Computers in Biology and Medicine 75 (2016) 257–266

Contents lists available at ScienceDirect

Computers in Biology and Medicine

journal homepage: www.elsevier.com/locate/cbm

Histogram and gray level co-occurrence matrix on gray-scale ultrasound images for diagnosing lymphocytic thyroiditis

Young Gyung Shin [a], Jaeheung Yoo [c], Hyeong Ju Kwon [d,e], Jung Hwa Hong [f], Hye Sun Lee [f], Jung Hyun Yoon [b], Eun-Kyung Kim [b], Hee Jung Moon [b], Kyunghwa Han [b], Jin Young Kwak [b,*]

[a] Department of Radiology, Kosin University Gospel Hospital, Research Institute of Radiological Science, Kosin University College of Medicine, Busan, Korea
[b] Department of Radiology, Severance Hospital, Research Institute of Radiological Science, Yonsei University College of Medicine, Seoul, Korea
[c] Severance Hospital, Yonsei University, College of Medicine, Seoul, Korea
[d] Department of Pathology, Yonsei University, College of Medicine, Seoul, Korea
[e] Department of Pathology, Yonsei University, Wonju College of Medicine, Wonju, Korea
[f] Department of Research Affairs, Biostatistics Collaboration Unit, Yonsei University College of Medicine, Seoul, Korea

ARTICLE INFO

Article history:
Received 1 February 2016
Received in revised form
9 June 2016
Accepted 13 June 2016

Keywords:
Thyroiditis
Autoimmune
Hashimoto disease
Thyroid diseases
Ultrasonography
Diagnosis
Texture analysis
Histogram and gray level co-occurrence matrix (GLCM)

ABSTRACT

The objective of the study was to evaluate whether texture analysis using histogram and gray level co-occurrence matrix (GLCM) parameters can help clinicians diagnose lymphocytic thyroiditis (LT) and differentiate LT according to pathologic grade. The background thyroid pathology of 441 patients was classified into no evidence of LT, chronic LT (CLT), and Hashimoto's thyroiditis (HT). Histogram and GLCM parameters were extracted from the regions of interest on ultrasound. The diagnostic performances of the parameters for diagnosing and differentiating LT were calculated. Of the histogram and GLCM parameters, the mean on histogram had the highest A_z (0.63) and VUS (0.303). As the degrees of LT increased, the mean decreased and the standard deviation and entropy increased. The mean on histogram from gray-scale ultrasound showed the best diagnostic performance as a single parameter in differentiating LT according to pathologic grade as well as in diagnosing LT.

1. Introduction

Lymphocytic thyroiditis (LT) is a common type of inflammation of the thyroid gland, and accurate diagnosis of LT helps clinicians better manage the disease process, reduces the number of unnecessary fine-needle aspirations (FNAs) performed, and helps predict thyroid failure [1]. Patients with LT can have a wide spectrum of histopathology from lymphocytic infiltration only to progressive loss of thyroid follicular cells, and formation of germinal centers associated with fibrosis that can change tissue hardness [2]. Pathologic grades of LT are separated at two points, chronic LT (CLT) and Hashimoto's thyroiditis (HT), depending on which features of LT are observed [2].

Gray-scale ultrasound (US) is the most common examination performed to diagnose suspected thyroid disease mainly due to its non-radioactive, non-invasive and superior diagnostic performance. It has been reported to have a role not only in the evaluation of masses, but also in the evaluation of inflammatory infiltrations, fibrosis, and differentiation of thyroid nodules within the diseased parenchyma [3–5]. Gray-scale US provides reproducible correlation between the functional status of Hashimoto's thyroiditis and hypoechogenicity of thyroid glands [6] and allows for supplementary judgements of thyroid function in Graves' disease [7]. However, US is entirely dependent on the performer with interobserver and intraobserver variations for diagnosing diffuse thyroid disease (DTD) [8]. To overcome the limitations of US, quantitative analysis has been performed using the histogram and gray level co-occurrence matrix (GLCM) to diagnose DTD [1,9–11]. However, to our knowledge, there have been no

Abbreviations: GLCM, gray level co-occurrence matrix; LT, lymphocytic thyroiditis; CLT, chronic lymphocytic thyroiditis; HT, Hashimoto's thyroiditis; DTD, diffuse thyroid disease; A_z, area under the curve; VUS, volume under the ROC surface

* Correspondence to: Department of Radiology, Research Institute of Radiological Science,Yonsei University College of Medicine, 50-1 Yonsei-ro, Seodaemun-gu, Seoul, Republic of Korea, 03722.
E-mail address: docjin@yuhs.ac (J.Y. Kwak).

http://dx.doi.org/10.1016/j.compbiomed.2016.06.014
0010-4825/

published studies on the diagnostic performance of texture analysis in LT according to the pathologic grades of LT. Therefore, we investigated the diagnostic performances of the histogram and GLCM parameters using gray-scale ultrasound images to diagnose LT and to differentiate conditions according to the pathologic grades of LT.

2. Materials and methods

This retrospective study was approved by the Institutional Review Board (IRB) of Severance Hospital, Seoul, Korea, and informed consent was waived.

2.1. Study population

Pre-operative staging US was performed in 575 patients suspected for thyroid malignancy at our institution from August to October 2013. Of 531 patients who underwent surgery, 90 were excluded because they did not have a sufficient amount of underlying thyroid parenchyma to establish correct diagnoses as there were multiple nodules in both thyroid glands. Finally, 441 patients were included in this study (Fig. 1). There were no patients with Graves' disease. Among the 441 patients, 358 (81.2%) were women and 83 (18.8%) were men. The mean age was 44.2 years for the women (range, 21–79 years) and 44.6 years for the

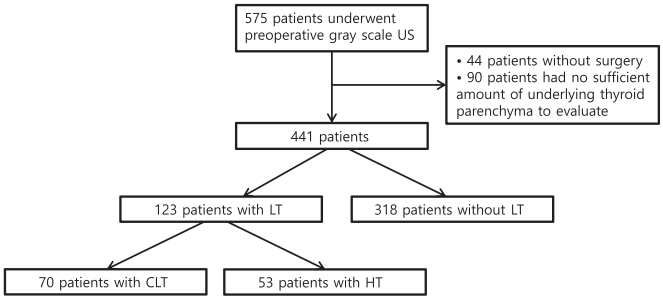

Fig. 1. Study population.

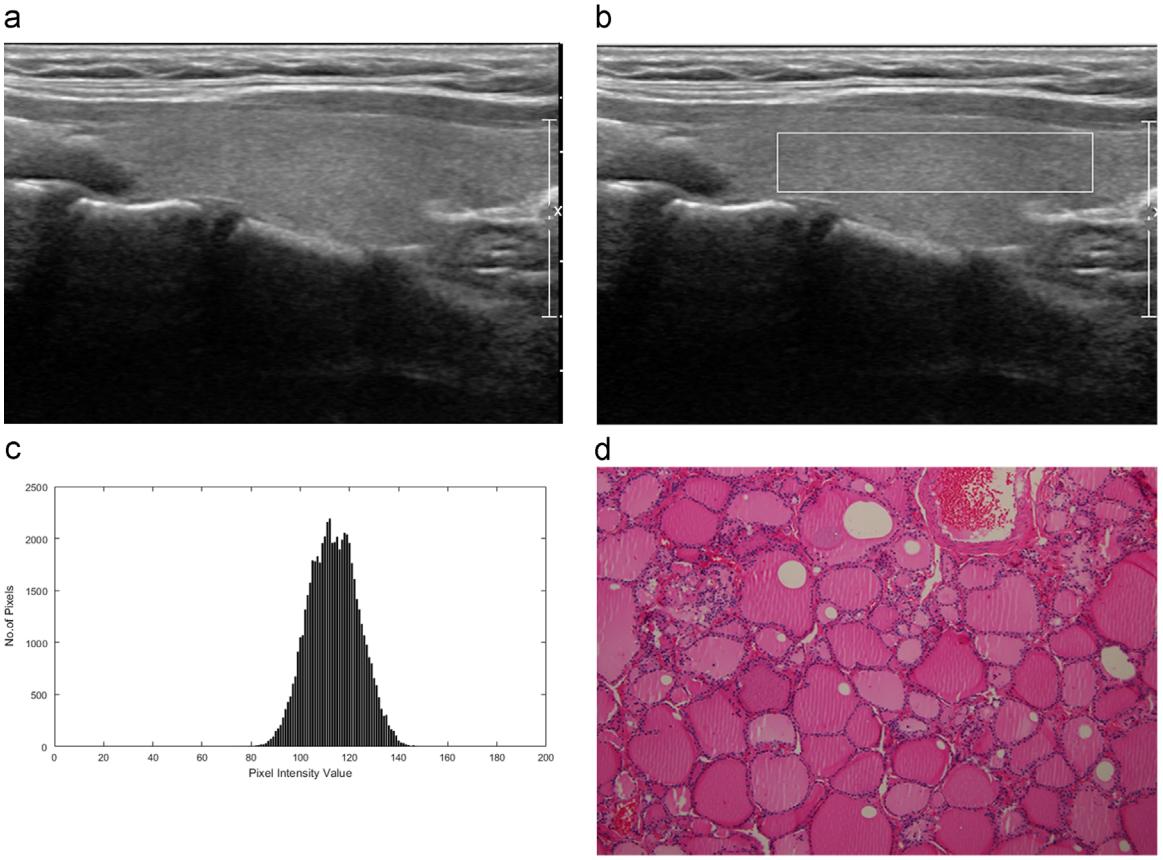

Fig. 2. A 37-year-old female without evidence of lymphocytic thyroiditis shows homogeneous parenchymal echogenicity on US (a). A region of interest including more than two-thirds of the thyroid lobe was drawn on the longitudinal scan of US while excluding thyroid nodules (b). Histogram analysis show the distribution of the number of pixels (*y*-axis) according to the pixel intensity value (*x*-axis) in the regions of interest of her thyroid gland (c). Pathology shows normal thyroid follicles which are variable in size and intact (hematoxylin and eosin stain, × 40) (d): Mean = 115.7, SD = 9.623, Skewness = 0.004, Kurtosis = 2.679, Entropy = 5.274.