Prediction of Uvulopalatopharyngoplasty Outcome: Anatomy-Based Staging System Versus Severity-Based Staging System

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Study Objective: To evaluate and compare outcomes of uvulopalatopharyngoplasty (UPPP) for obstructive sleep apnea/hypopnea syndrome (OSAHS) using anatomy- and severity-based staging systems.

Design: Prospective design with a retrospective review.

Setting: A tertiary-care, sleep disorder referral center.

Patients: In total, 110 patients with OSAHS (105 men, 5 women; mean age, 43 years; apnea-hypopnea index, 44.4 ± 28.8 events per hour; body mass index, 27.1 ± 3.3 kg/m^2).

Measurements: An anatomy-based staging system (stages I–IV) was used to classify patients with OSAHS by examining tongue-palate position, tonsil size, body mass index, and craniofacial deformities. Patients were also classified as having mild, moderate, moderate-severe, or severe OSAHS based on preoperative apnea-hypopnea index from polysomnography (a severity-based staging system). Surgical success was defined as a 50% or greater reduction in the apnea-hypopnea index and a postoperative apnea-hypopnea index of less than 20 events per hour.

Intervention: UPPP was performed in all patients.

Results: The overall success rate of UPPP was 78%. Success rates for mild (90%), moderate (73%), moderate-severe (81%), and severe (74%) diseases were similar (p = .10). Conversely, success rates for patients with anatomy-based stages I, II, III, and IV were 100%, 96%, 65%, and 20%, respectively; these rates were significantly different (p < .001). Changes in apnea-hypopnea index were significantly correlated with Friedman tongue position (FTP)(r = -0.33, p = .0004) and tonsil size (r = -0.37, p < .0001). The FTP (odds ratio = 0.43, SE = 0.13, p = .005, 95% confidence interval = 0.24–0.78) and tonsil size (odds ratio = 3.13, SE = 1.53, p = .02, 95% confidence interval = 1.20–8.17), but not the severity-based staging (odds ratio = 0.77, SE=0.18, p = .283, 95% confidence interval = 0.49–1.23), were predictive of surgical success.

Conclusion: The anatomy-based staging system predicted UPPP outcomes more effectively than did the severity-based staging. The anatomy-based staging system facilitates good case-selection information for counseling patients before UPPP surgery.

Keywords: Obstructive sleep apnoea, uvulopalatopharyngoplasty, anatomy-based staging system, severity-based staging system

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INTRODUCTION

OBSTRUCTIVE SLEEP APNEA/HYPOPNEA SYNDROME (OSAHS) IS CHARACTERIZED BY EPISODES OF COMPLETE OR PARTIAL PHARYNGEAL OBSTRUCTION during sleep, typically resulting in excessive daytime sleepiness and at least 2 other major symptoms.[1] Nasal continuous positive airway pressure is the preferred treatment for patients with OSAHS, acting by blowing pressurized air through the nasal passages to prevent airway collapse. Unfortunately, numerous patients cannot or are unwilling to use long-term nasal continuous positive airway pressure therapy and, therefore, seek surgical treatment to alleviate the symptoms of OSAHS.

Uvulopalatopharyngoplasty (UPPP) is most commonly utilized surgical modality for treating OSAHS. A previous study demonstrated that UPPP significantly enhances patients' perception of snoring, daytime sleepiness, and quality of life. However, the changes in subjective symptoms did not correlate with changes in the apnea-hypopnea index (AHI).[2] Success rates for UPPP vary from 25% to 85% when different definitions of success are applied.[3] A meta-analysis conducted by Sher et al[4] indicated the success rate was reduced to 40.8% for unselected patients when surgical success is defined as a 50% or greater reduction in the AHI and a postoperative AHI of less than 20.

Selecting appropriate patients for UPPP surgery remains challenging. Conventionally, a severity-based staging system has been applied to categorize the disease in patients with OSAHS. Fiberoptic nasopharyngolaryngoscopy combined with the Müller maneuver and imaging studies has been utilized to enhance patient selection for UPPP; however, no evidence exists demonstrating that these modalities are useful in predicting surgical outcomes.[5,6] Typically, patients with simple snoring or mild OSAHS are considered to be more suitable candidates for UPPP than are those with moderate or severe OSAHS. Although some studies have shown good outcomes for patients with mild disease, other reports have demonstrated that AHI alone is an unreliable predictor of UPPP outcome. Furthermore, some conflicting reports have shown that patients with severe diseases achieve better UPPP outcomes than do those with mild diseases.[7,8]

These conflicting reports have resulted in the development of an anatomy-based staging system with the goal of improving patient selection for UPPP. For instance, Friedman et al developed an anatomic staging system based on palate position, tonsil size, and body mass index (BMI) to classify patients into 1 of 3 stages.[3] Their clinical data showed that patients with stage I classification

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achieved an 80% success rate, those with stage II attained a 40% success rate, and the success rate for patients with a stage III classification was only 8%.[9] A previous report by the authors of this study obtained similar results, with UPPP success rates declining sharply for patients with unfavorable oropharyngeal anatomies.[10] However, few studies have compared the differences in success rates of UPPP using different staging systems to classify disease in patients with OSAHS. This study applied anatomy-based and severity-based staging systems to assess UPPP success rates and investigate their utility for patient selection.

MATERIALS AND METHODS

Study Population

In total, 110 consecutive patients (105 men and 5 women, age range, 21-61 years; mean age, 42.8 ± 9.4 years) were prospectively enrolled and underwent UPPP surgery for OSAHS. All subjects had been physician- or self-referred to the sleep clinic at Chang Gung Memorial Hospital due to habitual snoring, excessive daytime sleepiness, and other symptoms related to OSAHS. All patients underwent an otolaryngologic examination, the results of which were suggestive of the patients having a narrowed retropalatal space. A detailed explanation of the study and UPPP procedures, including success rate, complications, and alternatives was provided, and written informed consent was obtained. The study was approved by the ethics committee of the department of otolaryngology, Chang Gung Memorial Hospital. Patients received postoperative follow-up care for at least 1 year.

Anatomy-Based Staging System

Patients were asked to open their mouths widely without protruding their tongues or phonating. This procedure was repeated several times to allow the observer to select the most accurate grade reflecting the relationship between the tongue and palate. No intrarater or interrater reliability analyses were performed on the anatomic staging. However, a single observer (Dr. Li) rated all patients using the same criteria to avoid confounding factors from different observers. The Friedman[11] tongue position (FTP) grades I to IV were defined as follows: Grade I, the entire uvula and tonsils or pillars are clearly visible; Grade II, the uvula and not the tonsils are visible; Grade III, only the soft palate is visible; and, Grade IV, only the hard palate is visible. (Patients with higher FTP grades have narrower oropharyngeal inlets).Tonsil size was classified into the following 5 grades (0–IV): Grade 0, patient had a previous tonsillectomy; Grade I, tonsils are hidden in the tonsillar fossa; Grade II, tonsils extend to the pillars; Grade III, tonsils extend beyond the pillars and short of the midline; and Grade IV, tonsils, also known as "kissing tonsils," extend to the midline. (Patients with higher tonsil grades have narrower oropharyngeal inlets). Patient BMI was calculated as weight (in kg) divided by height (in m^2). Significant craniofacial or other anatomic deformities were recorded. All patients were assigned a stage (I-IV) based on morphologic findings. Table 1 presents the detailed staging system.

Polysomnography and Severity-based Staging System

Overnight polysomnography (PSG) (Nicolet UltraSom System, Madison, WI) was performed using techniques previously described[1] to document sleep and breathing for each patient before and approximately 1 year following surgery. The PSG studies were manually scored by the pulmonologist (Dr. Chen), who was blinded to the status of the patients. The AHI was defined as the total number of apnea and hypopnea episodes per hour of sleep; apnea was defined as a 10-second breathing pause, and hypopnea as a 10-second event during which breathing continued and the nasal pressure or thoracoabdominal movement was reduced by at least 50% from baseline.[1] Patients were categorized as having mild (AHI<15), moderate (AHI, 15–29), moderate-severe (AHI, 30-59), or severe (AHI≥60) disease and placed in respective groups.

Table 1—Anatomy-Based Staging System[a] for Patients With Obstructive Sleep Apnea/Hypopnea Syndrome

Stage	FTP	Tonsil size	BMI
I	1	3,4	< 40
	2	3,4	
II	1,2	0,1,2	
	3,4	3,4	< 40
III	3	0,1,2	< 40
	4	0,1,2	< 40
IV[b]	1,2,3,4	0,1,2,3,4	> 40

[a]After Friedman et al. Staging of obstructive sleep apnea/hypopnea syndrome: a guide to appropriate treatment. Laryngoscope 2004;114:454-9.
[b]All patients in Stage IV had significant craniofacial or other anatomic deformities.
FTP refers to Friedman tongue position; BMI; body mass index (kg/m^2).

Surgical Technique

All UPPP surgeries were performed under general anesthesia. Detailed surgical procedures are described elsewhere.[12] Briefly, the operation utilizes the following principal steps: bilateral tonsillectomy, removal of supratonsillar adipose tissue, box-shaped incision of the soft palate, dissection and stripping of the submucosal adipose tissue, development of a uvulopalatal flap, imbricating and suturing the flap to soft palate, closure of the tonsillar fossa, and maximized lateralization of the posterior pillar.

Statistical Analysis

The Wilcoxon signed-rank test was applied to compare preoperative and postoperative AHI at different stages. One-way analysis of variance was used to compare differences in AHI changes among patients with different stages. Surgical success was defined as a 50% or greater reduction of preoperative AHI and a postoperative AHI of less than 20 per hour. Success rates for different stages (both anatomy-based and severity-based) were compared using the Fisher exact test.

The Spearman correlation coefficient was employed to assess the associations between AHI changes and major components (FTP, tonsil size, and BMI) of the anatomy-based staging system. Multilevel logistic regression analysis was applied to investigate significance of independent variables—age, sex, BMI, severity-based staging, FTP, and tonsil size—in predicting surgical success. FTP and tonsil size are considered being incremental in the logistic regression model. The odds ratios are the relative odds for success, as compared with patients who have disease severity of 1

Table 2—Distribution of Anatomy-Based Staging System in 110 Patients With OSAHS

Grade	0	I	II	III	IV
FTP	NA	11	44	34	21
Tonsil Size	2	61	34	11	2
Stage	NA	5	55	40	10

OSAHS refers to obstructive sleep apnea-hypopnea syndrome; FTP, Friedman tongue position; NA, not available.

Table 3—Changes in AHI following UPPP Surgery in Patients Classified With the Anatomy-Based Staging System

Stage	Preop AHI	Postop AHI	Change of AHI	p Value[a]
I (n = 5)	35.5 ± 31.4	2.1 ± 2.1	-33.4 ± 30.5	.07
II (n = 55)	33.9 ± 28.6	6.2 ± 7.1	-27.8 ± 27.1	< .001
III (n = 40)	57.4 ± 22.7	21.3 ± 24.9	-36.1 ± 30.3	< .001
IV (n = 10)	54.5 ± 29.3	45.5 ± 26.8	-8.9 ± 36.3	.45

AHI refers to apnea-hypopnea index, the number of events/h.; UPPP, uvulopalatopharyngoplasty; Preop, preoperative; Postop, postoperative.
[a]Wilcoxon signed-rank test

grade less in given independent variables.

Continuous data are presented as mean ± standard deviation. A value of $p < .05$ was considered statistically significant.

RESULTS

Study Population

The mean age of the 105 men and 5 women was 43 ± 10 years (range, 21-61 years). All patients (110/110) completed follow-up. The mean preoperative AHI was 44.4 ± 28.8 events per hour (range, 5.1–111 events/h). There were 5 (5%), 55 (50%), 40 (36%), and 10 (9%) patients in anatomy-based stages I, II, III, and IV, respectively. Twenty (18%) patients had mild (AHI <15), 26 (24%) had moderate (AHI 15–29), 26 (24%) had moderate-severe (AHI 30–59), and 38 (34%) had severe (AHI ≥60) OSAHS based on severity of sleep respiratory disturbance. No patient had a BMI higher than 40 kg/m^2. Retrognathia was the sole reason for stage IV classification. Retrognathia is defined as anterior prominence of the chin (soft tissue pogonion) less than 2 mm behind the vertical line from the vermilion border of lower lip to the chin.[13] Table 2 presents the distributions of morphologic indicators among different stages.

Changes to BMIs and AHIs

BMI changed insignificantly from 27.1 ± 3.3 to 26.8 ± 4.5 ($p = .45$). Overall postoperative AHI decrease was -29.4 ± 29.9 events per hour; the difference between before and after the operation was statistically significant ($p < .001$). The individual decreases for the AHI following UPPP were statistically significant for anatomy-based stages II and III ($p < .0001$). Decreases in the AHI were insignificant for patients with anatomy-based stage I ($p = .07$) and IV ($p = .45$) disease. However, the degrees of AHI improvement were not significantly different among patients with different severity-based stages ($p = .07$). Table 3 presents AHI changes following UPPP surgery.

Table 4—Success Rates for Uvulopalatopharyngoplasty by Anatomy- and Severity-Based Staging Systems

Anatomy-based or severity-based stages	Success (%)	Failure (%)
I (n = 5)	5 (100)	0 (0)
II (n = 55)	53 (96)	2 (4)
III (n = 40)	26 (65)	14 (35)
IV (n = 10)	2 (20)	8 (80)
Mild (n = 20)	18 (90)	2 (10)
Moderate (n = 26)	19 (73)	7 (27)
Moderate-severe (n = 26)	21 (81)	5 (19)
Severe (n = 38)	28(74)	10 (26)
All (n = 110)	86 (78)	24 (22)

Table 5—Cross-tabulation of UPPP Outcome: Anatomy-Based Stages Versus Severity-Based Stages

Severity-based Anatomy-based	Mild (success / failure)	Moderate (success / failure)	Moderate-severe (success / failure)	Severe (success / failure)	Total (success / failure)
I	1 / 0	2 / 0	1 / 0	1 / 0	5 / 0
II	17 / 1	15 / 1	10 / 0	11 / 0	53 / 2
III	0 / 1	2 / 4	9 / 2	15 / 7	26 / 14
IV	0 / 0	0 / 2	1 / 3	1 / 3	2 / 8
Total	20	26	26	38	110

UPPP, uvulopalatopharyngoplasty

Success Rates

The overall success rate of UPPP was 78%. A significant trend existed for success rates among patients with different anatomy-based stages; patients with mild anatomic grading had significantly better success rates than those with severe anatomic grading ($p < .001$). However, the success rates among different severity-based stages were not significantly different ($p = .10$). Table 4 shows the UPPP success rates for individual anatomy-based and severity-based stages.

Cross-tabulation of UPPP outcomes between anatomy-based and severity-based staging is displayed in Table 5. Figure 1 demonstrates that success rates declined as anatomy-based staging increased (I to IV) in all severity-based staging groups.

Correlations, Trends and Outcome Predictors

The correlation analysis demonstrated that FTP ($r = -0.33$, $p = .0004$) and tonsil size ($r = 0.37$, $p < .0001$), rather than baseline AHI ($r = -0.105$, $p = .273$), were significantly correlated with the chance of surgical success. Table 6 demonstrates the associations between morphologic indicators and changes of the AHI in various anatomy-based stages. Logistic-regression analyses indicated that FTP (odds ratio [OR] = 0.43, standard error [SE] = 0.13, $p = .005$, 95% confidence interval [CI] 0.24–0.78) and tonsil size (OR = 3.13, SE = 1.53, $p = .02$, 95% CI 1.20–8.17), but not severity-based staging (OR = 0.77, SE = 0.18, $p = .283$, 95% CI 0.49–1.23), were significantly predictive of surgical success.

DISCUSSION

Sher at al[4] obtained a UPPP success rate of only 41% in unselected patients with OSAHS, suggesting that UPPP only ben-

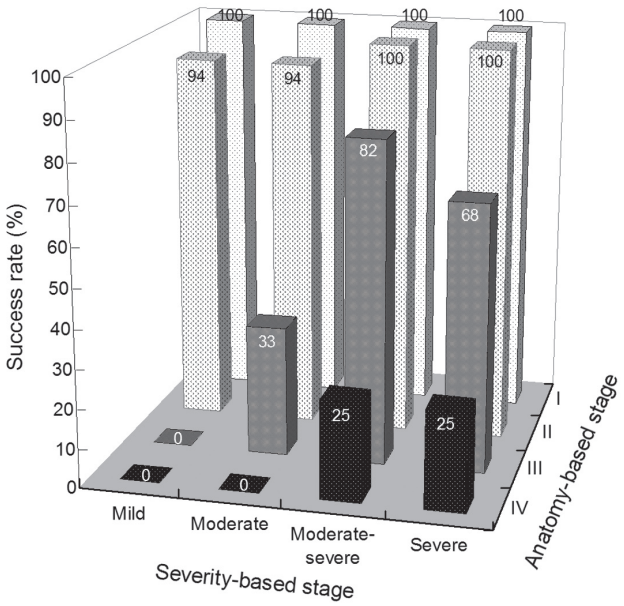

Figure 1—This figure demonstrates that success rates declined as anatomy-based staging increased (I to IV) in all severity-based staging groups.

efits specific patients and highlighting the importance of selecting appropriate candidates for UPPP to achieve good success rates. When determining treatment modality by disease severity (AHI), a traditional approach, only patients with mild to moderate disease were considered good candidates for UPPP. This perspective was based on the observation of a significant difference in mean AHI between responders and nonresponders.[4] Additionally, patients with mild to moderate disease achieved better surgical outcome with UPPP than did patients with severe disease.[14] However, AHI-based patient selection lacked sufficient consistency to increase the UPPP success rate. Researchers have found that patients with mild disease do not achieve better UPPP outcomes than do patients with severe disease.[15] Conversely, results of an observational study demonstrate that patients with severe disease may obtain UPPP outcomes superior to those for patients with mild disease.[7] Our data showed that, when using a severity-based staging system to categorize patients, the UPPP success rates for mild, moderate, moderate-severe, and severe disease are 90%, 73%, 81%, and 74%, respectively; no significant difference existed ($p = .10$) among success rates for these patient groups. The analytical results revealed that baseline AHI was not a determinant of UPPP success rates.

Logically, surgical outcome to correct an anomaly is likely more dependent on anatomy than on physiology. Friedman et al[3] proposed an anatomic staging system (grades I-III) based on tongue-palate position, tonsil size, and BMI. Once patients were classified, they achieved an 80% success rate for stage-I patients and 40% for stage-II patients. Stage-III patients obtained only an 8% success rate. The staging system was amended, and grade IV was added for patients with craniofacial deformities or a BMI greater than 40 kg/m^2. [11] Our analytic data in this study achieved UPPP success rates of 100%, 92.9%, 61.4%, and 20% for stages I, II, III, and IV, respectively. Significant differences ($p < .001$) of success rates existed among staging groups; patients with mild staging had the best success rates. Regression analyses confirmed that the staging system based on tongue-palate position and tonsil

Table 6—Associations Between Morphologic Indicators and Changes to the AHI as Classified by Anatomy-Based Stages

	Stage I	Stage II	Stage III	Stage IV	All
FTP	-0.53	-0.69[a]	-0.03	-0.25	-0.30[a]
Tonsil size	-0.91[a]	-0.63[a]	-0.29	-0.26	-0.42[a]
BMI	-0.08	-0.43[a]	0.12	0.34	-0.17

[a]Spearman correlation with $p < .05$
AHI refers to apnea-hypopnea index; FTP, Friedman tongue position; BMI, body mass index.

size, and not physiologic severity, is strongly predictive of UPPP outcomes. The OR of 0.43 for FTP shows that, when the oropharyngeal inlet becomes narrower, the chances of surgical success may decrease grade by grade. This indicates that tongue and palate positions can not be easily corrected by UPPP alone. To the contrary, patients with larger tonsils tend to improve significantly following UPPP. The chance of success (3.13 times) can increase grade by grade. Our results reveal that the anatomic staging, initially weighted to quantify features, is more likely to respond to UPPP outcome.

Cross-tabulation of UPPP outcomes between the anatomy- and severity-based staging systems suggested that patients with severe disease obtained a success rate of 100% for anatomy-based stages I and II, only 68% for anatomy-based stage III, and 33% for stage IV. Similar changes were demonstrated for patients with mild disease—a success rate of 100% was achieved for anatomy-based stage I, 94% for stage II, 33% for stage III, and 0% for stage IV patients. These decreasing success rates for severe anatomy-based stages were also noted in patients with moderate and moderate-severe diseases. This study clearly showed that UPPP outcome was more associated with anatomy than physiologic severity based on AHI. Notably, even patients with severe disease and favorable anatomic stages can obtain good outcomes from UPPP. However, patients with mild disease and unfavorable anatomic staging will likely obtain a poor UPPP outcome.

Stage IV, in the amended anatomy-based staging system, comprises patients with severe morbid obesity (BMI > 40 kg/m^2) or with significant skeletal deformities. In this study, no patient had a BMI greater than 40 kg/m^2; retrognathia was the sole reason for classifying patients as stage IV. The UPPP success rate for stage IV patients was only 20%. Retrospective data imply that narrow retroglossal space, in patients with retrognathia and confined framework, could not be enlarged via UPPP surgery. Direct skeletal surgery, such as maxillary mandibular advancement, is suggested for these patients to improve airway lumen and appearance. Additionally, the relatively lower success rate (65%) for patients with anatomy-based stage III suggests that these patients likely need further surgery on the tongue base or hypopharynx, rather than on the uvulopalatal complex alone. The significant decreases in the success rate in stage III and IV suggest that the weighting system should be applied to provide lower weights to soft- palate and tonsillar abnormalities and higher weights to tongue-base and craniofacial anomalies.

Regardless of baseline AHI, overall reduction in sleep-apnea events was statistically significant ($p < .001$) in this study cohort. Analytic results also demonstrate that improvements to AHI were significantly correlated with clinical predictors; associations were particularly strong for stage II patients. The relatively small

sample size of stage I (n = 5) patients likely explains why the significance between improvements in AHI and clinical predictors in this group were not obvious. For stage III and IV patients, UPPP did not resolve oropharyngeal narrowing caused by the tongue-base problem. Analytic results further provide evidence that enlargement of a narrowed oropharynx in patients with morphologically moderate OSAHS can reduce the incidence of sleep-apnea events.

Preoperative BMI was presumed to be capable of predicting OSAHS surgical outcomes.[16] However, this study demonstrated that baseline BMI did not correlate with overall and stage changes in AHI in patients who underwent UPPP surgery. This finding suggests that local morphologic factors, such as FTP and tonsil size, are likely better UPPP outcome predictors than is BMI.

Notably redundant postpharyngeal walls were identified in 89% (25/28) of patients with severe disease who responded well to UPPP; conversely, no patients with severe disease who had a poor response to UPPP had redundant postpharyngeal walls. We presume that redundant postpharyngeal walls are more compliant to lateralization and lead to a further widening of lateral retropalatal space that is reportedly associated with OSAHS severity.[17] This clinical finding suggests that redundant postpharyngeal walls may be a sign for good UPPP outcome; however, further study is required to confirm this hypothesis.

The study was limited in generalization due to small numbers of women. We presume that the disparity in sex exists widely in Asian ethnicity. However, enrollment of an adequate number of women may provide more generic data for further analysis.

CONCLUSION

Proper patient selection is essential to UPPP success. This study provides clinical evidence indicating that an anatomy-based staging system is a more reasonable measure than is a severity-based staging system in predicting UPPP outcomes. We suggest that surgeons should rely on anatomic findings when choosing candidates suited to UPPP.

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