RESEARCH ARTICLE

Study of Physical Parameters Used for Preoperative Prediction of Difficult Laryngeal Exposure during Suspension Microlaryngoscopy

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Abstract

Aim: The aim of this study is to analyze the various physical parameters used for the preoperative prediction of difficult laryngeal exposure (DLE) during suspension microlaryngoscopy.

Materials and methods: This is a single-center, retrospective study carried out in a tertiary care teaching hospital, comprising 50 patients who underwent suspension microlaryngoscopy at our center from June 2014 to April 2016. We assessed 10 physical parameters that can help in predicting DLE preoperatively.

Results: The patients' ages ranged from 20 to 69 years. The laryngeal exposure was assessed in all the patients and correlated with the 10 physical parameters. Out of the parameters assessed using the student *t* test, the modified Mallampati's index (MMI) (class II and above), body mass index (BMI) (>27.1 kg/m^2), thyroid–mental distance (≤4.9 cm), thyroid–mandibular angle (>122°), and horizontal thyroid distance (HTD) (≤3.8 cm) showed a statistical significance with $p < 0.001$. The ROC curve analysis showed that the thyroid–mental distance and HTD had the highest sensitivity (100%) and specificity (100%) each among the parameters assessed.

Conclusion: Based on our study results, we conclude that the age and the sex of the patient have no role in predicting the risk of DLE during suspension microlaryngoscopy. The MMI, BMI, thyroid–mental distance, thyroid–mandibular angle, and HTD measurements help in the prediction of DLE preoperatively.

Clinical significance: These physical parameters can be measured just prior to the surgery using simple measuring aids. The advantage of preoperative prediction of DLE being that it enables the surgeon to be prepared beforehand with additional measures to deal with the same and provide adequate treatment.

Keywords: Difficult laryngeal exposure, Laryngeal exposure prediction, Suspension microlaryngoscopy.

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Introduction

Microlaryngeal surgery using a direct straight laryngoscope is a widely used surgical procedure. This procedure is the treatment modality of various glottic conditions, ranging from a simple vocal cord cyst to a glottic malignancy. Adequate visualization of the vocal cords, especially the anterior half and the anterior commissure, plays a major role in the surgical management of any glottic condition. Incomplete exposure of the vocal cords can lead to an insufficient surgical management of the laryngeal pathology and inadvertent tissue injury.[1] The preoperative knowledge of difficult exposure of the glottic plane can alert the surgeon about the need for alternative measures to be considered. As most of the glottic lesions lie in the anterior half of the vocal cords, the DLE in our study is defined as the cases in which the anterior half of the true vocal cords and the anterior commissure are not visualized without any external manipulation. The external manipulations include external laryngeal counter pressure, shoulder support, extra head support,[2] flexible fiber-scope,[3,4] and others to alter the flexion–extension of the neck that improve the laryngeal exposure.

In glottic malignancy cases, the extent of exposure of the lesion has been a major determinant of the modality of treatment. The extent of visualization of the glottic plane in a suspension microlaryngoscopy is an important factor to be considered to choose Transoral Laser microsurgery as the treatment of choice. The anatomical structure of the larynx along with its relation to the surrounding structures has been a significant determinant of the glottic structures visualized during microlaryngeal surgeries.

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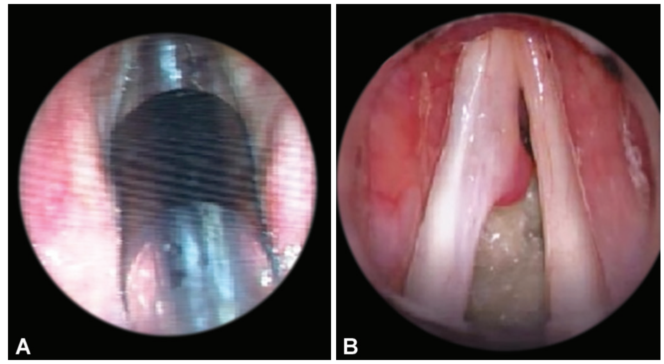
The aim of this study is to analyze various physical parameters used for the preoperative prediction of DLE during suspension microlaryngoscopy.

Materials and Methods

This is a single-center, retrospective study carried out in a tertiary care teaching hospital, comprising 50 patients who underwent suspension microlaryngoscopy at our center from June 2014 to April 2016. All patients of both sex and age group (more than 18 years) undergoing suspension microlaryngosurgery were included. Patients with cervical spine disorders were excluded. These patients were admitted in our center and had undergone suspension microlaryngosurgery procedure under general anesthesia for various diagnostic and therapeutic modalities. A detailed history of the patient including the onset, duration, progression of the complaints, previous medical illness, surgical procedures history, previous trauma history, personal history, family history, cervical spine disorders, and comorbid conditions was documented. Several parameters that could predict DLE have been recorded for each patient preoperatively. These included MMI, BMI, neck circumference (NC), hyoid–mental distance (HMD), thyroid–mental distance (TMD), and thyroid–mandible angle (TMA), HTD, vertical thyroid distance (VTD), inter-incisor length (IIL), and degree of maximum neck extension (MNE).

The MMI was evaluated by the extent of visualization of oropharyngeal structures while the patient opened the mouth with the tongue fully protruding. The grading of MMI: grade I, clearly visible fauces, pillars, uvula, and soft palate; grade II, only uvula, pillars, and fauces visible; grade III, soft palate and base of uvula visible; and grade IV, soft palate not visible at all. The BMI is calculated as the body mass divided by the square of the body height and is universally expressed in units of kg/m^2, resulting from mass in kilograms and height in meters. NC is measured with a standard measuring tape placed circumferentially around the neck touching the thyroid prominence anteriorly and occipital protuberance posteriorly. HMD (Fig. 1A) is measured while the patient is sitting upright with the head in a neutral position. It is the distance between the mental prominence and the midpoint of the hyoid bone body. Similarly, TMD (Fig. 1A) is the distance between the mental prominence and the thyroid notch. TMA (Fig. 1B) is measured as the angle between lines along the skin line from the thyroid notch to the mandible. Horizontal HTD (Fig. 1C) is obtained by measuring the horizontal component of the distance between the mental prominence and the thyroid notch. Vertical VTD (Fig. 1C) is obtained by measuring the vertical component of the distance between the mental prominence and the thyroid notch. Inter-incisor distance (IID) is obtained by measuring the distance between the upper and lower central incisors. MNE is measured while the patient is sitting upright with the head in a neutral position. The patient is asked to extend his neck backwards to the maximum possible extent and the angle between such position and the neutral position is measured in degrees.

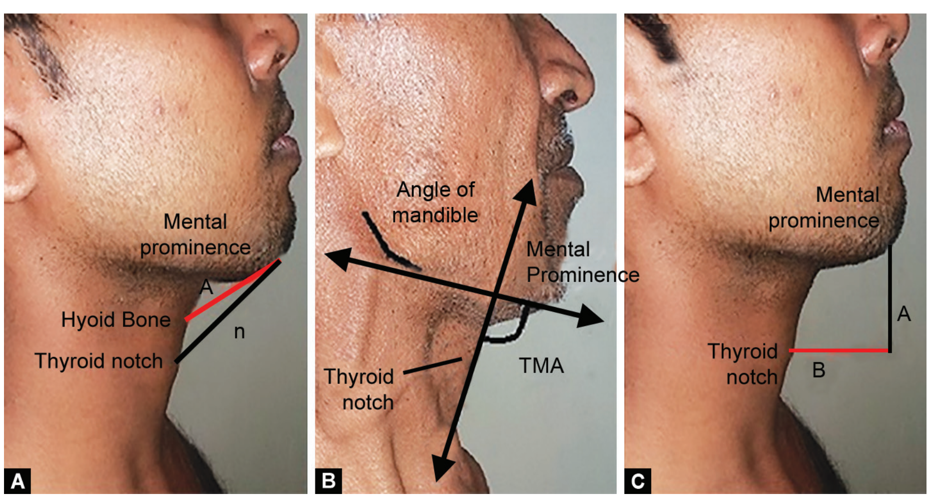


Figs 2A and B: (A) DLE and (B) non-DLE

These patients were admitted in our center and had undergone suspension microlaryngosurgery procedure under general anesthesia for various diagnostic and therapeutic modalities. The patient was placed on the operating table in a supine position with fully extended neck without any extra support under the head, neck, and chest. A Kleinsasser's rigid direct laryngoscope was passed into the mouth along the tongue to elevate the epiglottis and visualize the glottic structures. The laryngoscope was suspended and fixed in position by using a chest support. Based on the extent of the glottic structures visualized, they were broadly divided into two categories: DLE patients: inadequate visualization of the glottic structures (the anterior half of true vocal cords and the anterior commissure could not be seen) (Fig. 2A). Non-DLE patients: adequate visualization of the vocal cords (the anterior half of true vocal cords and the anterior commissure could be seen) (Fig. 2B).

Results

Out of the 50 patients studied, 45 patients (25 males, 20 females) belonged to non-DLE category that constituted 90% of the total and five patients (3 males, 2 females) belonged to DLE category that constituted 10% of the total. Gender analysis in both groups was comparable but not statistically significant (Table 1). The test used for the same was the Chi-square test. In this study, the age group of the non-DLE patients was ranging from 20 to 68 years, with a mean age being 41.17 years, and among the DLE group age ranged from 30 to 69 years with an average of 46.2 years, which



Figs 1A to C: (A) HMD—A, TMD—B; (B) TMA; (C) horizontal TMD—A, vertical TMD

Table 1: Comparison of clinical variables in relation to gender of patients studied (Student *t* test)

	Gender			
Variables	*Female*	*Male*	*Total*	*p value*
BMI (kg/m^2)	23.02 ± 2.72	24.03 ± 2.88	23.47 ± 2.81	0.210
NC (cm)	38.73 ± 4.17	38.88 ± 3.98	38.79 ± 4.05	0.899
HMD (cm)	4.98 ± 0.37	5.00 ± 0.40	4.99 ± 0.38	0.877
TMD (cm)	5.82 ± 0.50	5.88 ± 0.50	5.85 ± 0.50	0.697
TMA (deg)	116.32 ± 8.79	114.41 ± 6.67	115.48 ± 7.91	0.402
HTD (cm)	4.64 ± 0.49	4.70 ± 0.41	4.66 ± 0.45	0.669
VTD (cm)	3.30 ± 0.24	3.34 ± 0.27	3.32 ± 0.25	0.572
IIL (cm)	4.47 ± 0.36	4.42 ± 0.36	4.45 ± 0.36	0.663
MNE (deg)	59.11 ± 4.60	57.45 ± 4.84	58.38 ± 4.73	0.224

Table 2: Comparison of clinical variables in relation to the presence of DLE of patients studied (Student *t* test)

	DLE			
Variables	*Non-DLE*	*DLE*	*Total*	*p value*
BMI (kg/m^2)	23.00 ± 2.48	27.68 ± 2.13	23.47 ± 2.81	**<0.001**
NC (cm)	38.49 ± 3.85	41.54 ± 5.24	38.79 ± 4.05	0.111
HMD (cm)	5.03 ± 0.37	4.56 ± 0.05	4.99 ± 0.38	0.061
TMD (cm)	5.96 ± 0.38	4.82 ± 0.08	5.85 ± 0.50	**<0.001**
TMA (deg)	113.93 ± 6.55	129.40 ± 5.08	115.48 ± 7.91	**<0.001**
HTD (cm)	4.79 ± 0.26	3.54 ± 0.22	4.66 ± 0.45	**<0.001**
VTD (cm)	3.34 ± 0.25	3.12 ± 0.08	3.32 ± 0.25	0.062
IIL (cm)	4.48 ± 0.35	4.16 ± 0.34	4.45 ± 0.36	0.057
MNE (deg)	58.49 ± 4.63	57.4 ± 6.07	58.38 ± 4.73	0.630

was comparable but the difference was not statistically significant. The statistical test used was the analysis of variance (ANOVA) test.

Out of 45 patients in the non-DLE group, 14 (31.1%) were in class I of MMI, 25 (55.6%) were in class II of MMI, 3 (6.7%) were in class III of MMI, and 3 (6.7%) in class IV. Out of the five patients in the DLE group, two (40%) were in class II and three (60%) in class IV. After applying the Fisher exact test, the difference observed in the two groups is statistically significant ($p = 0.027$).

From the non-DLE group, 2 (4.4%) patients had a BMI < 18.5 kg/m^2, 34 (75.6%) had BMI between 18.5 and 25 kg/m^2, and 9 (20%) had a BMI between 25 and 30 kg/m^2. While in the DLE group, 1 (20%) had a BMI between 18.5 and 25 kg/m^2, and 4 (80%) had a BMI between 25 and 30 kg/m^2. After applying the Student *t* test, the difference observed in the two groups is statistically significant ($p < 0.001$) (Table 2).

Among the non-DLE patients, NC was less than 35 cm in 10 (22.2%), NC was between 35 and 41 cm in 26 (57.8%) of the patients, and NC was <42 cm in 9 (20%) of the patients. In the DLE group, one (20%) patient had NC <35 cm and one (20%) between 30 and 42 cm, while three (60%) had an NC >42 cm. This difference was found to be statistically nonsignificant after applying the Student *t* test ($p = 0.111$) (Table 2).

The HMD has been analyzed in the non-DLE and DLE groups. Measured HMD among the 45 non-DLE patients was <4.5 cm in 2 (4.4%) patients, between 4.5 and 5.5 in 38 (84.4%) patients, and >5.5 cm in 5 (11.1%) patients. From the five patients in the DLE group, all five (100%) had HMD between 4.5 and 5.5 cm. This difference was not statistically significant as per the Student *t* test ($p = 0.061$) (Table 2).

From the 45 of the non-DLE group, 3 (6.7%) had TMD <5.5 cm, 38 (84.4%) had TMD between 5.5 and 6.5 cm, and 4 (8.9%) had TMD >6.5 cm. All of the 5 patients (100%) in the DLE group had TMD <5.5 cm. According to the Student *t* test results, the difference was statistically significant ($p < 0.001$) (Table 2).

TMA was measured in all the patients. For 11 (24.4%) of the patients in the non-DLE group, TMA was <110°, for 33 (73.3%) patients, TMA was between 110 and 130°, and for 1 patient, TMA was >130°. In the DLE group, 2 (40%) patients' TMA was between 110 and 130°, and 3 patients' TMA was >130°. This observed difference was statistically significant. The statistical test used was the Student *t* test ($p < 0.001$) (Table 2).

While none of the non-DLE patients had HTD <4 cm, all 5 (100%) of the DLE patients had HTD <4 cm. Thirty-seven (82.2%) of the non-DLE patients had HTD between 4.5 cm and 8 (17.8%) of the non-DLE patients had HTD >5 cm. These observations were statistically significant as per the Student *t* test ($p < 0.001$). None of the patients had VTD <2.5 cm. Thirty-seven (82.2%) of the non-DLE patients had VTD between 2.5 and 3.5 cm, while all the 5 DLE patients had VTD between 2.5 and 3.5 cm. Eight (17.8%) of the non-DLE patients had VTD >3.5 cm. This difference was not statistically significant as per the Student *t* test ($p = 0.062$) (Table 2).

Among the non-DLE group, 3 (6.7%) of the patients had IIL <4 cm, 40 (88.9%) had IIL between 4 and 5 cm, and 2 (4.4%) had IIL >5 cm. Among the DLE group, 1 (20%) had IIL <4 cm and 4 (80%) had IIL between 4 and 5 cm. The difference between the two groups was not statistically significant as per the Student *t* test ($p = 0.057$) (Table 2). MNE was measured in all patients. Eleven (24.4%) of the 45 patients in the non-DLE group and MNE <55°, 30 (66.7%) of the patients had MNE between 55 and 65°, and 4 (8.9%) had MNE >65°. Two (40%) of the 5 patients in the DLE group had MNE <55° and 3 (60%) had MNE between 55 and 65°. According to the Student *t* test, this difference was not statistically significant ($p = 0.630$) (Table 2).

BMI with a cut-off value of more than 27.1 kg/m^2 showed a sensitivity of 80.0% and a specificity of 93.33%. TMD with a cut-off value of 4.9 cm or less showed a sensitivity of 100.0% and a specificity of 100.0%. TMA with a cut-off value of more than 122° showed a sensitivity of 100.0% and a specificity of 91.11%. HTD with a cut-off value of 3.8 cm or less showed a sensitivity of 100.0% and a specificity of 100.0% (Table 3).

Discussion

The incidence of DLE is reported to range from 1.5 to 24%.[7] The prediction of DLE preoperatively in a clinical scenario has been a daunting task to the laryngologist since the evolution of suspension MLS. Various promising attempts have been made in the recent past to foresee this obstacle to achieve a good glottic exposure.[5,6] The preoperative prediction of DLE helps the surgeon to prepare with additional measures to overcome the same.

Piazza et al.[8] conducted a prospective cohort study to identify a preoperative clinical predictor score for DLE during suspension microlaryngoscopy. They evaluated 319 patients before microlaryngoscopy for both the benign and malignant glottic diseases by using a standardized preoperative assessment protocol (laryngoscore) that included 11 parameters: inter-incisors gap (IIG), TMD, upper jaw dental status, trismus, mandibular prognathism, macroglossia, micrognathia, degree of neck flexion–extension, history of previous open-neck and/or radiotherapy, Mallampati's

Table 3: ROC curve analysis of physical parameters that showed a statistical significance with $p < 0.05$ as per the Chi-square test

	ROC results to predict DLE							
Variables	*Sensitivity*	*Specificity*	*LR+*	*LR−*	*Cut-off*	*AUROC*	*SE*	*p value*
BMI (kg/m^2)	80.0	93.33	12.00	0.21	>27.1	0.924	0.063	<0.001
TMD (cm)	100.00	100.00	1.00	0.0	≤4.9	1.000	0.00	<0.001
TMA (deg)	100.00	91.11	11.25	0.00	>122	0.964	0.025	<0.001
HTD (cm)	100.00	100.00	1.000	0.00	≤3.8	1.000	0.00	<0.001

modified score, and BMI. Each parameter was assessed to obtain a total score. Later, the patients were categorized into five classes according to the anterior commissure (AC) visualization: class 0, complete AC visualization with large-bore laryngoscopes in the Boyce–Jackson position; class I, as class 0 with external laryngeal counter-pressure; class II, as class I in the flexion–flexion position; class III, as class II using small-bore laryngoscopes; and class IV, impossible AC visualization. They concluded that the laryngoscore obtained is a good predictor of DLE and assists in selecting the ideal candidates for operative microlaryngoscopy. Ohno et al.[3] conducted a study on the management of vocal fold lesions in DLE cases. They concluded that the phonosurgery was possible even in DLE cases by modifying the direct laryngoscopy setup as needed to obtain an adequate view. The study had suggested the use of fiber-optic laryngoscope in certain difficult cases. Hekiert et al.[9] conducted a pilot study that was used to identify predictors of DLE in obese patients, develop strategies for efficient intubation and intraoperative visualization of the glottis, and to devise perioperative protocols for difficult laryngoscopies. They concluded that the anatomical challenges during difficult laryngoscopy included decreased neck extension, redundant folds of tissue in the oropharynx and hypopharynx, and upper airway collapsibility. They emphasized that neither weight nor body mass index did not play any role in the prediction of DLE. They also stated that the best visualization of the glottis was by using a straight blade laryngoscope with a distal flange as the depth of insertion was greater. Xidong et al.[10] conducted a study on the surgical management of DLE cases using a GlideScope video laryngoscope (GVL) to obtain an adequate laryngeal exposure for phonosurgery. They concluded that the use of a GVL has enabled a complete visualization of the larynx in all patients with a minimal need for internal or external pressure. Surgical procedures to remove simple lesions or performing a biopsy were done successfully. Roh et al.[11] proposed a new classification of laryngeal exposure based on the extent of glottic visualization. They investigated 15 physical parameters that could predict DLE. Cormack–Lehane and laryngeal exposure scores were acquired for each patient and compared with the parameters. The laryngeal exposure was graded as grade I, full view of the vocal folds; grade IIA, partial view of the vocal folds, but the anterior commissure not seen; grade IIB, partial view of the vocal folds (less than half); grade III, only the arytenoids visible; and grade IV, the entire glottis and arytenoids hidden. The study concluded that obese patients, patients with a muscular neck or retrognathia, are prone to present with DLE, and measurement of the predictors preoperatively might be useful in preparing for microlaryngosurgery. Paul et al.[12] conducted a prospective descriptive study aimed at identifying preoperative clinical predictors for DLE and to define a simple grading system for laryngeal exposure. DLE was predicted by NC of more than 34.25 cm and limited atlanto-occipital extension of less than 19.50°. The modified Cormack–Lehane score grade more than 2A done intraoperatively correlates well with difficult intubation.

The detailed discussion of the assessed parameters is as follows:

- Age: Hekiert et al.[9] reported that the age of the patient was not statistically significant in the prediction of DLE ($p = 0.47$). Roh et al.[11] also concluded that the age of the patient played no role in the prediction of DLE ($p = 0.794$). Hsiung et al.[5] conducted a study on 56 patients and stated that the age of the patients was not a reliable predictor of DLE. In our study, we observed that the age of the patient was not statistically significant in the prediction of DLE ($p = 0.441$).
- Sex: Hsiung et al.[5] claimed that most important factor in predicting a DLE is the sex of the patient with an odds ratio of 69.159 in a stepwise logistic regression model and concluded that the combination of sex along with the TMA contributed significantly as an initial clinical indicator to predict DLE intraoperatively. They hypothesized that men are more prone to have stiff larynges and muscular necks that led to restriction of laryngeal movement and neck flexibility. However, in our study, we observed that the gender had no statistically significant role in the prediction of DLE (Table 1).
- HTD: Hsiung et al.[5] also emphasized that the smaller HTD was proposed to assess the effect of the retrognathic profile in patients with DLE, but it was not considered to be a significant predictor. Roh et al.[11] assessed HTD and found that it had no significant role in the prediction of DLE ($p = 0.882$). However, as per the results obtained in our study, the shorter HTD (≤3.8 cm) showed a strong statistical significance ($p < 0.001$) in the visualization of the glottic extent.
- VTD: Roh et al.[11] assessed the VTD and found that it had no significant role in the prediction of DLE ($p = 0.812$). Similarly, in our study, the VTD showed no statistical significance in the prediction of DLE ($p = 0.062$).
- TTMD: Cormack et al.[13] stated that a smaller TMD of a value less than 6.5 cm as a cut off has been recorded to be a predictor of difficult endotracheal intubation. Roh et al.[11] concluded that TMD (<5.5 cm) was statistically significant in the prediction of DLE ($p = 0.022$). Meanwhile, as per our study, we have observed that the TMD had to be much lower (≤4.9 cm) comparatively to predict a DLE and, hence, showed a strong statistical significance ($p < 0.001$).
- HMD: Pinar et al.[7] investigated potential parameters to identify DLE and by multivariate analysis found that HMD (<6.05 cm) was statistically significant. Roh et al. reported that HMD ($p = 0.882$) did not show any statistical significance in the prediction of DLE. Similarly, in our study, we observed that HMD was not significant in the prediction of DLE ($p = 0.061$).
- BMI: Roh et al.[11] stated that BMI (>25 kg/m^2, $p = 0.031$) was a reliable indicator for the prediction of DLE. Hekiert et al.[9] reported that BMI (>30 kg/m^2, $p < 0.001$) was statistically

significant in the prediction of DLE. In our study, we found that BMI (>27.1 kg/m^2) was statistically significant in the prediction of DLE ($p < 0.001$).

- NC: Pinar et al.[7] investigated various potential parameters to identify DLE and multivariate analysis found that NC (>40 cm) was statistically significant in the prediction of DLE. Roh et al.[11] concluded that the muscular neck (NC > 39.5 cm, $p = 0.022$) was statistically significant in the prediction of DLE. Hekiert et al.[9] conducted a prospective study to determine the role of obesity in difficulty of obtaining adequate laryngeal exposure and observed that measurement of NC preoperatively did not help foresee the DLE. However, they reported that NC more than 40 cm ($p < 0.001$) was statistically significant in the prediction of DLE. In our study, we found that NC was not statistically significant in the prediction of DLE ($p = 0.111$).
- MMI: Roh et al.[11] reported that the MMI ($p = 0.731$) was not statistically significant in the prediction of DLE. Ohno et al.[3] stated that MMI ($p < 0.001$) was statistically significant in the prediction of DLE. Hekiert et al.[9] reported that MMI ($p < 0.001$) was statistically significant in the prediction of DLE. In our study, higher MMI (class II and above) was found to be statistically significant ($p = 0.027$) for the same.
- IIL: Piazza et al.[8] stated that reduced II (<4 cm) aided in the prediction of DLE and, therefore, was included in their laryngoscore formulation. Roh et al.[11] reported that II (0.761) was not statistically significant in the prediction of DLE. Similarly, in our study, we observed that the II was not significant in the prediction of DLE ($p = 0.057$).
- MNE: Piazza et al.[8] reported that the neck full flexion to full extension (p 0.016) was statistically significant in the prediction of DLE. Roh et al.[11] measured the angle of neutral to full neck extension (p 0.053), which was not significant. Similarly, in our study, we had observed that the angle of neutral to full neck extension ($p = 0.630$) was not statistically significant in the prediction of DLE.
- TMA: Hsiung et al.[5] claimed that one of the most important factors in predicting a DLE is the TMA ($p = 0.004$, odds ratio = 1.510). Ohno et al.[3] conducted a study on the management of vocal fold lesions in DLE cases and defined TMA as large if it was more than 120° in men and more than 130° in women. They found that a large TMA depicted a short neck and was statistically significant in the prediction of DLE. In our study, we observed that TMA more than 122° ($p < 0.001$) irrespective of the gender of the patient was statistically significant in the prediction of DLE.

Out the all the physical parameters measured, TMD, TMA, and HTD showed a very strong statistical significance in the prediction of DLE with high sensitivity and specificity.

Conclusion

Based on our study results, we conclude that various physical parameters aid in the preoperative prediction of DLE during suspension MLS. The age and the sex of the patient have no role in predicting the risk of DLE. Out of the parameters assessed, the MMI (class II and above), BMI (>27.1 kg/m^2), TMD ($\leq$4.9 cm), TMA (>122°), and HTD ($\leq$3.8 cm) play a vital role to predict DLE preoperatively. The TMD and HTD have the highest sensitivity (100%) and specificity (100%) each among the parameters assessed.

Clinical Significance

In our study, the physical parameters have been chosen in a manner so as to enable the surgeon to carry out the measurements with simple measuring aids in a minimal time span. This can be done even just prior to the surgery. The preoperative prediction of DLE helps the surgeon to be prepared with additional measures to overcome the same and provide optimal treatment.

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