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Diagnostic Value of the Friedman Tongue Position and Mallampati Classification for Obstructive Sleep Apnea: A Meta-analysis

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Sponsorships or competing interests that may be relevant to content are disclosed at the end of this article.

Abstract

Objective. To assess the association between the Mallampati classification and Friedman tongue position for obstructive sleep apnea severity as determined by apnea-hypopnea index and to determine which method is most closely correlated with prediction of obstructive sleep apnea severity.

Data Sources. English-language searches of PubMed, MedLine, and the Cochrane database. Reference sections of identified studies were examined for additional articles.

Review Methods. Databases through December 2011 were searched, combined with review of relevant article bibliographies, and assessed by 4 reviewers. Systematic review and random-effects meta-analysis of studies evaluating tongue position and obstructive sleep apnea severity were performed. Outcomes were reported as correlations.

Results. Ten studies met inclusion criteria and had data for pooling (2513 patients). Friedman tongue position and Mallampati classification were significantly associated with obstructive sleep apnea severity, with a correlation of 0.351 (0.094-0.564, P = .008). Analysis of the correlation of tongue position with obstructive sleep apnea severity reveals correlations of 0.184 (0.052, 0.310, P = .006) and 0.388 (0.049, 0.646, P = .026) for the Mallampati classification and Friedman tongue position, respectively. Publication bias does not yield a significant Egger regression intercept; however, 4 imputed values to the right of the mean were found using Duval and Tweedie's trim-and-fill method, yielding an overall correlation of 0.498 (confidence interval = 0.474-0.521).

Conclusion. The Mallampati classification and Friedman tongue position assessment techniques are significantly correlated with predicting obstructive sleep apnea severity. Publication bias does not significantly affect our results. The strength of this correlation is higher for Friedman tongue position, although 95% confidence intervals for the respective correlation coefficients overlap.

Keywords

Friedman tongue position, Mallampati classification, Mallampati, obstructive sleep apnea, modified Mallampati classification

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Obstructive sleep apnea (OSA) is a challenging diagnosis to make clinically during physical examination. With few physical examination components providing direct correlation to the presence or severity of the disease, clinicians rely on medical history and polysomnography (PSG) study results for diagnosis. Classical medical diagnosis relies on history and physical examination with confirmation by laboratory testing. Although a good history is highly diagnostic for OSA, an accurate history is not always forthcoming. Since sleep apnea is a disease of sleep, an ideal history is obtained from a bed partner. When no bed partner is available, the medical history is incomplete, making the diagnosis of OSA more challenging.

An attempt to identify physical findings suggestive of OSA have led clinicians to adopt either the Mallampati classification (MC) or Friedman tongue position (FTP) as a rapid physical assessment tool used in the prediction of the presence and severity of OSA. The MC system, first hypothesized by Dr Mallampati in 1983, asserted that the visualized anatomical relationship between tongue base, faucial pillars, soft palate, and uvula was a predictor of potential difficulty in endotracheal intubation.[1,2] He went on to develop 3 classes of tongue

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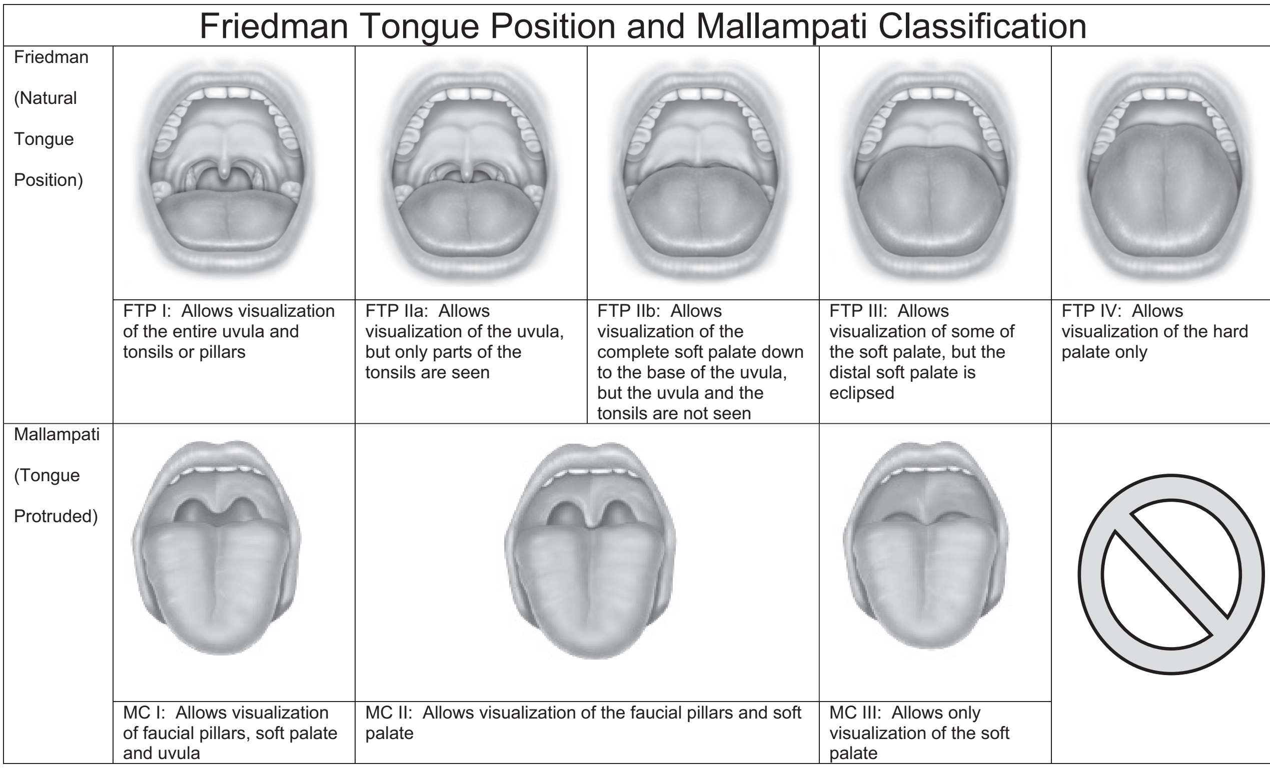


Figure 1. Comparison of Friedman tongue position (FTP) and Mallampati classification (MC).

position for describing the anatomical relationship of the oropharynx and its relation to the ease or difficulty of intubation. The MC requires the patient to be comfortably resting in a seated position with the mouth open and the tongue protruded without phonation, providing visualization of the oropharynx. Based on what is visualized, a classification from I to III is assigned: class I, faucial pillars, soft palate, and uvula visualized; class II, faucial pillars and soft palate visualized, uvula massed by the tongue base; and class III, visualization of soft palate only. The MC system has been accepted within the anesthesiology community as a clinical indicator for difficult intubation, but there are conflicting views on its utility in predicting the severity of OSA.

In 1999, Friedman et al made 2 major modifications to the original MC, creating what they called the modified Mallampati position (MMP) and eventually renamed the FTP.[3,4] The original MC required the patient to protrude the tongue, allowing the clinician to visualize the relationship of the soft palate and tongue. The FTP is based on evaluating the oropharynx in a natural position. This evaluation occurs with the tongue inside the mouth without any protrusion or phonation. The second modification made was the addition of a fourth class. The FTP went on to further subdivide class II into IIA and IIB, making the current FTP a 5-class assessment tool. The classes consist of the following: class I, visualization of tonsil, pillars, and entire uvula; class IIa, visualization of the entire uvula but not tonsils or pillars; class IIb, visualization of the soft palate and base of the uvula but not tonsils or pillars; class III, visualization of some of the soft palate but not tonsils, pillars, distal soft palate, or base of the uvula; and class IV, visualization of only the hard palate (**Figure 1**).

Both the MC and FTP have been examined as assessment tools for the prediction of the presence and severity of OSA. Conflicting conclusions have led to uncertainty of its value. These conflicting results require a comprehensive systematic review and meta-analysis of all studies reporting on the predictive quality of tongue position in determining OSA. By including smaller studies in this meta-analysis, we hope to bring attention to the tongue position assessment tool most correlated to the prediction of OSA severity.

Although the main value of FTP assessment in surgical planning is to predict whether a hypopharyngeal obstruction is a contributing factor, there is evidence that FTP can also be helpful in predicting the presence and severity of OSA.

Materials and Methods

Literature Search

A computerized search was conducted to identify literature on the topic of tongue position and OSA severity. The comprehensive literature search used PubMed, MedLine, and the Cochrane database. The following keywords were used as search terms: *Friedman tongue position modified Mallampati, Mallampati, obstructive sleep apnea severity, OSA*, and *sleep apnea*. Relevant article reference lists were examined for additional articles for review.

The initial search was performed by 4 independent reviewers (M.F., T.P., C.G.S., C.H.). Based on the initial

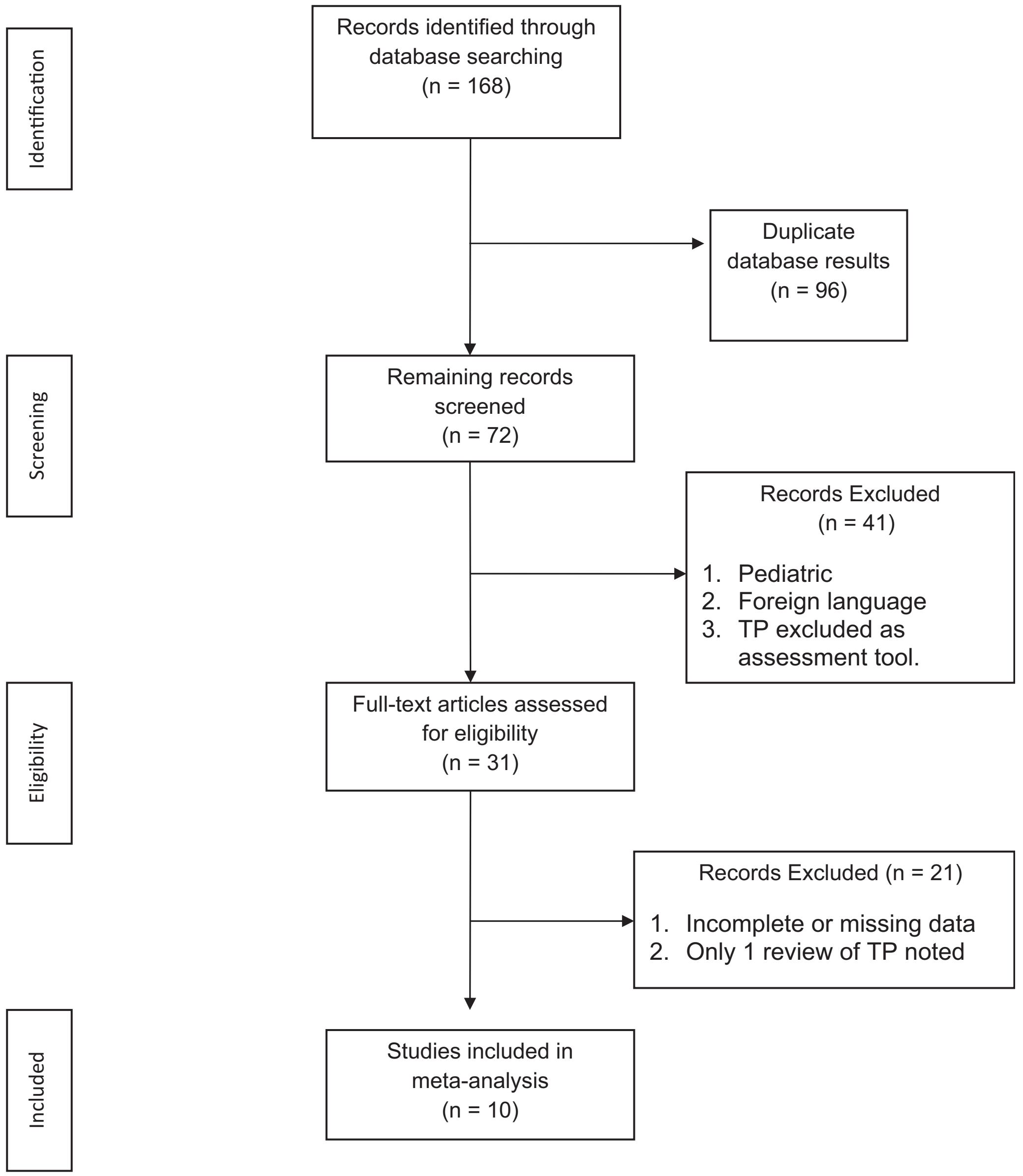


Figure 2. Graphic representation of the literature review and how inclusion/exclusion criteria were used to arrive at studies to be included for statistical analysis. PRISMA outline was used. OSA, obstructive sleep apnea; TP, tongue position.

search and examination of reference sections, 72 articles were identified. The initial screening of the article titles and abstracts was performed based on predetermined inclusion and exclusion criteria (refer to the Inclusion/Exclusion Criteria section). After discussion among all reviewers, 31 articles were found to be relevant to the study and progressed to the next stage for review.

Thirty-one articles underwent a second-stage review. These articles were read and discussed in detail by 4 reviewers (M.F., T.P., C.G.S., C.H.). Those studies found not to meet the inclusion criteria of correlating all tongue positions with OSA were excluded. Articles reviewed with incomplete or missing data or those in which tongue position classification was not determined by 2 independent reviewers were excluded. At the termination of the literature search and review, 10 studies (2513 patients) were identified that met all inclusion criteria for incorporation in this study (**Figure 2**).

Inclusion/Exclusion Criteria

The study was designed to review those studies reporting the FTP or MC score in the diagnosis of OSA severity. The research inquiry for the study was as follows: determine the association of OSA severity with both the Friedman and Mallampati tongue position scales and determine which assessment method most closely correlates with OSA severity (determined by apnea-hypopnea index [AHI]). The following inclusion criteria were used:

1. All subjects reported must be older than 18 years, or consent was provided for those younger

Table 1. Characteristics of Included Studies

Author	Year	Country	TP	SD	LOE	n	Age, y	Sex (M:F)	AHI	BMI, kg/m^2	LS
Friedman et al[3]	1999	United States	FTP	CS	4	172	44.5	110:62	28.8	32.4	—
Liistro et al[14]	2003	Belgium	MC	CS	4	202	49.4	161:41	19.1	29.5	6 mo
Barceló et al[6]	2011	Spain	FTP	CS	4	301	51.0	214:87	27.6	29.8	35 mo
Hukins[13]	2010	Australia	MC	CCS	3b	953	50.0	619:334	26.1	33.8	30 mo
Pang et al[8]	2006	United States	FTP	CS	4	102	50.2	65:37	37.9	32.9	6 mo
Thong and Pang [9]	2008	Singapore	FTP	CS	4	80	42.9	66:14	27.6	27.6	—
Zonato et al[10]	2003	Brazil	FTP	CS	4	223	48.0	142:81	23.8	29.0	10 mo
Erdamar et al[11]	2001	Turkey	FTP	CS	4	85	48.0	63:22	32.0	29.0	8 mo
Weihu et al[7]	2011	China	FTP	CS	4	103	53.2	48:55	20.3	28.18	—
Tagaya et al[12]	2011	Japan	FTP	CCS	3b	292	50.4	238:54	40.7	27.64	35 mo

Abbreviations: AHI, apnea-hypopnea index; BMI, body mass index; FTP, Friedman tongue position; LOE, level of evidence: 3b (individual case-controlled study), 4 (case series); LS, length of study; MC, Mallampati classification; SD, study design; TP, tongue position; CCS, case-control study; CS, case series.

2. Both male and female patients included
3. Tongue position for OSA diagnosis
4. All levels of OSA (mild, moderate, severe) were included
5. AHI or respiratory disturbance index included as a means to assess OSA severity
6. Authors describe FTP, MC, or MMP classes used
7. More than 1 researcher evaluated tongue position to determine class
8. All tongue position classes for FTP, MMP, or MC were included
9. All studies must include odds ratio or correlation

Only studies written in English were included for review. In addition, case reports, abstracts, and letters to the editor were not reviewed for inclusion.

Statistical Analysis

Data were retrieved and reviewed systematically. All calculations and plot syntheses were carried out using the Comprehensive meta-analysis software package.[5]

1. Cochran's Q test for determining heterogeneity was applied, where $P < .05$ was considered a significant difference of sample populations between studies.
2. The correlation between tongue position and AHI was calculated using a random effects model. All studies were weighted for effect. A forest plot was synthesized.
3. Sensitivity analysis was done to determine the correlation between those studies using MC versus those using FTP. Forest plots were synthesized.
4. Analysis of publication bias was performed by calculating the Egger regression intercept. Precision funnel plots with imputed values were created using Duval and Tweedie's trim-and-fill method.

Results

Ten studies[3,6-14] comprising data from a total of 2513 patients were included for review (**Table 1**). Of those analyzed, 68.7% (n = 1726) were men, and the mean age was 49.1 years. The average body mass index (BMI) was 31.11. The average AHI was 27.88 events per hour. The level of evidence and type of each study were included. Among the included studies, 8 were case series and 2 were case-controlled studies. Statistical analysis of the correlation yielded an *r* value of 0.351 (0.094-0.564, P = .008; **Figure 3**). This suggests that the Friedman and Mallampati tongue position are significantly associated with OSA severity, as determined by AHI.

Friedman Tongue Position

Eight studies[3,6-12] included in the analysis examined only the FTP as a tool for determining the severity of OSA. These studies include 1358 patients, of which 69.67% (946) were male, with an average age of 48.99 years, average AHI of 30.44, and average BMI of 29.41 kg/m^2. Statistical analysis of the correlation yielded an *r* value of 0.388 (0.049-0.646, P = .026; **Figure 4**). This suggests that FTP positively correlates with OSA severity determined by AHI. The higher the FTP, the higher the AHI. **Figure 4** displays statistics for each included FTP study.

Mallampati Tongue Position

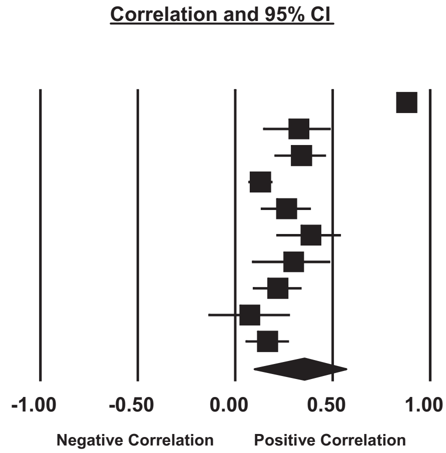
Two studies[13,14] included in the analysis examined only MC as a tool for determining the severity of OSA. These studies included 1055 patients, of which 64.83% (684) were male, with an average age of 50.02 years, average AHI of 27.24, and average BMI of 33.71 kg/m^2. Statistical analysis of the correlation yielded an *r* value of 0.184 (0.052-0.310, P = .006; **Figure 5**). This suggests that MC positively correlates with OSA severity determined by AHI.

Quality of Data

Analysis of the types of bias associated with each type of study is outlined in **Table 2**.

Study name	Subgroup within study	Correlation	Lower limit	Upper limit	p-Value	Z-Value
Barcelo et al.[6]	FTP-AHI	0.880	0.852	0.903	0.000	23.749
Weihu et al.[7]	FTP-AHI	0.327	0.142	0.490	0.001	3.395
Friedman et al.[3]	FTP-AHI	0.340	0.201	0.466	0.000	4.603
Hukins et al.[13]	MC-AHI	0.130	0.067	0.192	0.000	4.030
Liistro et al.[14]	MC-AHI	0.264	0.131	0.388	0.000	3.815
Pang et al.[8]	FTP-AHI	0.389	0.210	0.542	0.000	4.086
Throng et al.[9]	FTP-AHI	0.300	0.086	0.488	0.007	2.716
Zonato et al.[10]	FTP-AHI	0.219	0.090	0.340	0.001	3.300
Erdamar et al.[11]	FTP-AHI	0.075	-0.138	0.281	0.491	0.689
Tagaya et al.[12]	FTP-AHI	0.166	0.052	0.276	0.004	2.848
		0.351	0.094	0.564	0.008	2.640

Statistics for each study



Meta-Analysis: All Studies. Random Effects

Figure 3. Meta-analysis and forest plot of all studies included. Calculations based on random effects model. AHI, apnea hypopnea index; CI, confidence interval; FTP, Friedman tongue position; MC, Mallampati classification.

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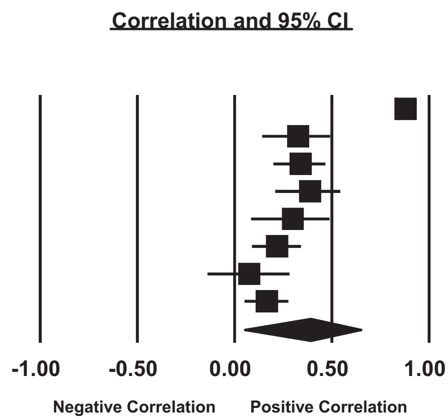
Tagaya et al.[12]	FTP-AHI	0.166	0.052	0.276	0.004	2.848
		0.388	0.049	0.646	0.026	2.225

Statistics for each study



Meta-Analysis: FTP Studies. Random Effects

Figure 4. Meta-analysis and forest plot of FTP studies. Calculations based on random effects model. AHI, apnea hypopnea index; CI, confidence interval; FTP, Friedman tongue position.

Assessment of Bias

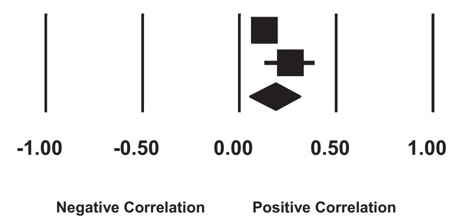
Publication bias was assessed both mathematically using the Egger regression intercept (P = .67715; 2-tailed) and graphically using a precision funnel plot with Duval and Tweedie's trim and fill (**Figure 6**). Four possible unpublished studies were found (black dots). The addition of these studies yielded a correlation of 0.498 (0.474, 0.521). This suggests that publication bias is likely and that if these studies were added, they would provide a stronger correlation between tongue position and OSA severity. As these are unpublished theoretical studies, they were not included in the statistical analysis.

Discussion

While there are multiple physical assessment measurements included in the evaluation of an OSA patient, few findings have been found to directly correlate with OSA severity,[6] leaving the diagnosis of OSA and its severity dependent on history and PSG. Barceló et al[6] suggested the difficulty in implementing predictive models based on clinical examination (with or without clinical data) is the result of a failure to standardize the description of the anatomical regions. The multitude of diagnostic methods currently in use is evidence for lack of agreement among physicians as to the single perfect method for determining the diagnosis of OSA and determining its severity.[15]

Study name	Subgroup within study	Statistics for each study				
		Correlation	Lower limit	Upper limit	p-Value	Z-Value
Hukins et al.[13]	MC-AHI	0.130	0.067	0.192	0.000	4.030
Liistro et al.[14]	MC-AHI	0.264	0.131	0.388	0.000	3.815
		0.184	0.052	0.310	0.006	2.726

Correlation and 95% CI



Meta Analysis: Mallampati Tongue Position. Random Effects

Figure 5. Meta-analysis and forest plot of MC studies. Calculations based on random effects model. AHI, apnea hypopnea index; CI, confidence interval; MC, Mallampati classification.

FTP and Mallampati score are 2 physical examination tools commonly used in the evaluation of OSA. No prior study has directly compared these methods with respect to predicting severity of OSA. Multiple studies have previously been conducted to evaluate the usefulness of FTP or MC in the prediction of OSA severity. Liistro et al[14] in 2003 studied Mallampati and nasal obstruction, determining that a high Mallampati score represents a predisposing factor for OSA only in those patients with nasal obstruction. Nuckton et al[16] in 2006 found the Mallampati score to be an independent predictor of both the presence and severity of OSA. In 2010, Hunkins[13] hypothesized that the higher the MC, the increased likelihood of severe OSA, while a lower MC would increase the likelihood of excluding OSA. Hunkins determined that the MC has no use in triaging patients for urgency for PSG based on the likelihood of OSA severity.[13]

Pang et al,[8] in a prospective study of 102 patients, determined that there was a strong correlation between FTP and AHI. Throng and Pang[9] determined that OSA severity correlated significantly with male gender, history of hypertension, BMI, FTP, and upper airway collapse during Muller maneuver. In contrast to studies reporting a correlation of FTP with predicting OSA severity, Erdamar et al[11] could not detect a correlation between OSA severity and MMP (FTP).

Current standardization of oropharynx examination in the context of OSA is lacking, with neither FTP nor MC gaining regular acceptance in otolaryngological examination protocols. This meta-analysis has shown a direct positive correlation, 0.351 (0.094-0.564, P = .008), between tongue position and OSA severity based on AHI. Examination of each tongue position technique (FTP and MC) independently shows a direct positive correlation with OSA severity. These independent correlations provide support for the use of MC or FTP in the evaluation of OSA severity. However, FTP shows a greater correlation of 0.388 (0.049-0.646, P = .026) when compared with MC 0.184 (0.052-0.310, P = .006). This variance in correlations could potentially result from the natural physiological position of the tongue within the mouth during examination using the FTP model. It is important to note the overlapping of the 95% confidence interval for each of the independent correlations.

Lack of an accepted predictive tongue position model has led physicians to classify tongue position and oropharynx crowding in an inconsistent manner. Although both MC and FTP are often used, the term MC is often used incorrectly. The original MC is based on the patient protruding his or her tongue, while the FTP assessment requires the tongue to remain relaxed within the mouth. Frequently the FTP model is used but mislabeled as MC. This further emphasizes the importance of standardization of a tongue position model when discussing OSA.

Friedman et al[15] in 2008 studied the interexaminer agreement of FTP (based on a kappa value of 0.81-0.92 as very good strength of agreement) among attending physicians (kappa = 0.827), fellows (kappa = 0.8367), and residents (kappa = 0.818), determining that FTP can be used as a reliable standard to describe anatomy in the context of OSA. This study went on to discuss how FTP provides clinicians a common language to discuss patients and reports.[15] Interexaminer evaluation of MC in the diagnosis or severity of OSA has not been studied. Determining interexaminer agreement of MC would provide greater evidence for determining the most reliable physical examination component that should be standardized among clinicians. Incorporation of either the MC or FTP model into physical examination protocols can provide a rapid, inexpensive tool to predict OSA severity and determine the need and urgency for further evaluation.

Limitations

One limitation of meta-analysis, especially pertaining to observational/clinical outcome studies, is the introduction of selection bias. Although the primary reviewers worked to lessen the effect of potential selection bias through the development of inclusion/exclusion criteria, this itself may act as a form of bias. For example, one article was not included for analysis because it was not written in English. While this ensured the articles we chose met all inclusion criteria, we potentially lost valuable data that could affect our results. The consequence of limiting selection bias is the potential inclusion of possible confounding factors. Publication bias was assessed using Egger's regression, which failed to show any substantial

Table 2. Case-Controlled and Case-Series Studies

Study	Design	Bias
Case-controlled studies		
Hukins[13]	Retrospective study, data from 953 patients undergoing PSG	Study did not evaluate nasal symptoms, which may affect OSA severity
	Compared MC, age, gender, and BMI to AHI for OSA severity	Selection bias regarding cohorts and assignment to each MC class[a]
Tagaya et al[12]	Prospective, controlled, 292 consecutive patients	Controls underwent a home (LS-20, Fukuda Denshi, Tokyo, Japan) respiratory monitoring while subjects underwent standard PSG
	Determined morphological features of the upper airway and relationship to prevalence and severity of OSAS with aging	Potential for recall bias and selection bias in the elderly population[a]
Case-series studies		
Friedman et al[3]	Prospective study of 172 patients	Selection bias
	Independent and combined effects of tonsil size, MMP, BMI grade, TMD, and HMD as it relates to OSA severity	Selection of subjects based on questionnaire[a]
Liistro et al[14]	Prospective study of 202 patients	Selection bias
	Evaluated nasal obstruction and MC score with OSA severity	All 202 subjects had nasal obstruction, no subjects included without[a]
Barceló et al [6]	Prospective, cross-sectional study, 301 patients	Selection bias
	Evaluated relationship between AHI values and sex, BMI, cervical perimeter, nasal flow, FTP, tonsil and uvula scores	Patients with other comorbidities were excluded, potential selection bias[a]
Pang et al[8]	102 consecutive patients	Selection bias
	Correlated clinical/physical history, patient self-perception, and physical examination to OSA severity	Less than 1% having FTP grades 1 and 2[a]
Thong and Pang[9]	80 consecutive patients	Measurement bias
	Correlated clinical symptoms to OSA severity	Interobserver variability during assessments[a]
Zonato et al[10]	Prospective study, 223 patients	Evaluation of dental occlusion was prevented due to poor dental health of population
	Evaluated presence of anatomical abnormalities and correlated with OSA severity	May suggest isolated demographic of population; caution in extrapolating results[a]
Erdamar et al[11]	Prospective study, 85 patients	PSG investigations were undertaken only if major symptoms or pathological changes were present on physical examination[a]
	Evaluated upper airway	
	Standardization of physical findings in OSA patients and correlation with severity	
Weihu et al[7]	103 consecutive Chinese patients	Selection bias by excluding patients with medical complications[a]
	Evaluated predictive power of physical examination (BMI, neck circumference, MMP) to identify OSA	

Abbreviations: AHI, apnea-hypopnea index; BMI, body mass index; FTP, Friedman tongue position; HMD, hyoid-mental distance; MC, Mallampati classification; MMP, modified Mallampati; OSA, obstructive sleep apnea; OSAS, obstructive sleep apnea syndrome; PSG, polysomnography; TMD, thyroid-mental distance.
[a]Studies focus on patients who were referred to or had diagnosis of OSA. Results cannot be generalized to population, as most participants were evaluated for OSA.

publication bias. A precision funnel plot further illustrates this by imputing 4 studies to the right of the mean, further strengthening the correlation between tongue position and OSA severity (**Figure 6**).

The calculated I^2 value (97.63) suggests significant heterogeneity, and the meta-analysis was performed using a random effects model. This model assumes that the studies were drawn from populations that differ from each other in parameters that may (or may not) have a direct effect on the outcome in question. This model also assumes that any observed differences will be due to either random error or true variation in effect. The random effects model is considered the standard

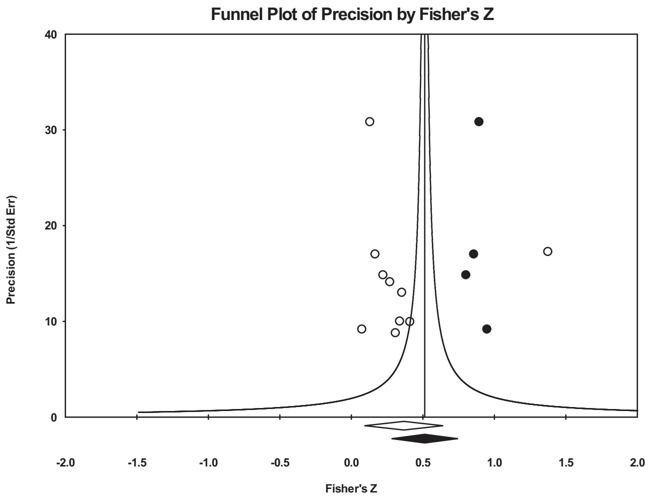


Figure 6. Precision funnel plot with imputed values of "missing" study as black dots.

choice for outcomes related to medical decision making as conclusions may be extrapolated beyond the study.

In addition to selection bias and confounding factors noted above, every meta-analysis is also reliant on the quality and quantity of the studies available for analysis. Of the 10 studies analyzed, 2 were case-controlled studies with an evidence level of 3b, while the remaining studies were case series with a level of evidence of 4 (**Table 2**).

Conclusion

This meta-analysis has examined tongue position assessment tools for their correlation with predicting OSA severity. We have shown that both methods of oropharynx evaluation correlate positively with predicting OSA severity, based on AHI. FTP correlates more strongly to OSA severity when compared with MC. This correlation and meta-analysis has shown that FTP should be the tongue position assessment tool used in the prediction of OSA severity prior to confirmatory testing by PSG. It is well known that other physical findings are also predictive of OSA. Further studies need to be done examining these physical findings together with FTP in diagnosing and predicting the severity of OSA.

Author Contributions

Michael Friedman, statistical analysis, manuscript drafting/revision; **Craig Hamilton**, study design, data collection/interpretation, drafting/revision; **Christian G. Samuelson**, study design, data collection/interpretation, statistical analysis; **Mary E. Lundgren**, research, data collection/interpretation, statistical analysis, drafting/revision; **Thomas Pott**, research, data collection/interpretation, statistical analysis, drafting/revision, presentation.

Disclosures

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