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# Assessment of 20-Minute Tc-99m Thyroid Uptake as a Predictor of 24-Hour I-131 Uptake in a Bangladeshi Patient Cohort

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ABSTRACT

Twenty-four-hour radioactive iodine uptake (RAIU) using I-131 is the conventional quantitative standard for thyroid function assessment. However, it requires delayed measurement and exposes patients to higher radiation. Tc-99m pertechnetate thyroid scintigraphy is routinely performed for imaging, but its quantitative uptake potential remains underutilized in Bangladesh. To evaluate the relationship between 20-minute Tc-99m uptake and 24-hour I-131 uptake in an overall Bangladeshi patient cohort and to determine whether Tc-99m uptake can reliably predict I-131 uptake. This cross-sectional study was conducted at National Institute of Nuclear Medicine and Allied Sciences (NINMAS). A total of 120 patients (42 males, 78 females; age 11–73 years) underwent both I-131 uptake measurement and Tc-99m thyroid scintigraphy. Tc-99m uptake was calculated using standardized region-of-interest (ROI) analysis from gamma-camera images. Descriptive statistics, paired t-test, Pearson correlation, regression analysis, and diagnostic concordance evaluation were performed. The mean 20-minute thyroid uptake of the administered Tc-99m dose was 2.19%, while the mean 24-hour thyroid uptake of the administered I-131 dose was 17.63%. Tc-99m uptake significantly underestimated I-131 uptake ($p < 0.001$). A moderate positive correlation was observed ($r = 0.77$, $p < 0.001$; $R^2 = 0.60$). Importantly, 20-minute Tc-99m uptake was a reliable predictor of 24-hour I-131 uptake. Diagnostic concordance between the methods was 88.33%, and a stronger correlation was seen in females, with sex-specific models further enhancing predictive accuracy. Twenty-minute Tc-99m uptake demonstrates correlation and high diagnostic agreement with 24-hour I-131 uptake. It may serve as a rapid, low-radiation, and cost-effective alternative for preliminary thyroid function assessment in Bangladesh.

Keywords: Tc-99m uptake, I-131 uptake, thyroid scintigraphy, nuclear medicine.

## 1. Introduction

Thyroid disorders are a significant global endocrine health burden, and in Bangladesh, where iodine deficiency and autoimmune thyroid diseases are common, about 30% of the population is affected [1]. Accurate assessment of thyroid functional status is essential for diagnosis, therapeutic planning, and radioactive I-131 dose calculation.

Traditionally, Iodine-131 (I-131) uptake has been considered the widely used method for assessing thyroid function because it reflects the physiological behavior of natural iodine, including trapping, organification, and hormone synthesis [2]. Measurement of I-131 uptake plays an important role in diagnosing hyperthyroidism, differentiating the causes of thyrotoxicosis, and planning radioactive I-131 therapy for Ca-thyroid, as it helps determine the appropriate therapeutic dose [3,4,5]. However, the routine uses of I-131 has several limitations, including a long physical half-life (8.05 days), delayed acquisition time (24 hours), and higher radiation exposure resulting from beta-particle emission when used for diagnostic purposes [6]. Therefore, alternative radiotracers are often considered.

Technetium-99m (Tc-99m) pertechnetate is widely used for thyroid imaging because it emits a 140.5-keV gamma photon with no significant particulate (β) emission, has a short physical half-life of approximately 6.01 hours, and therefore results in relatively lower radiation exposure, and enables thyroid imaging within 20 minutes after administration [7,8]. Importantly, while Tc-99m is routinely used for thyroid imaging, it is not typically employed for direct thyroid uptake measurement. In our study, we derived the thyroid uptake values indirectly from the scintigraphic images. Although Tc-99m is trapped by the thyroid gland, it is not organified, several studies have reported a significant correlation between Tc-99m uptake and I-131 uptake [5,9,10]. These findings suggest that Tc-99m uptake can serve as a surrogate marker for estimating I-131 uptake.

However, thyroid uptake measurements are influenced by several factors, including regional iodine nutrition, population characteristics, and methodological differences [11]. Consequently, predictive relationships established in one population may not be directly applicable to another and require validation before clinical implementation. To date, no large cohort study has evaluated the relationship between 20-minute Tc-99m uptake and 24-hour I-131 uptake in Bangladeshi patients.

Therefore, the present study aimed to evaluate the relationship between 20-minute Tc-99m thyroid uptake and 24-hour I-131 uptake in a Bangladeshi patient cohort and assess the predictive performance of Tc-99m uptake for estimating I-131 uptake in this population.

## 2. Materials and Methods

### 2.1 Study Design and Population

This cross-sectional study was conducted at the National Institute of Nuclear Medicine and Allied Sciences (NINMAS), Bangladesh Atomic Energy Commission, Dhaka. A total of 120 eligible patients (78 females and 42 males) aged between 11 and 73 years who were referred for thyroid function evaluation and met the study eligibility criteria were included in the study.

Pregnant or breastfeeding women and patients with known hypersensitivity to radiopharmaceuticals were not referred for this procedure and were therefore not included in the study. All participants were informed about the procedures prior to imaging.

Each patient underwent both conventional radioactive iodine uptake (RAIU) testing using I-131(10 μCi) and thyroid scintigraphy using Tc-99m pertechnetate for comparative analysis of Tc-99m thyroid uptake values with conventional I-131 uptake measurements.

### 2.2 I-131 Thyroid Uptake Measurement

Thyroid uptake using Iodine-131 was performed according to standard nuclear medicine protocols. Each patient received an oral dose of approximately 10 μCi of I-131 sodium iodide. Thyroid uptake measurements were obtained at 2 hours and 24 hours following tracer administration.

A calibrated thyroid uptake probe equipped with a NaI(Tl) scintillation detector and a lead collimator was positioned approximately 25 cm from the anterior neck of the patient. Background radiation counts were measured over the hand region and subtracted from the thyroid counts to obtain corrected values.

The percentage uptake of I-131 was calculated using the following standard formula:

$$\text{I-131 Thyroid Uptake (\%)} = \frac{(PSC-ESC)}{(NC-HC)} \times 100$$

Where NC is the thyroid (neck) counts, HC is the background counts, PSC is the pre-syringe counts, and ESC is the empty syringe counts. The normal reference range used in clinical practice at NINMAS was 10.00%–30.00% at 24 hours.

### 2.3 Tc-99m Thyroid Scintigraphy

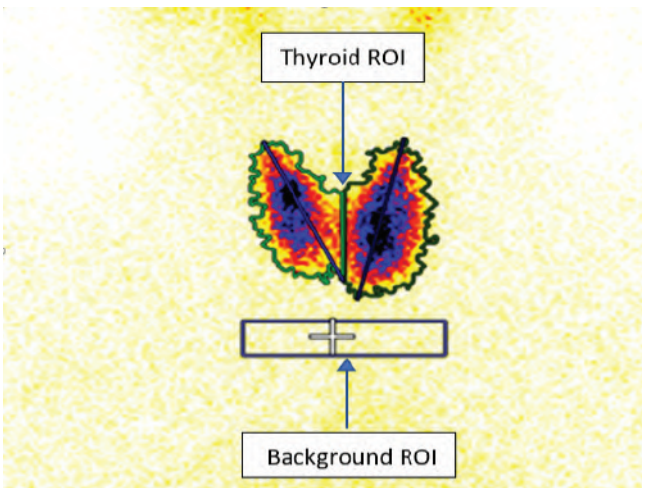
For technetium imaging, each patient received an intravenous injection of 1.5–3.5 mCi of Tc-99m pertechnetate. Imaging was performed 20 minutes after injection to allow adequate tracer trapping in the thyroid gland.

Thyroid scintigraphy was acquired using a single-head gamma camera equipped with a parallel-hole collimator. Images were obtained in the anterior view with the patient in a standing position and the neck slightly extended as shown in **Fig 1.** Static images were acquired in a 256 × 256 matrix with a 2-minute acquisition time centered on the thyroid region.

**Fig. 1**: Thyroid Scan with Gamma Camera

### 2.4 Tc-99m Thyroid Uptake Calculation

Tc-99m uptake was calculated using region-of-interest (ROI) analysis with the Inter View ™XP Clinical Processing System (version 3.07.007.0000; Mediso Medical Imaging Systems Ltd., Budapest, Hungary) on anterior thyroid images. First, a software-based ROI was automatically defined for the thyroid and background. When this was insufficient, such as in complex thyroid shapes or small nodules, manual ROI was used to ensure accuracy. A manual thyroid ROI was drawn on the gland, and a background ROI was placed nearby to account for non-thyroid activity, as shown in **Fig.2.** The background counts were corrected using the following formula:




**NFig. 2:** Thyroid ROI and Background ROIet Thyroid Counts

$$\textbf{= Thyroid ROI Counts -} \frac{(\text{Thyroid ROI Area} \times \text{Background ROI Counts})}{(\text{Background ROI Area}))}$$

The background-corrected thyroid counts were then used to calculate the percentage uptake of Tc-99m relative to the decay-corrected counts of the administered activity. The percentage thyroid uptake for Tc-99m is calculated using the formula:

$$\textbf{Tc-99m Uptake (\%) =} \frac{(\text{thyroid} - {}^{C}\text{BG})}{{}^{C}\text{std}}$$

Where Cthyroid is the thyroid counts, CBG is the background counts, and Cstd is the decay-corrected standard dose counts. International reference values of 0.75%–4.50% were used as the normal range for Tc-99m thyroid uptake [12].

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### 2.5 Statistical Analysis

Statistical analyses were performed using Microsoft Excel 2021 (Data Analysis ToolPak). Continuous variables were summarized using the mean, standard deviation (SD), median, and range (minimum–maximum). The relationship between 20-minute Tc-99m uptake and 24-hour I-131 uptake was evaluated using Pearson's correlation analysis. Simple linear regression was then performed to establish a predictive equation for estimating 24-hour I-131 uptake from 20-minute Tc-99m uptake. Since both uptake measurements were obtained from the same patients, a paired t-test was used to compare the mean uptake values of the two radiotracers. All statistical tests were two-tailed, and a p-value of less than 0.05 was considered statistically significant.

## 3. Results and Discussion

### 3.1 Overall Distribution of Thyroid Uptake According to Sex

The study included a total of 120 patients. The overall mean 20-minute Tc-99m uptake was 2.19%, while the corresponding mean 24-hour I-131 uptake was 17.63%. As the cohort included hypothyroid, euthyroid, and hyperthyroid patients with markedly different levels of thyroid function, a wide distribution of uptake values was expected. Therefore, median and 5th–95th percentile ranges were also reported to provide a more comprehensive description of the data.

The median uptake values were 0.83% for Tc-99m and 13.08% for I-131. The 5th–95th percentile range for Tc-99m uptake was 0.02%–8.45%, whereas for I-131 uptake it was 1.46%–45.73%.

Sex-wise thyroid uptake values are summarized in Table 1. Sex-wise analysis was included to provide baseline information for the subsequent sex-specific correlation and regression analyses. Overall, male patients tended to show higher mean uptake values than female patients for both Tc-99m and I-131.

**Table 1:** Thyroid Uptake Values by Sex for the Entire Patient Cohort.

| Gender | Patient Number | Average Tc-99m Uptake (%) | Tc-99m Min–Max Uptake (%) | Average I-131 Uptake (%) | I-131 Min–Max uptake (%) |
|---|---|---|---|---|---|
| Population | 120 | 2.19 | 0.01–18.72 | 17.63 | 0.80–75.00 |
| Female | 78 | 1.67 | 0.01–18.72 | 15.22 | 0.80–75.00 |
| Male | 42 | 3.14 | 0.02–13.80 | 22.10 | 1.05–74.00 |

A similar trend was reported by Wilson Soetanto and Robi Dany Riupassa [13], who observed higher Tc-99m pertechnetate uptake in male hyperthyroid patients than in females during thyroid scintigraphy. This difference may reflect sex-related physiological differences in thyroid function and tracer kinetics.

### 3.2 Age-Wise Distribution of Thyroid Uptake

The study cohort of 120 patients was categorized into three age groups: <30 years, 31–50 years, and >50 years. The majority of patients belonged to the 31–50 years' group (58.33%). Age-wise thyroid uptake data for both Tc-99m and I-131 are summarized in Table 2. The mean Tc-99m uptake demonstrated an increasing trend with age, reaching its highest value in patients aged over 50 years. In contrast, the highest mean I-131 uptake was observed in the 31–50 years' group, while patients aged under 30 years exhibited the lowest mean uptake values for both radiotracers. The median Tc-99m uptake values were 0.52%, 0.92%, and 0.85% for patients aged under 30 years, 31–50 years, and over 50 years, respectively, whereas the corresponding median I-131 uptake values were 9.00%, 14.25%, and 14.26%. The widest variation in uptake values for both radiotracers was also noted in the 31–50 years' group.

**Table 2:** Age-wise Uptake Distribution for All-Patients.

| Age Group | Patient Number (%) | Average Tc-99m Uptake (%) | Tc-99m Min–Max Uptake (%) | Average I-131 Uptake (%) | I-131 Min–Max uptake (%) |
|---|---|---|---|---|---|
| <30 Years | 29 (24.17%) | 1.12 | 0.01–7.05 | 14.52 | 1.05–67.00 |
| 31–50 Years | 70 (58.33%) | 2.49 | 0.01–18.72 | 19.15 | 0.90–75.00 |
| >50 Years | 21 (17.50%) | 2.62 | 0.01–13.79 | 16.84 | 0.80–45.70 |

These findings suggest modest age-related differences in thyroid uptake. The relatively higher uptake observed in middle-aged patients may reflect variations in thyroid physiology, iodine metabolism, and disease distribution across age groups. Similar age-related trends in Tc-99m pertechnetate thyroid uptake have been reported previously, with uptake values tending to increase with age in the studied population [12].

### 3.3 Comparison Between Tc-99m and I-131 Uptake (Paired t-Test)

A paired t-test was performed to compare the thyroid uptake values measured by 20-minute Tc-99m and 24-hour I-131 in the overall cohort (n = 120). The mean Tc-99m uptake was 2.19%, whereas the mean I-131 uptake was 17.63%. The analysis demonstrated a statistically significant difference between the two uptake measurements ($t = -12.38$, Degrees of freedom (df ) = 119, $p = 4.09 \times 10^{-23}$) (Table 3).

**Table 3:** Paired t-Test Results.

| Statistics | Tc-99m Uptake (%) | I-131 Uptake (%) |
|---|---|---|
| Mean | 2.19 | 17.63 |
| Variance | 10.83 | 257.84 |
| Observations | 120 | 120 |
| t Statistics (t-value) | –12.38 | |
| Degrees of freedom (df) | 119 | |
| Two-tailed p-value | $4.09 \times 10^{-23}$ | |

The lower Tc-99m uptake values observed in this study are consistent with the different physiological behavior of the two radiotracers. Tc-99m pertechnetate is actively trapped by the thyroid gland through the sodium–iodide symporter but is not organified within the thyroid follicles, whereas radioiodine undergoes both trapping and organification, resulting in greater intrathyroidal retention and consequently higher uptake values [14]. Similar

differences between Tc-99m and radioiodine uptake have been reported in nuclear medicine studies [15].

### 3.4 Correlation and Regression Analysis

A linear regression analysis was performed for the entire patient cohort (n = 120) using 20-minute Tc-99m uptake as the independent variable (x) and 24-hour I-131 uptake as the dependent variable (y). Linear regression analysis of the study data yielded the following regression equation:

**I-131 Uptake = 3.77 × (Tc-99m Uptake) + 9.38**

The coefficient of determination was $R^2 = 0.60$, indicating that 60% of the variability in I-131 uptake was explained by Tc-99m uptake. Pearson correlation analysis demonstrated a moderate positive correlation between Tc-99m and I-131 uptake values ($r = 0.77$, $p < 0.001$). The scatter plot illustrating the relationship between Tc-99m and I-131 uptake is presented in **Fig. 3.**

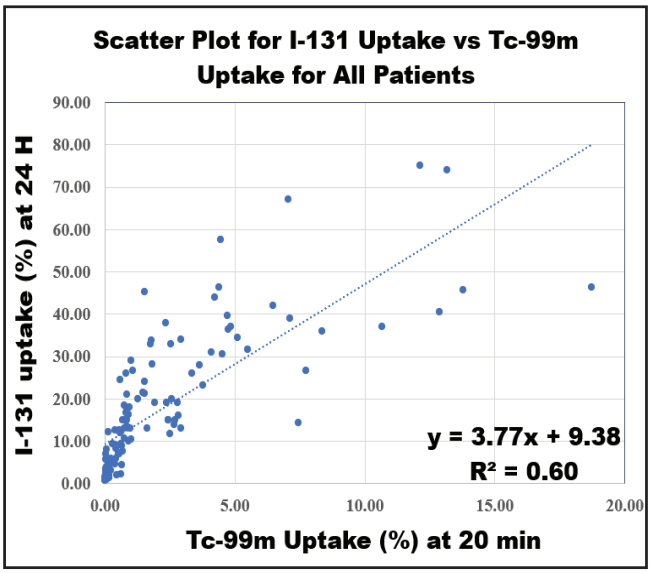


**Fig. 3:** Scatter Plot for the Uptake of Tc-99m at 20 Minutes and I-131 at 24 Hours in All Patients. The dashed line represents the fitted linear regression line.

Separate correlation analysis was conducted for male and female patients to explore sex-based differences in the relationship between Tc-99m and I-131 uptake. In male patients, a moderate positive correlation was observed ($r = 0.74$, $p < 0.01$), indicating a statistically significant but moderate association. In contrast, female patients demonstrated a stronger correlation ($r = 0.79$, $p < 0.001$), suggesting that Tc-99m uptake was a more robust predictor of I-131 uptake in the female subgroup.

Regression analysis further supported these findings. For males, the regression equation was: **I-131 uptake = 3.43 × (Tc-99m uptake) + 11.33,** ($R^2 = 0.55$). For females, the equation was: **I-131 uptake = 4.02 × (Tc-99m uptake) + 8.48,** ($R^2 = 0.62$). These findings suggest that sex-specific regression models may further improve the prediction of I-131 uptake. The scatter plots illustrating the relationship between Tc-99m and I-131 uptake for male and female patients are presented in **Fig. 4** and **Fig. 5**, respectively.

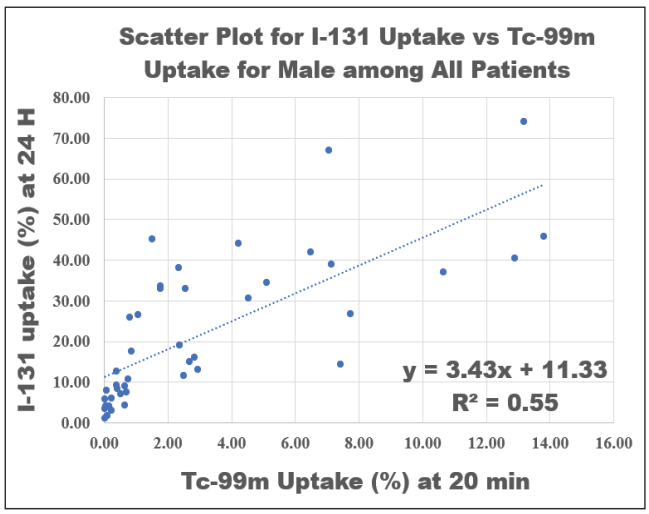


**Fig. 4:** Scatter Plot for the Uptake of Tc-99m at 20 Minutes and I-131 at 24 Hours in Male Patients. The dashed line represents the fitted linear regression line.

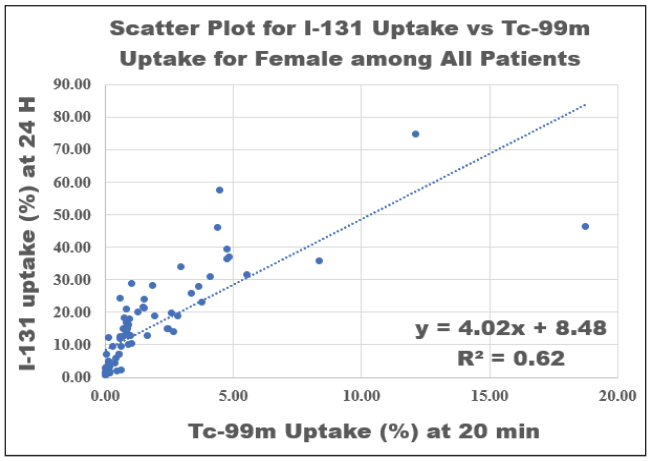


**Fig. 5:** Scatter Plot for the Uptake of Tc-99m at 20 Minutes and I-131 at 24 Hours in Female Patients. The dashed line represents the fitted linear regression line.

Despite the difference in absolute uptake values observed between the two radiotracers, the present study demonstrated a moderate positive correlation between Tc-99m uptake and I-131 uptake ($r = 0.77$) in the overall

patient cohort. This finding supports the potential utility of Tc-99m uptake for estimating 24-hour I-131 uptake. Smith JJ et al. [9] showed that 5-minute Tc-99m uptake measurements could reliably estimate 24-hour radioiodine uptake, reporting a strong correlation between the two parameters. Similarly, Chatchai Navikhacheevin et al. [16] reported that both 5- and 20-minute Tc-99m uptake measurements showed a strong correlation with 24-hour I-131 RAIU. In agreement with their findings, the present study demonstrated that 20-minute Tc-99m uptake was a significant predictor of 24-hour I-131 uptake in a Bangladeshi patient cohort. Likewise, Sadia Hossain et al. [10] also observed a strong correlation between 20-minute Tc-99m uptake and 24-hour I-131 RAIU, further supporting the predictive value of Tc-99m uptake for estimating radioiodine uptake.

Although positive correlations were observed in both sexes, the correlation coefficient was slightly higher in female patients (r = 0.79) than in male patients (r = 0.74). The difference was modest but may reflect biological or physiological factors influencing the relationship between Tc-99m and I-131 uptake measurements. Similar observations have been reported previously. Al-Jabri A et al. [17] found sex-related variability in the correlation between Tc-99m and I-131 uptake, although the correlation was stronger in male patients than in females. The discrepancy between their findings and those of the present study may be attributable to differences in patient characteristics, disease patterns, iodine nutritional status, sample size, or regional population characteristics. As the present study was conducted in a Bangladeshi patient cohort, these factors may have contributed to the observed variation.

### 3.5 Diagnostic Concordance and Clinical Implications of Tc-99m Uptake

Overall diagnostic agreement between Tc-99m and I-131 uptake-based thyroid function classification was 88.33%. Most patients were categorized identically as hypothyroid, euthyroid, or hyperthyroid by both methods. The distribution of concordant and discordant classifications is illustrated in **Fig. 6**.

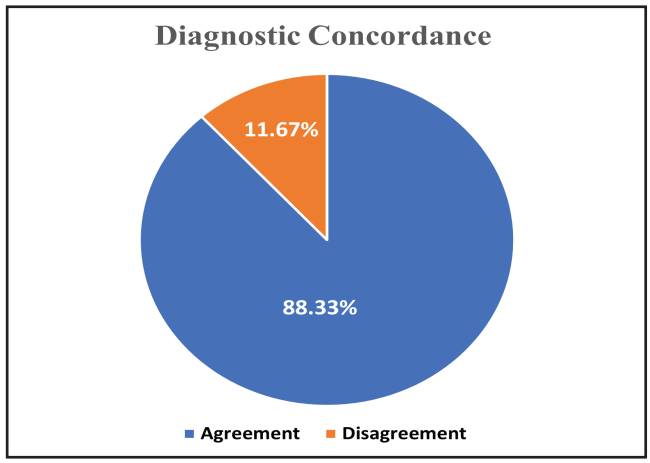


**Fig. 6:** Diagnostic Concordance Between Tc-99m and I-131 Uptake-Based Thyroid Function Classification in the Entire Patient Cohort.

The observed diagnostic concordance indicates that 20-minute Tc-99m uptake-based classification was largely consistent with that obtained using the conventional 24-hour I-131 uptake test. Similarly, M Ohiduzzaman et al. [18] reported a diagnostic concordance of approximately 95%; however, their study included only hyperthyroid patients, whereas the present study evaluated agreement across hypothyroid, euthyroid, and hyperthyroid patients. The small proportion of discordant classifications may reflect the inherent physiological differences between Tc-99m pertechnetate and radioiodine, together with biological and methodological variations in thyroid uptake measurements.

From a clinical perspective, the high diagnostic concordance observed in the present study suggests that 20-minute Tc-99m uptake may provide a practical alternative for thyroid function classification when 24-hour I-131 uptake measurement is not feasible or is less convenient. In addition, Tc-99m imaging can be performed rapidly with relatively lower radiation exposure than I-131 uptake studies, making it a practical option for routine nuclear medicine practice and busy clinical settings.

The present study also provides valuable data for the Bangladeshi population, where population-specific reference values for Tc-99m uptake remain limited. Because thyroid uptake measurements may vary among regions due to differences in iodine intake, dietary habits, and environmental factors, locally generated data are important for improving the interpretation of thyroid uptake studies and for developing population-specific predictive models. Similar geographic variations in

Tc-99m pertechnetate thyroid uptake have been reported in other populations, highlighting the importance of establishing region-specific reference ranges for accurate clinical interpretation (Gholami A et al.) [19].

Several limitations should be considered. This was a single-center study, and differences in imaging equipment or acquisition protocols across institutions may influence thyroid uptake measurements. In addition, long-term patient follow-up was not available to evaluate the predictive value of Tc-99m uptake in guiding therapeutic decisions. Future multicenter studies with larger patient cohorts and standardized imaging protocols are warranted to further validate these findings and to establish population-specific reference ranges for Tc-99m uptake in Bangladesh.

## 5. Conclusions

This study demonstrated that 20-minute Tc-99m pertechnetate thyroid uptake has a moderate positive relationship with conventional 24-hour I-131 radioactive iodine uptake in a Bangladeshi patient cohort. Although Tc-99m uptake values are lower due to differences in tracer physiology, the significant correlation and high diagnostic agreement between the two methods indicate that Tc-99m uptake can serve as a useful predictor of radioiodine uptake in many clinical situations.

Given its rapid acquisition time, lower radiation exposure, and wide availability, Tc-99m thyroid uptake measurement may provide a practical alternative for initial assessment of thyroid function and estimation of I-131 uptake in routine nuclear medicine practice. Further multicenter studies are recommended to validate these findings and to establish population-specific reference ranges for Tc-99m uptake in Bangladesh.

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