

ULTRASOUND-GUIDED HYOMENTAL DISTANCE AND INTERNAL DISTANCE BETWEEN TWO THYROID LAMINAE FOR I-GEL SUPRAGLOTTIC AIRWAY SIZE SELECTION: A PROSPECTIVE RANDOMISED COMPARATIVE STUDY

Anaesthesiology

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ABSTRACT

Background and Aims: Accurate I-gel size selection is critical for optimal airway seal, ventilation adequacy, and patient safety. Conventional weight-based sizing assumes a reliable body-mass–airway dimension relationship that may not universally hold. We aimed to evaluate whether ultrasonographically measured hyomental distance (HMD) and internal distance between the two thyroid laminae (TLD) correlate with the appropriate I-gel size and offer better predictive accuracy than the conventional weight-based method. **Methods:** In this prospective randomised comparative study at a tertiary care centre, 75 patients (aged 10–60 years, ASA I–II, Mallampati I–II) undergoing elective surgery under general anaesthesia were randomised into three equal groups: Group Wt (weight-based sizing), Group HMD (HMD-guided sizing), and Group TLD (TLD-guided sizing; n=25 each). Preoperative USG measurements were performed in the sniffing position by a single operator. Primary outcome was agreement between the predicted and final I-gel size inserted. Secondary outcomes included oropharyngeal leak pressure (OLP), tidal volumes, adequacy of ventilation, and peri-operative airway complications. Spearman's correlation assessed relationships between USG parameters and final I-gel size. **Results:** All groups were demographically comparable ($p>0.05$). TLD showed the strongest correlation with final I-gel size ($\rho=0.792$, $p<0.001$), surpassing HMD ($\rho=0.670$, $p<0.001$). Predicted–final size agreement was highest in Group TLD (80%), followed by Group Wt (76%) and Group HMD (56%; $p=0.465$). OLP was clinically adequate across all groups (Wt: 24.8 ± 1.99 ; HMD: 24.1 ± 2.12 ; TLD: 25.6 ± 2.20 cmH₂O; $p=0.108$). Ventilation adequacy was 96%, 92%, and 100% in Groups Wt, HMD, and TLD respectively ($p=0.353$). Airway trauma occurred exclusively in Group Wt (8%; $p=0.128$). No laryngospasm was recorded. **Conclusion:** Both HMD and TLD demonstrate significant positive correlations with optimal I-gel size, with TLD exhibiting superior predictive accuracy. TLD should be explored as a practical adjunct to weight-based I-gel sizing, particularly in patients where body habitus may not reliably reflect airway dimensions.

KEYWORDS

Airway Ultrasonography, Hyomental Distance, I-Gel, Oropharyngeal Leak Pressure, Supraglottic Airway Device, Thyroid Lamina Distance

INTRODUCTION

Airway management remains the cornerstone of safe anaesthetic practice. Although tracheal intubation is the gold standard in many situations, the evolution of supraglottic airway devices (SADs) has revolutionised perioperative airway control by providing dependable and less invasive alternatives.^{1,2} Among second-generation devices, the I-gel (Intersurgical Ltd., UK) has gained wide acceptance both in elective anaesthesia and as a rescue airway.^{3,4} Its cuffless thermoplastic elastomeric design conforms naturally to the perilaryngeal anatomy, offering effective sealing without cuff-related mucosal injury, while its integrated bite block and gastric drainage channel yield high first-pass success rates and consistently favourable oropharyngeal leak pressures (OLP) across patient populations.^{5,6}

Despite these merits, the clinical performance of the I-gel is critically dependent on accurate size selection.⁷ Manufacturer guidelines recommend weight-based sizing—size 3 for 30–60 kg, size 4 for 50–90 kg, and size 5 for >90 kg—an approach that is convenient but assumes a reliable relationship between body mass and airway dimensions.⁸ This assumption is not universally valid. Individuals of comparable weight frequently exhibit marked variation in craniofacial structure, mandibular length, neck circumference, and laryngeal width, all of which influence supraglottic device seating and sealing.^{9,10} Mis-sized I-gel placement can result in inadequate ventilation, airway obstruction, or repeated re-insertion attempts, increasing the risk of trauma and morbidity.

Point-of-care airway ultrasonography has emerged as an objective, non-invasive tool for pre-anaesthetic evaluation.^{11,12} The hyomental distance (HMD)—the linear distance from the mentum to the hyoid bone—has been studied as a predictor of difficult laryngoscopy.^{13,14} The internal distance between the two thyroid laminae (TLD), measured transversely across the thyroid cartilage, directly reflects laryngeal inlet width—the dimension anatomically proximate to the I-gel seating zone. Wang et al. demonstrated that HMD-based supraglottic airway selection outperformed weight-based prediction in accuracy (77.14% vs. 51.51%).¹⁵ However, TLD as a sizing parameter for the I-gel has not been systematically evaluated.

We conducted this prospective randomised comparative study to: (i)

quantify the correlation of preoperative ultrasonographic HMD and TLD with the final I-gel size used; and (ii) compare the clinical performance of HMD-guided and TLD-guided size selection with the conventional weight-based method in terms of ventilation adequacy, OLP, and peri-operative airway complications.

MATERIALS AND METHODS

The study was approved by the Institutional Human Ethics Committee, BRD Medical College, Gorakhpur (Ref. IHEC/BRD/2024), and conducted in accordance with the Declaration of Helsinki and ICMR Guidelines 2021. Written informed consent was obtained from all participants or their legal guardians. The trial was prospectively registered with the Clinical Trials Registry – India (CTRI; Reg. No.: [to be inserted]).

Study Design and Participants

This was a prospective randomised single-centre comparative study conducted over one year in the Department of Anaesthesiology at BRD Medical College, Gorakhpur—a tertiary referral centre serving a predominantly rural and semi-urban North Indian population. Patients aged 10–60 years, ASA physical status I–II, Modified Mallampati Score (MPS) Grade I–II, scheduled for elective surgical procedures under general anaesthesia were eligible. Exclusion criteria comprised: anatomical airway abnormalities, history of difficult airway or prior airway surgery, MPS Grade III–IV, risk factors for aspiration (including GERD), and any contraindication to SAD placement.

Sample size was calculated using the formula $n = Z^2 \cdot p \cdot (1-p) / e^2$, with $Z=1.96$, anticipated proportion of correct size selection $p=0.87$, and margin of error $e=0.08$, yielding $n=77$; 75 patients were enrolled (25 per group). Randomisation to one of three groups was performed immediately before anaesthetic induction using the sealed-envelope method by an independent observer.

Study Groups

Group Wt — I-gel size selected per manufacturer's weight-based guidelines (conventional control).

Group HMD — Size selected based on preoperative ultrasonographic HMD in the sniffing position.

Group TLD — Size selected based on preoperative ultrasonographic TLD in the sniffing position.

Ultrasound Measurements

All measurements were performed preoperatively by a single trained anaesthesiologist (to minimise inter-observer variability) using a Sonosite Edge II ultrasound machine (Bothell, Washington, USA). Patients were positioned supine with the neck extended in the sniffing position.

HMD: A curvilinear probe (4–10 MHz) was placed in the sagittal midline of the suprahyoid region. The linear distance between the mentum (hyperechoic curved structure) and the hyoid bone (hyperechoic protuberance with posterior acoustic shadowing) was measured in centimetres.

TLD: A high-frequency linear probe (6–13 MHz) was placed transversely over the thyroid cartilage. The thyroid laminae, appearing as an inverted V-shaped hyperechoic structure, were identified and the maximum internal distance between the two laminae was measured at the midpoint of the cartilage. Each measurement was performed in triplicate; the mean was recorded.

Measurement of Internal Distance Between Two Thyroid Laminae (TLD):

For TLD measurement, a high-frequency linear probe (6–13 MHz) was placed transversely over the thyroid cartilage.

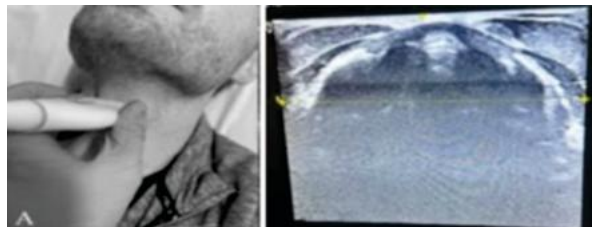
The thyroid cartilage was visualized as an inverted V-shaped hyperechoic structure, with its arms representing the right and left thyroid laminae.

The maximum internal distance between the two laminae was measured at the midpoint of the thyroid cartilage.



Each measurement was performed three times, and the average was calculated to minimize operator error.

All ultrasound images were acquired in real-time and measured immediately on the machine's digital interface to avoid manual recording bias.



I-gel Aperture Dimensions

The various sizes of the I-gel and their corresponding aperture widths were as follows:

I-gel Size	Aperture Width (cm)
1	1.5 cm
2	2.0 cm
3	3.0 cm
4	3.5 cm
5	3.8 cm

Anaesthetic Protocol

Standard monitoring (ECG, SpO₂, NIBP) was established. After pre-oxygenation with 100% O₂ for three minutes, patients received glycopyrrolate 0.004 mg/kg, midazolam 0.05 mg/kg, and fentanyl 2 µg/kg intravenously. Anaesthesia was induced with propofol 2 mg/kg and vecuronium 0.08–0.1 mg/kg. I-gel insertion was performed by a single experienced anaesthesiologist per the manufacturer's technique. Correct placement was confirmed by bilateral symmetrical chest rise, consistent EtCO₂ waveform, and audible leak pressure assessment (APL valve closed; fresh gas flow 3 L/min). Anaesthesia was maintained with O₂/N₂O and isoflurane 0.5–1%. Residual neuromuscular blockade was reversed with neostigmine and

glycopyrrolate at procedure end.

Outcome Measures and Statistical Analysis

The *primary outcome* was predicted–final I-gel size agreement (exact concordance). *Secondary outcomes* were: OLP (cmH₂O); set and inspiratory tidal volumes (mL); adequacy of ventilation (adequate/optimal/suboptimal); and peri-operative airway complications. All data were analysed using SPSS v24.0. Categorical variables were compared by Chi-square test; continuous variables by Welch's one-way ANOVA. Spearman's rank correlation (*rho*) quantified associations between USG parameters and final I-gel size. Two-tailed *p* < 0.05 was considered statistically significant.

RESULTS

Seventy-five patients completed the study (25 per group). The three groups were well-matched across all baseline characteristics, with no statistically significant inter-group differences in age, sex, ASA grade, MPS, or preoperative USG parameters (Tables 1 and 2).

Table 1. Demographic and Baseline Characteristics (n=75; 25 per group). Chi-square Test Applied for all Comparisons.

Parameter	Group Wt (n=25)	Group HMD (n=25)	Group TLD (n=25)	p-value
Age Distribution — n (%)				
10–20 years	6 (24.0)	4 (16.0)	4 (16.0)	0.898
21–40 years	10 (40.0)	10 (40.0)	9 (36.0)	
41–60 years	9 (36.0)	11 (44.0)	12 (48.0)	
Sex — n (%)				
Female	13 (52.0)	14 (56.0)	15 (60.0)	0.850
Male	12 (48.0)	11 (44.0)	10 (40.0)	
ASA Physical Status — n (%)				
Grade I	12 (48.0)	14 (56.0)	14 (56.0)	0.807
Grade II	13 (52.0)	11 (44.0)	11 (44.0)	
Modified Mallampati Score — n (%)				
Grade I	11 (44.0)	14 (56.0)	13 (52.0)	0.638
Grade II	13 (52.0)	11 (44.0)	12 (48.0)	
Grade III	1 (4.0)	0 (0.0)	0 (0.0)	

Table 2. Preoperative Ultrasonographic Airway Parameters. No Significant Inter-group Difference was Observed for Either Parameter, Confirming Baseline Comparability.

Parameter	Group Wt (n=25)	Group HMD (n=25)	Group TLD (n=25)	p-value	Test
Hyomental Distance (cm)	4.32 ± 0.613	4.35 ± 0.681	4.38 ± 0.571	0.939	Welch's ANOVA
Thyroid Lamina Distance (cm)	2.92 ± 0.631	2.93 ± 0.548	3.07 ± 0.532	0.579	Welch's ANOVA

I-Gel Size Distribution and Predicted–Final Size Agreement

The distribution of final I-gel sizes was comparable across all groups (*p* = 0.731); sizes 3 and 4 accounted for the majority (37.3% and 38.7% respectively), consistent with the adult–adolescent composition of the cohort. Size 2 was used exclusively in Group Wt (8%), reflecting inclusion of younger and lighter patients. Predicted–final size agreement was highest in Group TLD (80%), followed by Group Wt (76%) and Group HMD (56%; *p* = 0.465; Table 3). The numerically superior agreement in Group TLD is clinically noteworthy, despite not reaching statistical significance.

Table 3. I-gel Size Distribution and Predicted–final Size Agreement. Agreement = Exact Concordance Between Predicted and Final I-gel Size Inserted. Chi-square Test Applied.

Parameter	Group Wt (n=25)	Group HMD (n=25)	Group TLD (n=25)	p-value
Final I-Gel Size Inserted — n (%)				
Size 2	2 (8.0)	0 (0.0)	0 (0.0)	0.731
Size 2.5	3 (12.0)	3 (12.0)	3 (12.0)	
Size 3	7 (28.0)	11 (44.0)	10 (40.0)	
Size 4	10 (40.0)	9 (36.0)	9 (36.0)	
Size 5	3 (12.0)	2 (8.0)	3 (12.0)	
Predicted vs. Final Size Agreement — n (%)				

Match	19 (76.0)	14 (56.0)	20 (80.0)	0.465
Mismatch	6 (24.0)	11 (44.0)	5 (20.0)	

Correlation of Ultrasound Parameters with Final I-Gel Size

Spearman's correlation analysis demonstrated statistically significant positive associations between both USG parameters and final I-gel size (Table 4). TLD exhibited a very strong correlation with final I-gel size ($\rho=0.792$, $p<0.001$), exceeding that of HMD ($\rho=0.670$, $p<0.001$). Both parameters were strongly interrelated ($\rho=0.686$, $p<0.001$), reflecting anatomical consistency. TLD also correlated strongly with weight-based predicted I-gel size ($\rho=0.692$, $p<0.001$), indicating that body weight partially tracks laryngeal framework dimensions.

Table 4. Spearman's Correlation Analysis (n=75). * $p<0.001$. ρ : 0.40–0.69 = Moderate-strong; 0.70–1.00 = very strong.**

Variable 1	Variable 2	Spearman's ρ	p-value	Interpretation
Final I-Gel Size	Hyomental Distance (cm)	0.670	<0.001 ***	Strong positive
Final I-Gel Size	Thyroid Lamina Distance (cm)	0.792	<0.001 ***	Very strong positive
Hyomental Distance	Thyroid Lamina Distance	0.686	<0.001 ***	Strong positive
Thyroid Lamina Distance	Predicted I-Gel Size (Weight method)	0.692	<0.001 ***	Strong positive

Ventilation Parameters

OLP was comparable across all three groups (Wt: 24.8 ± 1.99 ; HMD: 24.1 ± 2.12 ; TLD: 25.6 ± 2.20 cmH₂O; $F=2.282$, $p=0.108$), all exceeding the 20 cmH₂O threshold for clinically adequate I-gel sealing. Set and inspiratory tidal volumes showed no significant intergroup differences ($p=0.422$ and $p=0.455$ respectively). The set–inspiratory volume difference (leak volume) was least in Group TLD (4 mL) and greatest in Group HMD (17 mL). Adequacy of ventilation was 96.0%, 92.0%, and 100.0% in Groups Wt, HMD, and TLD respectively ($p=0.353$); Group TLD achieved 100% adequacy (Table 5).

Table 5. Ventilation Parameters Across Study Groups. Welch's ANOVA for Continuous Variables; chi-square for Categorical. OLP = Oropharyngeal Leak Pressure.

Parameter	Group Wt (n=25)	Group HMD (n=25)	Group TLD (n=25)	p-value
Oropharyngeal Leak Pressure				
OLP (cmH ₂ O) Mean $\pm$ SD	24.8 ± 1.99	24.1 ± 2.12	25.6 ± 2.20	0.108
Tidal Volumes				
Set Tidal Volume (mL) Mean $\pm$ SD	450 ± 67.2	426 ± 111.3	424 ± 87.4	0.422
Inspiratory Tidal Volume (mL) Mean $\pm$ SD	440 ± 70.2	409 ± 110.1	420 ± 87.6	0.455
Set–Inspiratory Difference (mL)	10	17	4	—
Adequacy of Ventilation — n (%)				
Adequate	24 (96.0)	23 (92.0)	25 (100.0)	0.353
Optimal	1 (4.0)	1 (4.0)	0 (0.0)	
Suboptimal	0 (0.0)	1 (4.0)	0 (0.0)	

Peri-Operative Airway Complications

Overall complication rates were low across all groups (Table 6). Airway trauma and blood staining on the device occurred exclusively in Group Wt (2/25, 8%; $p=0.128$), with no cases in either ultrasound-guided group. Desaturation was observed in one patient in Group HMD (4%; $p=0.363$). No laryngospasm was recorded in any group. Nausea and vomiting were comparable (Wt 12%, HMD 8%, TLD 8%; $p=0.854$).

Table 6. Peri-operative Airway Complications. Chi-square or Fisher's Exact Test (Where Expected Cell Frequency <5). Airway Trauma Occurred Exclusively in Group Wt, in Association with Mis-sizing or Size-change Attempts.

Complication	Group Wt (n=25)	Group HMD (n=25)	Group TLD (n=25)	Total (n=75)	p-value
Desaturation (SpO ₂ <90%)	0 (0.0)	1 (4.0)	0 (0.0)	1 (1.3)	0.363

Laryngospasm	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	—
Airway Trauma / Blood on Device	2 (8.0)	0 (0.0)	0 (0.0)	2 (2.7)	0.128
Nausea / Vomiting	3 (12.0)	2 (8.0)	2 (8.0)	7 (9.3)	0.854
Sore Throat / Throat Discomfort	1 (4.0)	0 (0.0)	0 (0.0)	1 (1.3)	0.363

DISCUSSION

The principal finding of this study is a statistically significant positive correlation between ultrasonographically measured TLD and the appropriate I-gel size ($\rho=0.792$, $p<0.001$), which surpassed the correlation observed for HMD ($\rho=0.670$, $p<0.001$). This is, to our knowledge, the first study to evaluate TLD as a sizing parameter for the I-gel and to directly compare its predictive performance against both HMD-guided and conventional weight-based selection in the same cohort.

The anatomical basis for TLD's superior correlation lies in its spatial proximity to the I-gel's seating zone. The thyroid cartilage's internal transverse diameter directly approximates laryngeal inlet width—the dimension that governs I-gel aperture fit and circumferential sealing. In contrast, HMD reflects the submandibular complex distance (mentum to hyoid), which correlates with supraglottic space volume but is one anatomical level removed from the I-gel seating zone. This reasoning is supported by TLD's stronger correlation with both the final clinical size used and the weight-based predicted size ($\rho=0.692$ vs. 0.670), suggesting that TLD integrates direct anatomical information beyond what body weight alone can predict.

Our findings align with the established airway ultrasound literature. Wojtczak demonstrated that the hyomental distance ratio (HMDR) differed significantly between easy and difficult airways (1.14 ± 0.02 vs. 1.02 ± 0.01 ; $p<0.002$).¹⁵ Gomes et al. showed HMD in the extended position to be a strong predictor of laryngoscopy grade ($p<0.0001$),¹⁶ and Sekar et al. found HMD > 5.5 cm associated with easier laryngoscopy in 89.4% of cases.¹⁷ Wang et al., studying hyomental distance for laryngeal mask size selection, reported 77.14% accuracy with USG-guided versus 51.51% with weight-based sizing¹⁸—directly paralleling our observation of superior TLD concordance (80%) over the other two methods.

The counterintuitive finding of relatively lower predicted–final agreement in Group HMD (56%) warrants consideration. This may reflect the non-linear relationship between submandibular length and laryngeal dimensions; patients with proportionally longer chins relative to their laryngeal aperture would be over-predicted for larger device sizes by HMD. TLD, by directly measuring the laryngeal framework, circumvents this anatomical decoupling.

All three groups achieved clinically acceptable ventilation, with OLP values in the range 24.1 – 25.6 cmH₂O—consistent with established benchmarks for I-gel performance.^{3,18} Whilst intergroup differences were not statistically significant ($p=0.108$), Group TLD's numerically highest OLP (25.6 ± 2.20 cmH₂O), 100% ventilation adequacy, and smallest set–inspiratory volume leak (4 mL) collectively suggest a trend toward better device–airway congruence when sizing is guided by direct laryngeal anatomy. The clinical benefit is expected to be more pronounced in patients at the extremes of the weight-for-airway dimension continuum—such as obese patients with proportionally narrower larynges, or thin patients with broader laryngeal frameworks.

Airway trauma occurred exclusively in Group Wt (8%; $p=0.128$), consistent with the hypothesis that size mismatches—which were most frequent in the weight-based group—necessitate re-insertion attempts and increase mucosal injury risk. This aligns with Guerrier et al., who reported higher complication rates with incorrectly sized SADs.⁷

Limitations include the single-centre design, modest sample size ($n=75$), restriction to elective ASA I–II patients, and single-operator ultrasound measurements. Validated universal cut-off values for TLD-to-I-gel-size mapping remain to be established. Long-term airway morbidity, intraoperative device stability, and fiberoptic confirmation of placement were not assessed in this study.

CONCLUSION

Ultrasonographic measurement of the internal distance between the two thyroid laminae (TLD) demonstrates a very strong correlation with optimal I-gel size ($\rho=0.792$, $p<0.001$) and achieves the highest

predicted-final size agreement (80%) among the three methods evaluated. TLD outperforms HMD as a predictive anatomical parameter and appears to confer advantages in ventilation adequacy and reduction of airway trauma compared to conventional weight-based sizing. Larger multicentre trials are required to establish validated TLD cut-off values, with a view to integrating TLD-guided sizing as a practical adjunct to weight-based I-gel selection in routine anaesthetic practice.

Key Message: Ultrasound-guided thyroid lamina distance (TLD) shows the strongest correlation with appropriate I-gel size ($\rho=0.792$) and highest size-prediction accuracy (80%). It represents a promising anatomy-based adjunct to conventional weight-guided I-gel sizing, with potential for reducing airway trauma and improving device fit in routine clinical practice.

Declarations

Financial Support and Sponsorship: None declared.

Conflicts of Interest: None declared.

Ethical Approval: Approved by IHEC, BRD Medical College, Gorakhpur. Conducted in accordance with the Declaration of Helsinki and ICMR Guidelines 2021.

Author Contributions: [To be completed as per ICMJE authorship criteria before final submission].

Data Availability: De-identified data are available from the corresponding author on reasonable written request.

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