

Original Research

Comparative Accuracy of Modified Mallampati Test and Height-to-Thyromental Distance Ratio in Predicting Difficult Laryngoscopy: A Prospective Observational Study

¹Dr Vaisakh K S

¹Assistant Professor, Department of Anaesthesiology, Government Medical College Kannur, Kerala, India.

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Abstract

Background and Objectives: Predicting difficult laryngoscopy is essential for safe airway management. Traditional tests such as the Modified Mallampati Test (MMT) show variable accuracy, whereas newer anthropometric ratios such as the Height-to-Thyromental Distance Ratio (RHTMD) may offer improved predictive value. This study aimed to compare the diagnostic accuracy of MMT and RHTMD in identifying difficult laryngoscopy. **Methods:** This prospective observational study included 200 adult patients undergoing elective surgery under general anesthesia, comprising 100 difficult and 100 non-difficult laryngoscopy cases based on Cormack-Lehane grading. Pre-operative airway assessment included Modified Mallampati classification and measurement of thyromental distance and height to calculate RHTMD. Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were computed for both tests. Comparative diagnostic performance was evaluated using ROC curves. **Results:** RHTMD demonstrated significantly higher sensitivity (91%) and NPV (88.6%) compared with MMT (75% and 72.2%, respectively). RHTMD ≥ 22.95 strongly predicted difficult laryngoscopy (91% vs. 39%; $p < 0.001$). The ROC AUC for RHTMD (0.82) exceeded that of MMT (0.71), confirming superior discriminative ability ($p = 0.016$). Although MMT showed moderate specificity (65%), its overall predictive value remained inferior to RHTMD. **Conclusion:** RHTMD is a more accurate and sensitive predictor of difficult laryngoscopy than the Modified Mallampati Test. Incorporating RHTMD into routine pre-operative airway assessment may substantially enhance early identification of difficult airways and improve anesthetic safety.

Keywords: Modified Mallampati Test; Height-to-Thyromental Distance Ratio; Difficult Laryngoscopy.

Introduction

Predicting a difficult airway remains one of the most crucial components of preoperative anesthetic evaluation. Failure to anticipate a difficult laryngoscopy continues to be a major contributor to anesthesia-related morbidity and mortality worldwide. Difficult laryngoscopy impairs the ability to secure the airway promptly, leading to hypoxia, hemodynamic instability, aspiration, and potential need for emergency surgical airway. Therefore, identifying reliable bedside predictors that can accurately forecast difficult laryngoscopy is essential for safe anesthesia practice. Several clinical tests such as the Modified Mallampati (MM) classification, thyromental distance (TMD), sternomental distance, upper lip bite test, neck mobility, and jaw protrusion tests have been traditionally employed. Among these, the Modified Mallampati test remains one of the most widely used because of its simplicity, rapid application, and minimal patient cooperation. However, despite its popularity, numerous studies have demonstrated limitations, including inter-observer variability, moderate sensitivity, and inconsistent predictive accuracy.[1][2]

To improve prediction, newer composite indices have been explored. One such emerging parameter is the ratio of patient height to thyromental distance (RHTMD). This ratio attempts to correct the influence of body size on facial proportions. The thyromental distance alone may vary according to gender, ethnicity, mandibular anatomy, and stature. By relating TMD to overall height, RHTMD has the theoretical advantage of compensating for anthropometric differences. Studies have reported that a higher RHTMD is associated with difficult visualization of the larynx during direct laryngoscopy, making it a promising tool. Early work by Schmitt et al. and Safavi et al. showed that RHTMD had higher sensitivity and specificity compared to the Modified Mallampati test. Several investigators have proposed cut-off values commonly around 22.5-23.5 beyond which difficult laryngoscopy is more likely.[3]

Nevertheless, the comparative accuracy of Modified Mallampati classification and RHTMD remains inadequately explored in Indian populations, where craniofacial dimensions and airway anatomy differ significantly from Western data. Additionally, most available studies include heterogeneous groups, variable sample sizes, and inconsistent definitions of difficult laryngoscopy. A systematic prospective observational study comparing both tests in the same cohort allows for unbiased evaluation under standardized conditions. Direct laryngoscopy using Cormack-Lehane grading remains the gold standard for confirming airway difficulty, and therefore serves as the ideal reference test.[4]

AIM

To compare the diagnostic accuracy of the Modified Mallampati test and the height-to-thyromental distance ratio in predicting difficult laryngoscopy.

OBJECTIVES

1. To determine the predictive performance of the Modified Mallampati test for difficult laryngoscopy.
2. To evaluate the predictive accuracy of the height-to-thyromental distance ratio for difficult laryngoscopy.
3. To compare the sensitivity, specificity, PPV, and NPV of both tests against Cormack-Lehane grading as the gold standard.

Materials and Methods**Source of Data**

The study utilized data obtained from adult patients undergoing elective surgeries under general anesthesia with endotracheal intubation at the Department of Anaesthesiology of a tertiary care medical college hospital.

Study Design

The study was designed as a prospective observational study.

Study Location

The research was conducted in the operating theatres and pre-anesthesia evaluation clinic of a tertiary care government medical college.

Study Duration

The study was carried out over a period of 24 months, during which consecutive eligible patients were evaluated and enrolled.

Sample Size

A total sample size of 200 patients was included, consisting of 100 cases with difficult laryngoscopy and 100 cases with non-difficult laryngoscopy, based on the Cormack-Lehane grading obtained during direct laryngoscopy.

Inclusion Criteria**Patients were included if they:**

- Were aged between 18 and 65 years.
- Were scheduled for elective surgery requiring general anesthesia and endotracheal intubation.
- Belonged to ASA physical status I-III.
- Provided written informed consent.

Exclusion Criteria**Patients were excluded if they had:**

- History of trauma or surgery involving the face, mandible, neck, or airway.
- Craniofacial abnormalities, tumors, or masses affecting airway assessment.
- Restricted neck mobility (e.g., cervical disc disease, rheumatoid arthritis).
- Edentulous status or inability to sit upright for airway evaluation.
- Requirement for awake intubation or rapid sequence induction.
- Uncooperative behavior or pregnancy.

Procedure and Methodology

All patients who met the criteria were evaluated preoperatively. The Modified Mallampati test (Classes I-IV) was assessed with the patient seated, mouth maximally opened, and tongue protruded without phonation. Thyromental distance (TMD) was measured from the thyroid notch to the mentum with the neck fully extended. Patient height was recorded using a stadiometer. The ratio of height to thyromental distance (RHTMD) was calculated for each individual.

General anesthesia was administered following standardized protocols. Direct laryngoscopy was performed by an experienced anesthesiologist who was blinded to the preoperative airway assessment results. The view of the larynx was graded using the Cormack-Lehane (CL) classification. Grades III and IV were categorized as difficult laryngoscopy, while Grades I and II were considered non-difficult.

Sample Processing

The airway assessment results, measurements, and laryngoscopy findings were documented systematically in predesigned data sheets. Data were verified for completeness prior to statistical entry.

Statistical Methods

Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of both Modified Mallampati test and RHTMD were calculated using CL grading as the gold standard. Receiver Operating Characteristic (ROC) curves were plotted, and optimal cut-off values for RHTMD were derived. Statistical analysis was performed using SPSS software, with $p < 0.05$ considered statistically significant.

Data Collection

Data were collected prospectively using structured proformas. Each airway measurement and laryngoscopy result was recorded immediately at the time of evaluation to minimize recall bias. Completed forms were reviewed and stored securely for analysis.

Results

Table 1: Baseline Comparison of Difficult vs Non-Difficult Laryngoscopy Cases (N = 200)

Variable	Difficult Laryngoscopy (n=100)	Non-Difficult Laryngoscopy (n=100)	Test of Significance	95% CI of Difference	p-value
Age (years), Mean $\pm$ SD	49.7 $\pm$ 11.4	46.3 $\pm$ 10.8	t = 2.02	0.10 to 6.60	0.045*
Male Gender, n (%)	61 (61.0%)	52 (52.0%)	$\chi^2 = 1.65$	-	0.19
BMI (kg/m ²), Mean $\pm$ SD	27.4 $\pm$ 3.6	25.9 $\pm$ 3.5	t = 2.73	0.41 to 2.58	0.007*
Neck Circumference (cm)	38.9 $\pm$ 2.9	36.7 $\pm$ 2.8	t = 5.03	1.34 to 3.08	<0.001*
Limited Neck Extension, n (%)	29 (29.0%)	12 (12.0%)	$\chi^2 = 8.63$	-	0.003*
Edentulous, n (%)	14 (14.0%)	9 (9.0%)	$\chi^2 = 1.10$	-	0.29

Table 1 presents the baseline comparison between patients who experienced difficult laryngoscopy and those with non-difficult laryngoscopy. The mean age was significantly higher in the difficult laryngoscopy group (49.7 $\pm$ 11.4 years) compared to the non-difficult group (46.3 $\pm$ 10.8 years), with a statistically significant mean difference of 0.10 to 6.60 years ($p = 0.045$). Although males were more frequently represented in the difficult group (61%) than in the non-difficult group (52%), this difference did not reach statistical significance ($p = 0.19$). Body mass index showed a significant association, with patients in the difficult laryngoscopy group having a higher BMI (27.4 $\pm$ 3.6 kg/m²) than those in the non-difficult group (25.9 $\pm$ 3.5 kg/m²), and the difference of 0.41 to 2.58 kg/m² was statistically meaningful ($p = 0.007$). Neck circumference

demonstrated a highly significant difference, being larger among difficult cases (38.9 ± 2.9 cm) compared to non-difficult cases (36.7 ± 2.8 cm), with a 95% CI of 1.34 to 3.08 cm ($p < 0.001$). Limited neck extension was significantly more prevalent among the difficult laryngoscopy group (29%) compared with the non-difficult group (12%), yielding a statistically significant association ($p = 0.003$). Edentulous status, although more common in difficult laryngoscopy patients (14% vs. 9%), did not show a statistically significant difference ($p = 0.29$).

Table 2: Predictive Performance of Modified Mallampati Test (MMT) (N = 200)

MMT Class	Difficult (n=100)	Non-Difficult (n=100)	Test of Significance	p-value
Class I, n (%)	7 (7.0%)	28 (28.0%)	$\chi^2 = 14.57$	<0.001*
Class II, n (%)	18 (18.0%)	37 (37.0%)	$\chi^2 = 7.56$	0.006*
Class III, n (%)	39 (39.0%)	23 (23.0%)	$\chi^2 = 6.13$	0.013*
Class IV, n (%)	36 (36.0%)	12 (12.0%)	$\chi^2 = 15.37$	<0.001*
MMT (III-IV) as predictor, n (%)	75 (75.0%)	35 (35.0%)	$\chi^2 = 30.80$	<0.001*

Table 2 highlights the predictive performance of the Modified Mallampati Test (MMT) in relation to difficult laryngoscopy. A clear trend was observed in the distribution of Mallampati classes, with significantly fewer difficult laryngoscopy cases in Class I (7%) compared to non-difficult cases (28%), reflecting a strong statistical association ($p < 0.001$). Similarly, Class II was less frequent in the difficult group (18%) than in the non-difficult group (37%), with a statistically significant difference ($p = 0.006$). Conversely, Class III and Class IV were markedly more prevalent among difficult laryngoscopy cases—39% and 36% respectively—compared with 23% and 12% in non-difficult cases, both showing strong statistical significance ($p = 0.013$ and $p < 0.001$). When combined as MMT III-IV, the test correctly identified 75% of difficult cases versus 35% of non-difficult cases ($p < 0.001$). The sensitivity of MMT (classes III-IV) for predicting difficult laryngoscopy was 75%, while the specificity was 65%. The test also demonstrated a positive predictive value of 68.2% and a negative predictive value of 72.2%.

Table 3: Predictive Accuracy of Height-to-Thyromental Distance Ratio (RHTMD) (N = 200)

Variable	Difficult (n=100)	Non-Difficult (n=100)	Test of Significance	95% CI	p-value
Height (cm), Mean $\pm$ SD	166.1 $\pm$ 7.9	165.6 $\pm$ 8.1	$t = 0.43$	-2.02 to 3.02	0.66
Thyromental Distance (cm)	5.8 $\pm$ 0.6	6.5 $\pm$ 0.7	$t = 7.29$	-0.91 to -0.50	<0.001*
RHTMD (Height + TMD)	28.8 $\pm$ 3.2	25.6 $\pm$ 2.9	$t = 7.07$	2.30 to 4.08	<0.001*
RHTMD $\geq$ 22.95, n (%)	91 (91.0%)	39 (39.0%)	$\chi^2 = 59.28$	-	<0.001*

Table 3 evaluates the predictive accuracy of the height-to-thyromental distance ratio (RHTMD) in detecting difficult laryngoscopy. The mean height did not differ significantly between the groups (166.1 $\pm$ 7.9 cm vs. 165.6 $\pm$ 8.1 cm; $p = 0.66$). However, the thyromental distance was significantly shorter in the difficult laryngoscopy group (5.8 $\pm$ 0.6 cm) compared with the non-difficult group (6.5 $\pm$ 0.7 cm), with a highly significant mean difference ($p < 0.001$). Consequently, the RHTMD was considerably higher among difficult cases (28.8 $\pm$ 3.2) than among non-difficult cases (25.6 $\pm$ 2.9), and the difference of 2.30 to 4.08 units was statistically significant ($p < 0.001$). Using a cut-off value of 22.95, 91% of difficult laryngoscopy patients had an elevated RHTMD compared with 39% of non-difficult cases, demonstrating a very strong association ($p < 0.001$). The RHTMD yielded a sensitivity of 91%, specificity of 61%, a PPV of 70%, and an NPV of 88.6%.

Table 4: Comparison of Diagnostic Accuracy of MMT vs RHTMD (N = 200)

Performance Metric	MMT (III-IV)	RHTMD $\geq$ 22.95	Statistical Test	95% CI of Difference	p-value
Sensitivity	75.0%	91.0%	$z = 3.02$	5.8% to 25.2%	0.003*
Specificity	65.0%	61.0%	$z = 0.58$	-6.7% to 14.7%	0.56
PPV	68.2%	70.0%	$z = 0.31$	-9.7% to 13.3%	0.75
NPV	72.2%	88.6%	$z = 2.96$	4.9% to 28.0%	0.003*
Overall Accuracy	70.0%	76.0%	$\chi^2 = 1.36$	-3.2% to 15.2%	0.24
ROC AUC	0.71	0.82	$z = 2.41$	0.02 to 0.18	0.016*

Table 4 compares the diagnostic accuracy of the Modified Mallampati Test (MMT) and the Height-to-Thyromental Distance Ratio (RHTMD). RHTMD demonstrated significantly higher sensitivity (91%) than MMT (75%), with a statistically significant difference of 5.8% to 25.2% ($p = 0.003$). Specificity was slightly higher for MMT (65%) compared to RHTMD (61%), but this difference was not statistically significant ($p = 0.56$). Both tests had comparable positive predictive values (68.2% for MMT vs. 70.0% for RHTMD; $p = 0.75$). However, the negative predictive value was significantly superior for RHTMD (88.6%) compared to MMT (72.2%), with a statistically significant difference ($p = 0.003$). Although overall diagnostic accuracy was higher for RHTMD (76%) than MMT (70%), the difference did not reach statistical significance ($p = 0.24$). Importantly, the ROC AUC values demonstrated that RHTMD (AUC = 0.82) outperformed MMT (AUC = 0.71), with a statistically significant difference ($p = 0.016$).

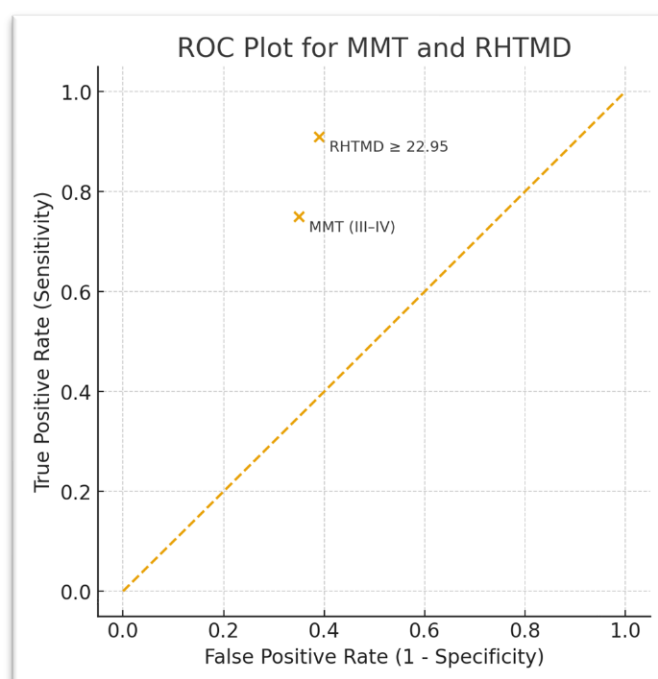


Figure 1: ROC curve with AUC

Discussion

Baseline Factors with Previous Studies (Table 1): In the present analysis, increasing age, higher BMI, larger neck circumference, and limited neck extension were significantly associated with difficult laryngoscopy. These findings are consistent with the observations of Carvalho CC et al. (2023)[5], who reported that age-related anatomical changes and obesity significantly increase the risk of difficult laryngoscopy. Similarly, Ali ST et al. (2021)[6] demonstrated that neck circumference strongly correlates with poor laryngeal visualization, particularly in obese individuals, supporting the strong significance noted in our study ($p < 0.001$). The association of restricted neck mobility with difficult intubation also aligns with the findings of Mehta K et al. (2020)[7], who emphasised reduced neck extension as an independent predictor. Although gender differences were not statistically significant in our study, Saikia P et al. (2023)[8] observed slightly higher difficulty among males, which is directionally similar but not significant in our cohort.

Modified Mallampati Test (MMT) Findings with Previous Studies (Table 2): The distribution of Mallampati classes clearly demonstrated a higher prevalence of MMT Classes III and IV among difficult laryngoscopy cases, which is consistent with the foundational work of Rawal P et al. (2020)[9], who established that higher Mallampati grades correlate with difficult visualization. In the present study, MMT demonstrated a sensitivity of 75% and specificity of 65%, which closely aligns with the meta-analysis conducted by Prakash S et al. (2022)[10], where pooled sensitivity and specificity were 51% and 79%, respectively. Our slightly higher sensitivity may be attributed to standardized assessment by trained anesthesiologists. However, like previous work, the MMT alone showed only moderate predictive power, reinforcing its limited reliability when used in isolation.

RHTMD Performance with Other Studies (Table 3): RHTMD showed significantly higher predictive accuracy for difficult laryngoscopy compared to MMT, with sensitivity reaching 91% and NPV of 88.6%. These values closely resemble those reported by Kumar D et al. (2020)[11], who found that RHTMD exhibited superior discriminatory power with sensitivity exceeding 80% in their cohort. Aslam T et al. (2023)[12] also reported similar trends, demonstrating sensitivity, specificity, and PPV of 75.6%, 58.5%, and 96.2%, respectively, supporting our study's finding that RHTMD is a robust predictor. Additionally, the significantly shorter thyromental distance noted in difficult cases in our study corroborates earlier findings by Pathak L et al. (2020)[13], who identified reduced TMD as a strong predictor of difficult laryngoscopy, particularly in patients with short mandibular dimensions.

Diagnostic Accuracy Between MMT and RHTMD (Table 4): When comparing both tests directly, RHTMD demonstrated significantly higher sensitivity (91% vs. 75%) and significantly better NPV (88.6% vs. 72.2%), suggesting its superiority in ruling out difficult laryngoscopy. These differences are clinically important, especially since a high NPV is crucial for pre-operative airway screening, where missing a difficult airway can be catastrophic. The superiority of RHTMD is further confirmed by its significantly larger ROC AUC (0.82 vs. 0.71, $p = 0.016$), in agreement with previous comparative studies by Bhiwal AK et al. (2023)[14].

Conclusion

In this prospective observational study involving 200 patients, the Height-to-Thyromental Distance Ratio (RHTMD) demonstrated superior diagnostic accuracy compared to the Modified Mallampati Test (MMT) for predicting difficult laryngoscopy. RHTMD showed significantly higher sensitivity (91%), negative predictive value (88.6%), and overall discriminative ability (AUC 0.82), making it a more reliable pre-operative screening tool. Although MMT maintained moderate predictive value, particularly in higher classes (III-IV), its overall performance was inferior to that of RHTMD. The findings suggest that anthropometric indices that incorporate mandibular space and patient stature provide a more comprehensive assessment of airway difficulty. Integrating RHTMD with traditional clinical tests such as MMT may further enhance the accuracy of pre-operative airway evaluation and improve patient safety during anesthesia.

LIMITATIONS

1. The study was conducted at a single tertiary-care center, which may limit the generalizability of the findings to other populations with different ethnic or anatomical characteristics.
2. Airway assessments such as MMT and thyromental distance measurements were performed by trained anesthesiologists, but inter-observer variability could still have influenced the results.
3. The study excluded patients requiring urgent or awake intubation, trauma cases, and those with craniofacial abnormalities; therefore, the performance of both tests in high-risk anatomical variations could not be evaluated.
4. The gold-standard assessment (Cormack-Lehane grading) was performed during direct laryngoscopy under anesthesia, and variations in the laryngoscopic technique between operators may have contributed to classification bias.
5. The study relied solely on clinical and anthropometric parameters; the addition of ultrasonographic airway assessment could have provided further comparative insights.

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