Correlation Of Radiomics Features from Thyroid Planar Scan with ^{99m}Tc Uptake– A Preliminary Study

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ABSTRACT

Background: Use of radiomics features (RF) is being increasingly applied for the computer aided risk stratification of malignancy in thyroid nodules, using two- and three-dimensional imaging data. We explored the characteristic of radiomic features extracted from 99mTc thyroid planar scan (TTPS) images.

Patients and methods: Anterior planar images from patients who underwent TTPS with quantification of percent ^{99m}Tc-uptake (%TU) were analyzed in LIFEX software to generate RF data from two regions of interest (ROI): right lobe and left lobe per patient. Correlation of the RF from multiple categories were checked against the TU of each lobe. After discovering RF with significant correlation with demographic and clinical variables, the RF in each category with smallest p-value (i.e. the best correlation) were shortlisted.

Results: A total of 140 RF were extracted from 44 lobes in 22 consecutive patients. Among the RF, 21 of 32 morphological, 21 of 23 intensity based, 24 of 29 intensity histogram derived, 22 of 24 Gray-Level Co-occurrence Matrix (GLCM) based, 8 of 11 Gray-Level Run-Length Matrix (GLRLM) based, four of five Neighboring Gray Tone Difference Matrix (NGTDM) based and 10 of 16 Gray Level Size Zone (GLSZM) based, showed significant correlation with %TU ($p < 0.05$). The RF with lowest p-values in each category were, morphological integrated intensity ($R = 0.89$, $p = 3.59e-16$), intensity-based energy ($R = 0.94$, $p = 5.48e-21$), intensity histogram maximum histogram gradient ($R = 0.9$, $p = 1.56e-16$), GLCM angular second moment (R 0.92, $p = 5.13e-19$), GLRLM long runs emphasis ($R = 0.95$, $p = 3.36e-23$), NGTDM coarseness ($R = -0.59$, $p = 2.59e-05$), GLSZM large zone emphasis ($R = 0.96$, $p = 8.06e-25$), GLSZM large zone high grey level emphasis ($R = 0.96$, $p = 6.46e-25$), GLSZM zone size variance ($R = 0.96$, $p = 6.8e-25$).

Conclusions: Correlations of RF with %TU indicate the possibility of finding RF as biomarkers for nodular and generalized parenchymal thyroid diseases from TTPS images as well as possible usefulness of these RF in the prediction of disease outcome.

Keywords: Radiomics, ^{99m}Tc thyroid planar scan, % 99mTc uptake

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INTRODUCTION

The role of thyroid imaging in the current standards of practice is expected to expand with the adaptation of radiomics. Quantitative radiomic feature (RF) from thyroid imaging data can help differentiate between benign and malignant nodules, reduce biopsies, improve diagnostic accuracy in cases of indeterminate nodules, predict lymph node metastasis, predict treatment response and help in the modification of treatment plan (1-4). So far, the RF has been extracted from multiple imaging modalities that include 2D and 3D high resolution ultrasound, contrast enhanced ultrasound, shear wave elastosonography, magnetic resonance imaging, X ray computed tomography and F-18-FDG positron emission tomography (1, 5, 6). ^{99m}Tc thyroid planar scan (TTPS) images, being a reflector of sodium-iodine symporter (NIS) function (7) is a time-tested gold standard in the diagnosis and quantification of thyroid functional state, thyroid autonomy, the detection of ectopic thyroid and discrimination of hyperthyroidism from destructive thyrotoxicosis (8). Therefore, RF extracted from TTPS can be used to develop computer aided diagnosis in the management of not only thyroid nodules but also other entities of thyroid parenchymal disease. Consequently, this retrospective cross-sectional study was done to explore the correlation of percent ^{99m}Tc-uptake (%TU) with RF extracted from TTPS images from patients with various types of clinical and biochemical status. However, there was almost no correlation between serum TSH levels and HAM-A scores (Figure-3)

PATIENTS AND METHODS

Images from all patients who underwent TTPS with %TU were selected. The DICOM image data was used for the analysis. First, the DICOM images were loaded to freeware, Local Image Feature Extraction (LIFEX). Thereafter, region of interest (ROI) was drawn on each of the thyroid lobes to generate radiomic feature (RF) output data. The output data were then complied and compared to %TU of lobe to find

RFs with significant correlation, using *corrplot* package on R. A p-value < 0.05 (5e-2) was considered significant. Thereafter the p-value threshold was gradually lowered, starting from 0.01 (1e-2), 0.001 (1e-3) and so on, until the RF with lowest p-value was discovered (Figure 1). The correlation plots of the shortlisted RF with %TU are shown.

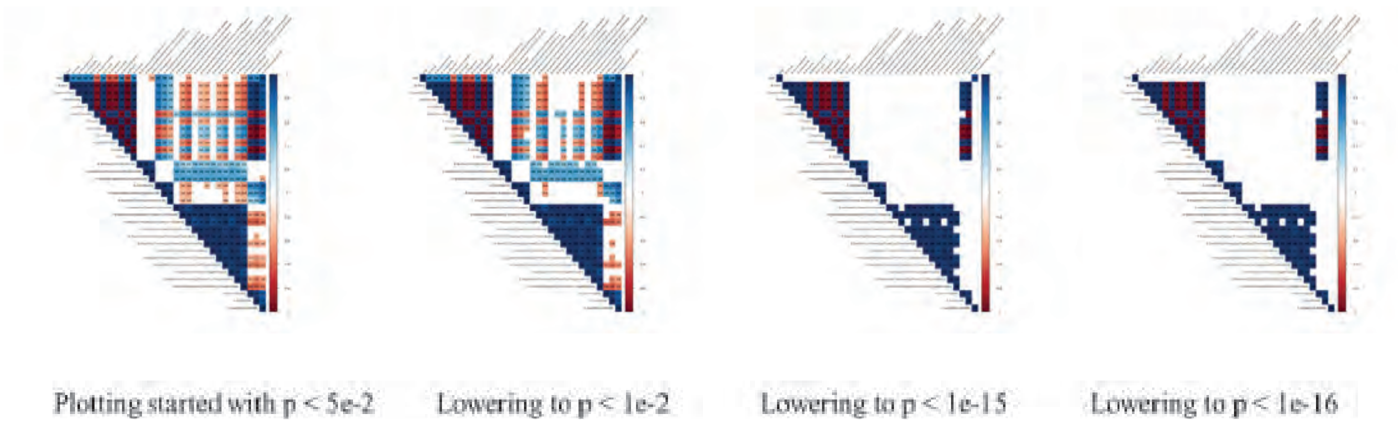

Figure 1: Example image of step-by-step discovery of RF with smallest p value by gradual lowering of p-value threshold in corrplot function. The plotting started with p 5e-2 revealed 21 of the 32 morphological RF were significantly correlated with %TU. Gradual lowering of p from 1e-2 until < 1e-16 revealed no remaining RF. Therefore, the last remaining RF at P< 1e-15 was marked as the morphological RF having the lowest p-value can be marked as RF that correlates the strongest.

RESULTS

A total of 25 patients underwent TTPS with %TU from October 2024 to December 2024. Image data from three patients were excluded due to radiotracer concentration in the thyroid not being discernible in comparison to the background activity. Images of 22 patients (18 males) with mean (± SD) age of 34.3 ± 11.7 years were included in the analysis. Categorically, eight had clinical and biochemical features of hypothyroidism, four were hyperthyroid and 10 were euthyroid.

After analyzing the DICOM image data in the LIFEX, a total of 140 RF per ROI (thyroid lobe) per patient were extracted from 22 consecutive patients. Among the RF, 21 of 32 morphological, 21 of 23 intensity based, 24 of 29 intensity histogram derived, 22 of 24 Gray-Level Co-occurrence Matrix (GLCM) based, 8 of 11 Gray-Level Run-Length Matrix (GLRLM) based, four of five Neighboring Gray Tone Difference Matrix (NGTDM) based and 10 of 16 Gray Level Size Zone (GLSZM) based, showed significant correlation with %TU (p < 0.05).

The RF with lowest p-values in each category were (Figure 2A-I), morphological integrated intensity (R = 0.89, p = 3.59e-16), intensity-based energy (R = 0.94, p = 5.48e-21), intensity histogram maximum histogram gradient (R = 0.9, p = 1.56e-16), GLCM angular second moment (R 0.92, p = 5.13e-19), GLRLM long runs emphasis (R = 0.95, p = 3.36e-23), NGTDM coarseness (R = -0.59, p = 2.59e-05), GLSZM large zone emphasis (R = 0.96, p = 8.06e-25), GLSZM large zone high grey level emphasis (R = 0.96, p = 6.46e-25), GLSZM zone size variance (R = 0.96, p = 6.8e-25).

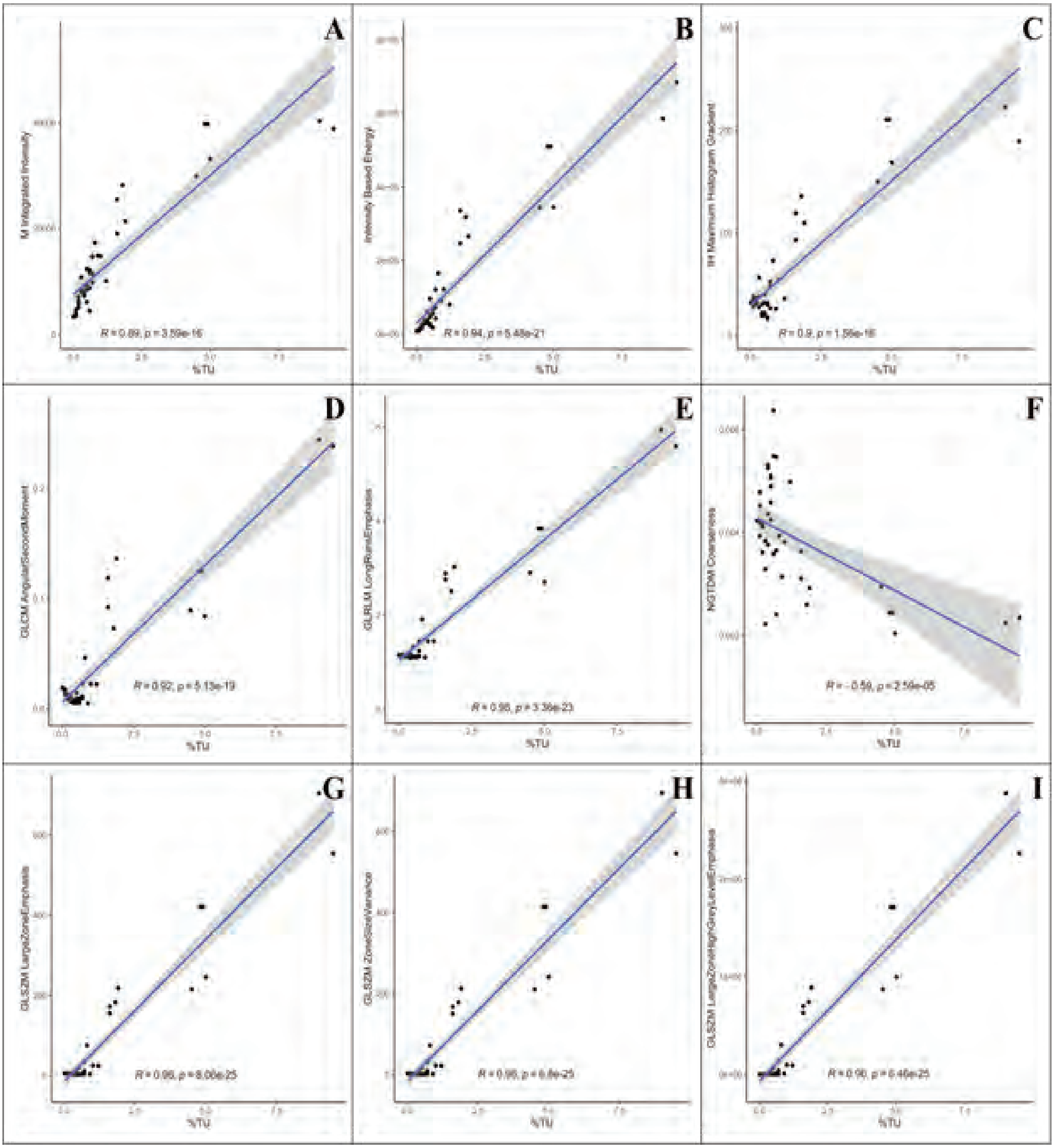

Figure 2: Correlation scatter plots showing the RF (in y-axes) with lowest p-values in each category, plotted against %TU (in x-axes).

Thus, 110 of 140 RF were found to have significant correlation with %TU while nine among those 110 were found to have best correlation based on the lowest p-value. Eight RF were found to be in positive correlation while one was in negative correlation.

DISCUSSION

The current interpretation of %TU is based on its normal range and that may vary according to geographical location (9-11). The prognostic role of %TU in clinical outcome of Graves' disease (12) and the role of extrathyroidal ^{99m}Tc

uptake see in of TTPS images in the prognoses of differentiated thyroid cancers (DTC) is known so far (13). Since the %TU reflects the NIS function (7), the RF that correlates with %TU are expected to contribute as important imaging biomarkers for Graves' disease, Hashimoto's thyroiditis, congenital hypothyroidism and iodine deficiency disorders that are associated NIS dysfunction (14). This contribution may extend into prediction of cases with poor prognosis, associated with failed expression of NIS gene despite TSH stimulation which is estimated to be up to 20% of differentiated thyroid cancers (15).

There remains scope for further exploration of eligibility of the RF from TTPS as biomarkers for prediction of patient outcome in thyroiditis, prediction of outcome of radioiodine therapy in hyperthyroidism patient who are refractory to pharmacotherapy. Moreover, discover of RF as surrogate for histopathological and immunohistochemical markers may aid in the shortlisting of patients as candidates for biopsy and then formation of an RF based risk prediction models in differentiated thyroid cancer.

Since the extraction of RF is dependent upon 99mTc uptake, this study was not capable to include cases with no uptake in the thyroid, which may be considered as a limitation of the current study. Future research with appropriate strategy to study those type of thyroid gland will be useful for clinical decision making.

CONCLUSION

This preliminary study shortlists a set of RF that have strongest correlation with %TU and may emerge as imaging biomarkers of NIS dysfunction. Further research in larger scale with inclusion of demographic, clinical, biochemical, histopathological and immunohistochemical data is required to end up with a clinically meaningful result.

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