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Original Research Article

# Clinical Assessment between Measurement of Mandibular Condylar Mobility (USG Guided) Versus Maximum Condyle-Tragus Distance in Predicting Difficult Laryngoscopy

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**Abstract**

**Background:** Prediction of difficult laryngoscopy remains a critical component of preoperative airway evaluation, as unanticipated airway difficulty can lead to severe complications.

**Aim and Objective:** To compare ultrasound-guided mandibular condylar mobility with traditional airway assessment parameters, inter-incisor gap (IIG), upper lip bite test (ULBT), mandibular protrusion distance, and maximum condyle–tragus distance in predicting difficult laryngoscopy.

**Methods:** This prospective observational study included 90 adult patients undergoing elective surgery under general anaesthesia. Preoperative measurements included ultrasound-guided condylar mobility and four clinical airway tests. Laryngoscopy was performed using a standard technique, and Cormack–Lehane (CL) grading was recorded. CL grade III–IV was defined as difficult laryngoscopy. Diagnostic accuracy was analysed using sensitivity, specificity, predictive values, and odds ratios.

**Results:** The majority [79 (87.8%)] had easy laryngoscopy, and 11 (12.2%) had difficult laryngoscopy. Ultrasound-guided mandibular condylar mobility demonstrated the highest sensitivity (81.8%) and perfect specificity (100%). Maximum condyle–tragus distance and IIG also showed strong diagnostic performance, with sensitivities of 72.7% and 97.5%, respectively, and specificities of 98.7% and 98.7%, respectively. Mandibular protrusion distance and ULBT had perfect specificity (100%) but lower sensitivity (36.4% and 27.3%). All parameters showed significant association with difficult laryngoscopy ($p < 0.0001$).

**Conclusion:** Ultrasound-guided mandibular condylar mobility is the most accurate single predictor of difficult laryngoscopy, demonstrating superior sensitivity and perfect specificity. However, multivariate analysis showed that no parameter independently predicted difficult laryngoscopy. A combined approach using both ultrasound-based and conventional tests enhances the reliability of airway assessment and improves preparedness for difficult laryngoscopy.

**Keywords:** Difficult Laryngoscopy, Airway Assessment, Mandibular Condylar Mobility, Ultrasonography, Temporomandibular Joint, Inter-Incisor Gap.

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## Introduction

A difficult airway remains one of the most critical challenges in anaesthetic practice. According to the American Society of Anaesthesiologists (ASA), a difficult airway is defined as a clinical situation in which a qualified anaesthesiologist encounters difficulty with mask ventilation, tracheal intubation, or both. Difficult mask ventilation is the inability to maintain oxygen saturation above 90% with 100% oxygen and positive-pressure ventilation in a patient with a baseline saturation above 90%. In contrast, difficult intubation is characterized by the need for more than three attempts or more than 10 minutes to achieve successful tracheal tube placement with conventional laryngoscopy [1]. Unanticipated difficult laryngoscopy and intubation remain major perioperative concerns, as they are associated with serious complications including hypoxemia, bradycardia, cardiac arrest, and neurological injury [2]. Thus, accurate preoperative airway assessment is crucial to minimize morbidity and mortality related to airway management.

Traditional bedside airway assessments such as the Modified Mallampati classification, inter-incisor distance (IID), mandibular protrusion tests, thyromental distance, and sternomental distance are routinely used in clinical practice. Although these measurements demonstrate acceptable specificity and negative predictive value, their overall sensitivity and positive predictive value remain limited, mainly due to interobserver variability and dependence on patient cooperation [3]. While several multivariate indices have been proposed to improve prediction, identifying a reliable single anatomical predictor would substantially simplify clinical decision-making.

Various clinical, composite, and radiological parameters have been explored as predictors of airway disease. Advanced imaging techniques such as CT and MRI offer detailed structural assessment but are impractical for routine preoperative use due to cost, radiation exposure, and limited availability. Ultrasound (USG) has increasingly gained attention as a practical alternative because it is non-invasive, cost-effective, widely accessible, and capable of providing real-time visualization of upper airway structures [4].

With recent technological advancements, ultrasonography has shown significant promise in airway assessment and can improve the prediction of difficult laryngoscopy [5]. Despite multiple validated tests, unexpectedly difficult airways still occur, highlighting the need for more objective and reproducible assessment techniques [6].

The temporomandibular joint (TMJ) plays an essential role during laryngoscopy, as adequate anterior and inferior mandibular movement is required to optimize glottic visualization. Restricted TMJ mobility, especially reduced anterior translation of the mandibular condyle, increases the likelihood of encountering a difficult laryngoscopic view.

Anatomically, the TMJ is a bilateral synovial joint that allows the condyle to glide anteriorly and inferiorly under the articular disc and eminence during mouth opening; limited translation compromises mandibular lift and impairs visualization [7]. Traditional clinical tests such as the IID, ULBT, and mandibular protrusion distance only indirectly assess TMJ movement [7-9]. Although TMJ assessment is included in the ASA difficult airway algorithm [1], objective and reproducible TMJ-specific methods remain limited. Landmark-guided measurement of the condyle–tragus distance and ultrasonographic evaluation of mandibular condylar mobility have emerged as promising tools.

Given these considerations, this study aims to compare ultrasound-guided mandibular condylar mobility with established clinical parameters—including inter-incisor gap, upper lip bite test, mandibular protrusion distance, and maximum condyle–tragus distance—in predicting difficult laryngoscopy. Identifying accurate and practical preoperative predictors may enhance airway assessment strategies and reduce the incidence of unexpected challenging airway encounters.

## Materials and Methods

**Study Design and Ethical Approval:** This prospective observational study was conducted after obtaining Institutional Ethics Committee approval. The study was carried out in the Department of Anaesthesiology, Gandhi Medical College, and the associated Hamidia Hospital, Blocks 1 & and 2, Bhopal. A total of 90 adult patients scheduled for elective surgeries under general anaesthesia requiring endotracheal intubation were enrolled. Written informed consent was obtained from all participants before inclusion, and all patients followed standard preoperative fasting guidelines as per institutional protocol.

**Study Population:** Patients aged 18–75 years of either sex and classified as American Society of Anesthesiologists (ASA) physical status I or II were considered eligible. Patients with known craniofacial abnormalities, previous maxillofacial surgery, documented temporomandibular joint (TMJ) disorders, restricted mouth opening due to trauma or pathology, cervical spine instability, edentulism, upper airway masses, or those who refused to participate were excluded from the study. Patients with abnormal coagulation, local infection near the TMJ, or inability to cooperate for airway assessment were also excluded.

**Airway Assessment and Preoperative Evaluation:** All patients underwent a standardized preoperative airway evaluation. Clinical parameters recorded included Modified Mallampati classification, inter-incisor distance (IID), upper lip bite test (ULBT), mandibular protrusion distance, thyromental distance, and sternomental distance.

TMJ mobility was assessed by palpation during maximal mouth opening. Two TMJ-specific measurements—maximum condyle–tragus distance and ultrasound-guided mandibular condylar mobility—were also performed following a uniform protocol.

**Ultrasound-Guided Condylar Mobility Assessment:** Ultrasonography was performed using a high-frequency linear probe (6–13 MHz). With the patient seated and the head in the neutral position, the probe was placed transversely over the zygomatic arch, anterior to the tragus, to visualize the mandibular condyle as a hyperechoic, rounded structure. Condylar translation was measured from the closed-mouth to the wide-open-mouth position in real time. Trained anaesthesiologists took measurements, and proper visualization of condylar movement was ensured before recording values.

**Landmark-Guided Condyle–Tragus Distance Measurement:** For the landmark-guided method, the maximum condyle–tragus distance was measured using anatomical surface landmarks during whole mouth opening. All measurements were performed in a seated posture with the head in neutral alignment.

**Laryngoscopy Procedure and Group Allocation:** Laryngoscopy was performed by an experienced anaesthesiologist who was blinded to all preoperative airway measurements. A standard Macintosh laryngoscope blade was used in all patients. Cormack–Lehane (CL) grading was documented during intubation. Patients with CL Grade I–II were classified as having easy laryngoscopy, while those with CL Grade III–IV were categorized as having difficult laryngoscopy. No adjuncts were used during laryngoscopy to maintain uniformity.

**Outcome Measures:** The primary outcome was the association of ultrasound-guided mandibular condylar mobility and other airway parameters with difficult laryngoscopy. Sensitivity, specificity, positive predictive value, negative predictive value, and odds ratios were calculated for each predictive test. Secondary outcomes included the correlation between clinical and ultrasonographic TMJ mobility parameters and laryngoscopic grades.

**Statistical Analysis:** Data analysis was performed using IBM SPSS version 27.0. Continuous variables were expressed as mean ± standard deviation, and comparisons were made using the Student's t-test or ANOVA. Categorical variables were expressed as frequencies and percentages and analyzed using the chi-square test. Pearson correlation coefficients were used to evaluate relationships between airway parameters and laryngoscopic grade. A p-value <0.05 was considered statistically significant.

## Results

**Demographic and Baseline Characteristics:** A total of 90 patients were included in the study. The mean age of the study population was 35.93 ± 13.454 years. There were 31 males (34.4%) and 59 females (65.6%). Most patients belonged to ASA Grade I (52.2%), followed by ASA Grade II (47.8%). The baseline characteristics of the patients are presented in Table 1.

**Table 1: Baseline Characteristics of Patients (n = 90)**

| Variable | Value |
|---|---|
| Age (years), mean ± SD | 35.93 ± 13.454 |
| Sex – Male, n (%) | 31 (34.4%) |
| Sex – Female, n (%) | 59 (65.6%) |
| ASA Grade I, n (%) | 47 (52.2%) |
| ASA Grade II, n (%) | 43 (47.8%) |

**Laryngoscopy Difficulty and Cormack–Lehane Grades:** Laryngoscopy revealed that 56 patients (62.2%) had a Cormack–Lehane Grade I view, 23 (25.6%) Grade II, and 11 (12.2%) Grade III. No patient exhibited a Grade IV view. Based on these findings, 79 patients (87.8%) were categorized as having easy laryngoscopy (Grade I–II), whereas 11 patients (12.2%) were classified as having difficult laryngoscopy (Grade III). These findings are summarized in Table 2.

**Table 2: Distribution of Cormack–Lehane Grade and Laryngoscopy Inference (n = 90)**

| Parameter | Category | n (%) |
|---|---|---|
| Cormack–Lehane Grade | Grade I | 56 (62.2%) |
| | Grade II | 23 (25.6%) |
| | Grade III | 11 (12.2%) |
| Final Laryngoscopy Inference | Easy | 79 (87.8%) |
| | Difficult | 11 (12.2%) |

**Diagnostic Accuracy of Airway Assessment Methods:** The diagnostic performance of various airway predictors is shown in Table 3. Ultrasound-guided mandibular condylar mobility demonstrated the highest sensitivity (81.8%) and perfect specificity (100%). Maximum condyle–tragus distance and inter-incisor gap (IIG) also showed strong predictive capability with sensitivities of

72.7% each and specificities of 97.5% and 98.7%, respectively. Mandibular protrusion distance and ULBT exhibited perfect specificity (100%) but lower sensitivity.

**Table 3: Diagnostic Performance of Airway Assessment Tests for Predicting Difficult Laryngoscopy**

| Test | Sensitivity (%) | Specificity (%) | PPV (%) | NPV (%) | Odds Ratio |
|---|---|---|---|---|---|
| USG Condylar Mobility | 81.8 | 100 | 100 | 97.5 | 604.2 |
| Max Condyle–Tragus Distance | 72.7 | 97.5 | 80 | 96.3 | 102.67 |
| Mandibular Protrusion | 36.4 | 100 | 100 | 91.9 | 95.4 |
| Inter-incisor Gap (IIG) | 72.7 | 98.7 | 88.9 | 96.3 | 208 |
| Upper Lip Bite Test (ULBT) | 27.3 | 100 | 100 | 90.8 | 65.47 |

**Correlation between Mandibular Mobility Parameters:** Correlation analysis demonstrated a strong positive relationship between ultrasound-guided condylar mobility and maximum condyle–tragus distance (r = 0.707), inter-incisor gap (r = 0.753), and mandibular protrusion distance (r = 0.647).

Correlation with ULBT was weaker (r = 0.351) but statistically significant. These data are summarized in Table 4.

**Table 4: Correlation Analysis between Airway Assessment Parameters**

| Parameter | MCM Grade | MCT Grade | MP Grade | IIG Grade | ULBT Grade |
|---|---|---|---|---|---|
| Mandibular Condylar Mobility (MCM) | 1.000 | 0.707** | 0.647** | 0.753** | 0.351** |
| Max Condyle–Tragus (MCT) | 0.707** | 1.000 | 0.610** | 0.825** | 0.525** |
| Mandibular Protrusion (MP) | 0.647** | 0.610** | 1.000 | 0.467** | 0.260* |
| Inter-incisor Gap (IIG) | 0.753** | 0.825** | 0.467** | 1.000 | 0.557** |
| Upper Lip Bite Test (ULBT) | 0.351** | 0.525** | 0.260* | 0.557** | 1.000 |

***Correlation significant at $p < 0.05$, ** Correlation significant at $p < 0.01$**

Ultrasound-guided mandibular condylar mobility emerged as the most reliable single predictor of difficult laryngoscopy. The inter-incisor gap and the maximum condyle–tragus distance also showed strong diagnostic utility. ULBT and mandibular protrusion distance showed excellent specificity but low sensitivity, making them more suitable as confirmatory predictors than as primary screening tools. All airway assessment parameters demonstrated a significant association with difficult laryngoscopy (p < 0.0001).

## Discussion

Pre-operative airway assessment remains a cornerstone of safe anaesthetic practice, as unanticipated difficult laryngoscopy continues to be associated with serious adverse events such as hypoxia, hypercapnia, arrhythmias, and, in severe cases, cardiac arrest [10]. Despite the availability of several bedside airway tests, no single parameter has consistently demonstrated high sensitivity and specificity across diverse populations [11]. Traditional predictors are often limited by subjectivity and inter-observer variability. In recent years, ultrasound has emerged as a reliable, non-invasive, and objective modality for evaluating upper airway anatomy. Carsetti et al. demonstrated the usefulness of airway ultrasonography in identifying patients at risk of difficult laryngoscopy, supporting its role in enhancing perioperative airway management strategies. Current guidelines also recommend integrating multiple validated tests because reliance on a single predictor is insufficient to reliably anticipate challenging airway scenarios [6]. In this context, the present study evaluated the diagnostic value of ultrasound-guided assessment of mandibular condylar mobility, along with conventional parameters such as maximum condyle–tragus distance, ULBT, inter-incisor gap (IIG), and mandibular protrusion distance [12].

This prospective observational study included 90 patients undergoing elective surgical procedures under general anaesthesia. The incidence of difficult laryngoscopy in our population was 12.2%, comparable to rates reported in previous Indian and international studies.

A similar trend was observed by Prakash et al., who evaluated 330 Indian patients using multiple bedside airway indices and reported a 9.7% incidence of difficult laryngoscopy. The slightly higher rate in our study may be attributed to differences in demographic distribution, assessment techniques, and population characteristics [2]. Ultrasound-guided mandibular condylar mobility emerged as the most accurate predictor in our study, exhibiting a sensitivity of 81.80% and perfect specificity of 100%. These findings are consistent with results reported by Yao et al. [7], who also used a <10 mm cutoff for condylar translation in 484 Chinese patients and obtained comparable sensitivity (81%) and a high negative predictive value. However, their specificity and positive predictive value were lower than ours, possibly due to ethnic variation and methodological differences. For maximum condyle–tragus distance, Yao et al. reported lower sensitivity (54%) and specificity (86%) than those observed in our dataset (72.70% and 97.50%), suggesting better discriminatory performance in our study population.

Bindu et al. [13] evaluated ultrasound-guided TMJ mobility in 70 morbidly obese patients and reported slightly higher sensitivity (93.3%) than ours. Differences in BMI, airway anatomy, and cutoff selection may explain this variation. However, similar to our findings, they observed very low sensitivity for IIG when using a narrower cutoff. Our IIG cutoff of <5 cm yielded a sensitivity of 72.70%, which is much higher than the 20% reported by Bindu et al., who used a cutoff of <4 cm.

Xu J et al. [14] studied 1000 Chinese patients and reported sensitivity (81%) and NPV (99%) values similar to those obtained in the present study. Their specificity and PPV were comparatively lower, with variability linked to anatomical differences among populations. Xu L et al. [15] also evaluated condylar translation in parturients and obtained lower predictive accuracy than in our adult population, likely due to pregnancy-related airway changes.

Wu et al. [16] analyzed ULBT, IIG, Mallampati test, and condyle–tragus distance in 304 patients and reported lower sensitivity and specificity for condyle–tragus distance (46.9% and 92.9%) as compared to our values. Their IIG sensitivity was also substantially lower (42.9% vs 72.70%). ULBT results also differed, reflecting the influence of ethnic variation and the assessment thresholds used.

Lamba S et al. [17] assessed Indian patients using ULBT, IIG, and mandibular protrusion distance. Their IIG sensitivity (20%) was markedly lower than ours, likely due to the cutoff used in their study. Their mandibular protrusion distance showed specificity similar to ours (99.06% vs 100%) but with differences in PPV. These findings reinforce the idea that clinical tests are influenced by anatomical variability and study methodology. Among all the parameters evaluated, ultrasound-guided mandibular condylar mobility demonstrated the strongest overall performance. The precise specificity of USG condylar mobility, ULBT, and mandibular protrusion distance indicates an excellent ability to rule in a difficult airway when abnormal. However, lower sensitivity values for ULBT and mandibular protrusion suggest they may miss several cases when used alone. High specificity across parameters is clinically advantageous because it minimizes false-positive predictions and helps avoid unnecessary preparation for challenging airway scenarios.

The findings of the present study confirm that no single bedside test can reliably predict all complex airway cases. However, integrating USG-based TMJ assessment with conventional clinical tests significantly improves prediction accuracy. Ultrasound provides an objective and reproducible evaluation of condylar mobility, reducing subjectivity and enhancing the clinician's ability to identify high-risk patients preoperatively.

## Conclusion

All five airway assessment parameters—ultrasound-guided mandibular condylar mobility, upper lip bite test (ULBT), inter-incisor gap (IIG), maximum condyle–tragus distance, and mandibular protrusion distance—demonstrated a significant association with difficult laryngoscopy in the present study. Among these, ultrasound-guided condylar mobility showed the highest sensitivity and negative predictive value.

In contrast, USG-guided condylar mobility, mandibular protrusion distance, and ULBT exhibited perfect specificity, making them strong predictors when positive. Despite this, multivariate regression analysis indicated that none of these parameters functioned as independent predictors of difficult laryngoscopy after adjustment for confounding variables. The findings emphasize the importance of a comprehensive airway evaluation strategy that combines ultrasound-based assessment with conventional clinical parameters to enhance accuracy in predicting and managing difficult laryngoscopy.

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