography in thyroid disease. Med Ultrason 2015;17:74-96.
5. Hefeda MM. Value of the new elastography technique using acoustic radiation force impulse in differentiation between Hashimoto's thyroiditis and Graves' disease. J Clin Imaging Sci 2019;9:17.
6. Kaliszewski K, Strutyńska-Karpińska M, Zubkiewicz-Kucharska A, Wojtczak B, Domosławski P, Balcerzak W, et. al. Should the prevalence of incidental thyroid cancer determine the extent of surgery in multinodular goiter? PloS One 2016;11:e0168654.
7. Cerit MN, Oktar SO. Lenf Bezleri, Tükrük Bezleri ve Boyun Kitlelerinde Elastografi. Türk Radyoloji Seminerleri 2019;7:38-49.
8. Akçakaya A, Koç B, Ferhatoğlu F. [Thyroid anatomy and surgical approach]. Okmeydanı Tıp Dergisi 2012;28(Suppl 1):1-9. [Article in Turkish]
9. Shin JH, Han BK, Ko EY, Kang SS. Sonographic findings in the surgical bed thyroidectomy: comparison of recurrent tumors and nonrecurrent lesions. J Ultrasound Med 2007;26:1359-66.
10. Frates MC. Ultrasound in recurrent thyroid disease. Otolaryngol Clin N Am 2008;41:1107-16.
11. Cantisani V, Lodise P, Grazhdani H, Mancuso E, Maggini E, Di Rocco G, et al. Ultrasound elastography in the evaluation of thyroid pathology. Current status. Eur J Radiol 2014;83:420-8.
12. Menzilcioglu MS, Duymus M, Gungor G, Citil S, Sahin T, Boysan SN, et al. The value of real-time ultrasound elastography in chronic autoimmune thyroiditis. Br J Radiol 2014;87:20140604.
13. Menzilcioglu MS, Duymus M, Avcu S. Sonographic elastography of the thyroid gland. Pol J Radiol 2016;81:152-6.
14. Yang Z, Zhang H, Wang K, Cui G, Fu F. Assessment of diffuse thyroid disease by strain ratio in ultrasound elastography. Ultrasound Med Biol 2015;41:2884-9.
15. Yurttutan N, Gungor G, Bilal N, Kizildag B, Baykara M, Sarica MA. Interpretation of thyroid glands in a group of healthy children: real-time ultrasonography elastography study. J Pediatr Endocrinol Metab 2016;29:933-7.
16. Gode S, Turhal G, Kismali E, Ozturk K, Midilli R. A novel method for comparison of tissue fibrosis after inferior turbinate surgery: ultrasound elastography. Am J Rhinol Allergy 2015;29:e33-6.
17. Korkusuz H, Happel C, Klebe J, Ackermann H, Grünwald F. Diagnostic accuracy of elastography and scintigraphic imaging after thermal microwave ablation of thyroid nodules. Rofo 2015;187:353-9.