Efficacy, predictors of success and failure of an updated lateral pharyngoplasty approach as an independent procedure in treating obstructive sleep apnea with CPAP failures

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Abstract

Purpose To assess predictors of success and failure of an updated lateral pharyngoplasty as an independent procedure in treating obstructive sleep apnea with CPAP failures.

Methods Forty-six patients with known OSAS who were resistant to CPAP or failures were included. BMI, Stop-Bang score, and sleep study data were recorded before and after the updated Cahali pharyngoplasty procedure. Pre-operative DISE was done for all cases; however, postoperative DISE was done only for non-responders.

Results Successful operation outcomes achieved in 69.6% (32 cases) and 30.4% (14 cases) were failure rates. Postoperative snoring index, Stop Bang score, and AHI were significantly decreased compared to pre-operative data (p value < 0.001). There is statistically a significant increase in minimal and baseline SpO_2 postoperatively (p value < 0.001). Patients with no laryngeal collapse (L0) predict operation success. However, patients with high pre-operative snoring index, collapse at lateral wall hypopharynx, high tongue collapse, laryngeal collapse, tongue palate interaction, and low grades tonsils (1, 2) predict the failure of the surgery (p value $= 0.006^*, 0.024^*, 0.047^*$, respectively).

Conclusion Updated Cahali lateral pharyngoplasty could not be used as an independent procedure in all OSA patients. The lack of laryngeal collapse (L0) is a considerable success predictor for the procedure. However, the pre-operative low-grade tonsils (1, 2) and high snoring index predict operation failure.

Keywords Obstructive sleep apnea · Lateral pharyngoplasty · CPAP failure · Sleep study · Polysomnography

Introduction

Obstructive sleep apnea (OSA) is a major subgroup of sleep apnea distinguished by repetitive episodes of upper airway partial or total collapse despite the effort to breathe during sleep and is accompanied by a reduction in blood oxygen [1].

Severe sleep apnea patients had an increased risk for many systemic diseases as coronary artery disease, diabetes mellitus, and stroke [2]. A sleep study (polysomnography) is considered now as the "gold-standard" of diagnosis of obstructive sleep apnea and its degree [3].

The prevalence of OSA varies depending on the definition of hypopneas. Utilizing the traditional definition, hypopnea necessitates a 4% reduction in oxygen saturation of the blood. A cohort sleep study by Wisconsin approximated that 17.4% of ladies versus 33.9% of men in the united states aged 30–70 suffered from mild OSA (AHI of 5–14.9) [4].

People suffered from OSA are associated with a narrow upper airway, usually caused by parapharyngeal fat pads and pharyngeal muscles fat deposition or craniofacial structure abnormalities [5].

Many treatment options for obstructive sleep apneas syndrome (OSA) are obtainable, ranging from non-invasive

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behavioral modification to continuous positive airway pressure (CPAP) devices to surgical procedures. Patient selection for these therapies is a complex process due to variability in anatomy and physiology in every patient, patient preference, the severity of the disease, and controversy about the adequacy of the treatments accessible for the patients [3].

Lateral pharyngoplasty (LP) was introduced in 2003 by Cahali [6], and since then, it was updated several times [7–12] till it came to the updated Cahali lateral pharyngoplasty technique [13].

Cahali suggested that his updated lateral pharyngoplasty approach would benefit all OSA patients regardless of the sleep endoscopy results. The soft palate, tongue, and the thickness of the posterior tonsillar pillar are not selection factors [13].

Up till now, he has discovered no motivation to accept that the area or pattern of obstruction shown in drug-induced sleep endoscopies would better indicate or contraindicates this technique [13].

This proposition is against the current management plan, which recommends that a surgical treatment plan is made according to the obstruction site(s) [14].

This study intends to assess predictors of success and failure of an updated lateral pharyngoplasty as an independent procedure in treating obstructive sleep apnea with CPAP failures.

Materials and methods

This research examined 46 patients who suffered from OSAS with CPAP failures; it included 25 males (54.3%) and 21 females (45.7%) with ages ranging between 25 and 54. This research was carried out in Kafrelsheikh and Mansoura university hospitals from December 2018 to March 2020 and approved by Kafrelsheikh University Hospital ethical committee; explanation and informed written consent for this research has been endorsed from all patients.

Inclusion criteria

Adult patients > 18 years, general anesthesia fitness, obstructive sleep apneas syndrome patients confirmed and graded by polysomnography, CPAP failures patients with no history of sleep surgery.

Exclusion criteria

Young patients < 18 years, general anesthesia unfitness, patients with a past history of palatal surgery, e.g., Uvulopalatopharyngoplasty, morbid obesity, the presence of uncontrolled hypothyroidism, and considerable craniofacial abnormalities, e.g., Down syndrome, micrognathia, and retrognathia.

Evaluation

Every patient has been assessed by history with concern to sleep history utilizing the Stop Bang score. A thorough general examination is carried, with concern to BMI, neck circumference. ENT examination is carried for a deviated septum, hypertrophied turbinates, or any nasal masses; evaluation of the oral cavity for tongue, uvula, tonsils sizes, and Friedman's tongue position. Brodsky grading scale was utilized to grade the tonsils into five grades: grade 0 (tonsils inside the tonsillar fossa), grade 1 (tonsils only outside of the tonsillar fossa and involve ≤ 25% of the oropharyngeal width), grade 2 (tonsils involve 26–50% of the oropharyngeal width), grade 3 (tonsils involve 5–75% of the oropharyngeal width), and grade 4 (tonsils involve > 75% of the oropharyngeal width) [15].

Polysomnography

Patients had a pre-operative and 6 months postoperative polysomnography utilizing (SOMNOscreen™ plus, USA) device to diagnose and grade the severity of OSAS. Apnea was characterized by airflow cessation for at least 10 s at the nostril and mouth, while hypopnea was characterized by a 30% or more reduction in oro-nasal airflow for at least 10 s with > 4% decline in baseline oxyhemoglobin saturation. Apnea–hypopnea index (AHI) is calculated by summation of apneas and hypopneas that occur in 1 h of sleep [16]. According to AHI, the OSA was graded to; mild: AHI = 5–15/hour, moderate: AHI = 15–30/hour, and severe: AHI > 30/hour.

Drug-induced sleep endoscopy (DISE)

Drug-induced sleep endoscopy (DISE) was performed in anesthetized patients with obstructive sleep apneas as a procedure of choice for analyzing the anatomic and dynamic areas of collapsibility prior to surgery [17]. Observation of the lateral pharyngeal wall, soft palate, tongue base, and larynx for anatomical and dynamic collapsible regions [18, 19], then lateral pharyngeal wall, palate, tongue, and larynx (LwPTL) grading system was utilized to classify the level of obstruction in our patients [19].

Surgical technique

Updated lateral pharyngoplasty by Dr. Cahali was done to our study patients independent of the sleep endoscopy results. The procedure began with bilateral tonsillectomy under general anesthesia; however, if previously performed, the tonsillar fossa mucosa was eliminated to distinguish the palatoglossus and palatopharyngeus muscles. The Brodsky grading scale was utilized to assess tonsil size, and none of our cases had a grade of 0, so tonsillectomy was performed for all cases. An upside-down 'V-shape' incision of mucosa and muscle of the oral lateral free margin of the soft palate and anterior pillar was eliminated [13]. A monopolar cautery and sharp dissection undermined the palatopharyngeus muscle (cranial half) from the superior pharyngeal constrictor muscle (SPC) until we reached the buccopharyngeal fascia (Fig. 1).

Stitch (3–0 monofilament absorbable suture) was inserted at the palatopharyngeus muscle at its lower end, where SPC is still linked there. A long Hartman nasal dressing forceps was utilized to undermine and elevate the caudal part of the SPC from the buccopharyngeal fascia medially within the tonsillar fossa to enlarge the retropalatal segment, then cut and cauterize the SPC vertically till the posterior pillar arch (less than 1 cm), then stitch the palatopharyngeus flap to the anterior pillar utilizing three to four separated 3–0 absorbable monofilament, vertical mattress stitches, with attention to that the higher the stitching place for the flap, the more anteriorly soft palate will be pulled (Fig. 2a,b,c) [13, 20]**.**

Finally, the wound's margins might be everted and stitched by simple interrupted stitches of absorbable 3–0 monofilament type close to the uvula. A vertical loosening incision in the posterior pharyngeal wall's mucosa is done medial to the flap from the soft palate's free edge until it meets the first relaxing incision, complete the separation of the flap from the pharynx.

All the procedure steps should be repeated on the opposite side. Extubation should be delayed till the patients are fully awake with good muscle tone. The patients should be checked for 1–2 h in the recovery room before setting off to the ward. The surgical procedure should be assessed for: duration of surgery, the incidence of bleeding, and other complications, duration of hospital stay, and postoperative complications [13, 20].

The most recent strategy's primary changes were planned to avoid extending the pharyngeal mucosa, increase retropalatal space, and splint the upper lateral pharyngeal wall with mucosal palatopharyngeus flap [13]. It contrasts with ordinary Cahali lateral pharyngoplasty, which relies principally on the laterally based flap of superior constrictor muscle stitched anteriorly to the palatoglossus muscle by four or five separate stitches [21].

Fig. 1 The division of the palatopharyngeus from the superior pharyngeal constrictor muscle (SPC)
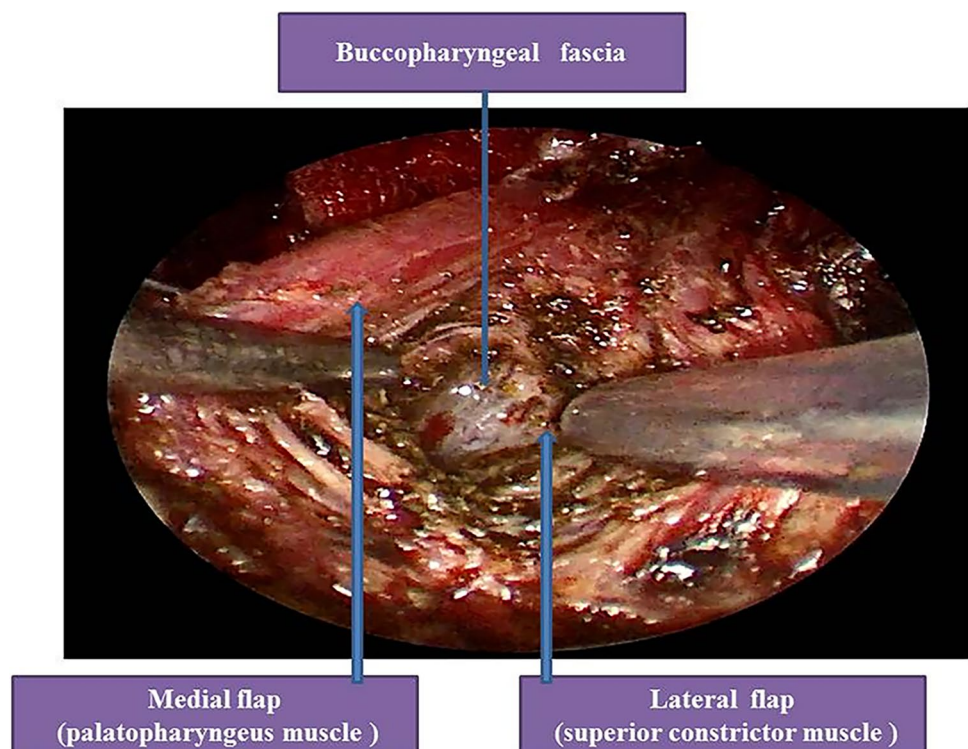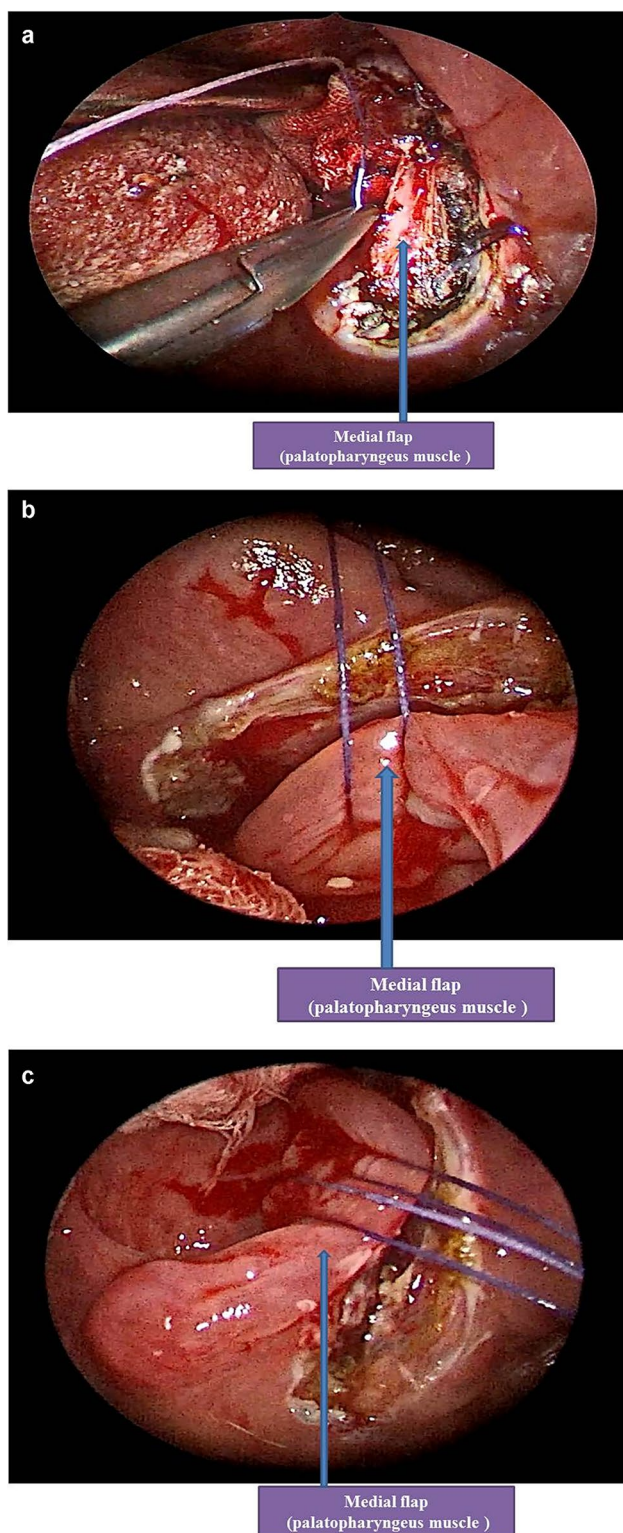
Fig. 2 Suturing the palatopharyngeus flap to the anterior pillar **a**, **b**. However, we do not fix those stitches until the next step, which is the cross-cutting of the palatopharyngeus muscle, comprise its pharyngeal mucosa, at the caudal portion of the flap, which acts for the first relaxed incision **c** next; we tie those sutures just tightly enough to oppose the edges

Follow-up

All patients were postoperatively checked at 1 week, 2 weeks, 1 month, and 6 months as outpatient visits to assess complications and manifestation relief. In addition, 6 months postoperatively, polysomnography was performed to report the AHI and other respiratory parameters to compare it to the pre-operative data. ***Sher's success standards*** were utilized to define the surgical success; 50% reduction of the pre-operative AHI and AHI < 20 events/h. The surgical cure was reported if AHI became < 5 events/h postoperatively [22]. Six months after surgery, drug-induced sleep endoscopy (DISE) was repeated for failed cases to evaluate the pattern and level of obstruction and correlate as a predictor of failure for the procedure.

Statistical analysis

Data analysis was performed using the software SPSS (Statistical Package for the Social Sciences) version 20. Quantitative variables were described using their means and standard deviations. Categorical variables were described using their absolute frequencies and were compared using the Chi-squared test and the Fisher's exact test when appropriate. Kolmogorov–Smirnov (distribution-type) and Levene (homogeneity of variances) tests were used to verify assumptions for use in parametric tests. An independent sample *t* test (used with normally distributed data) was used to compare two groups' means. The Wilcoxon signed-rank test was used to compare the same group medians at two points of time (when data is not normally distributed). To compare the means of quantitative normally distributed variables for the same group at two points of time, a paired sample *t* test was used. Binary logistic regression was used to predict the odds of being a case based on the independent variables' values (predictors). The level of statistical significance was set at 5% ($p < 0.05$). A highly significant difference was present if $p \leq 0.001$.

Results

The research assessed 46 patients with obstructive sleep apneas syndrome with CPAP failure performed updated lateral pharynogoplasty; 25 males (54.3%) and 21 females (45.7%) and aged 25–54 with a mean 39.04 ± 6.802. All patients' pre-operative clinical parameters as BMI, Stop Bang, AHI, snoring index, minimal SpO_2, and baseline SpO_2 were announced in the Table 1. Drug-induced sleep endoscopy (DISE score) for all study patients were announced in Table 2.

The results of the study based on ***Sher's success criteria*** [22] (a decrease of the AHI by 50% and AHI < 20), that the

Table 1 Pre-operative and postoperative clinical variables of the patients

Parameter	Pre-operative N=46	Postoperative N=46	Wx/t	p value
Stop Bang				
Median	4	2	− 5.605	<0.001**
Range	2–7	0–6		
AHI*				
Mean ± SD	34.05 ± 12.38	16.6 ± 9.28	16.225	<0.001**
Range	12–63.1	3.2–41		
Snoring index				
Mean ± SD	157.74 ± 35.293	82.65 ± 33.35	21.858	<0.001**
Range	70–213	43–170		
Minimal SPO$_2$			− 15.935	<0.001**
Mean ± SD	78.8 ± 5.68	87.72 ± 3.87		
Range	69–91	77–94		
Baseline SPO$_2$			− 4.165	<0.001**
Mean ± SD	96.2 ± 0.91	96.54 ± 0.94		
Range	95– 98	95–98		

*AHI apnea–hypopnea index, Wx Wilcoxon signed-rank test, t paired sample t test

**p ≤ 0.001 is statistically significant

Table 2 The relation between DISE findings and their impact on improvement

DISE lateral wall-collapse	Total frequency	Successful (n=32) Frequency (%)	Failed (n=14) Frequency (%)	χ^2	p value
LV	35 (76.1%)	26 (81.2%)	9 (64.3%)	1.54	0.215
LH	4 (8.7%)	0 (0%)	4 (28.6%)	Fisher	0.006*
LS	5 (10.9%)	4 (12.5%)	1 (7.1%)	Fisher	>0.999
LW0	2 (4.3%)	2 (6.2%)	0 (0%)	Fisher	>0.999
PHL	2 (4.3%)	1 (3.1%)	1 (7.1%)	Fisher	0.521
PL	27 (58.7%)	21 (65.6%)	6 (42.9%)	2.082	0.149
P0	17 (37%)	10 (31.3%)	7 (50%)	1.47	0.225
TH	4 (8.7%)	0 (0%)	4 (28.6%)	Fisher	0.006*
TL	3 (6.5%)	3 (9.4%)	0 (0%)	Fisher	0.543
T0	39 (84.8%)	29 (90.6%)	10 (71.4%)	Fisher	0.176
L0	43 (93.5%)	32 (100%)	11 (78.6%)	Fisher	0.024*
L1	3 (6.5%)	0 (0%)	3 (21.4%)	Fisher	0.024*
TP interaction	3 (6.5%)	0 (0%)	3 (21.4%)	Fisher	0.024*

LS lateral wall at salpingopharyngeal folds, LV lateral wall at the velum, LH (lateral wall at hypopharynx), Lw0 no collapse at the lateral wall, PH (high palate collapse) vertical palate, PL palate collapse oblique palate, P0 no palatal collapse, TH high tongue base collapse, TL low tongue base collapse, T0 no tongue collapse, L1 laryngeal collapse, L0 no laryngeal collapse, TP interaction tongue palate interaction, χ^2 Chi-squared test

*p < 0.05 is statistically significant

success rate was 69.6% (32 cases) and 30.4% failure rate (14 cases) while 19.6% (nine patients) was a cure rate (AHI < 5 events/h).

There is statistically a significant increase in minimal and baseline SpO$_2$ postoperatively (pre-operative minimal SpO$_2$ increased from 78.8 to 87.72%, and pre-operative baseline SpO$_2$ increased from 96.2 to 96.54%). There is a statistically significant decline in the snoring index from 157.74 to 82.65. Similarly, there is a statistically significant decrease in the apnea–hypopnea index from 34.05 to 16.6. There is a statistically significant decrease in the stop bang index (median decreased from 4 to 2) Table 1.

In this study, surveying the relationship between DISE results and their effect on operation results announced that patients with lateral wall hypopharynx collapse, high tongue, laryngeal collapse, and tongue palate interaction

considerably predict failure of the surgery (p value $= 0.022$). In comparison, the absence of laryngeal collapse (L0) predicts a successful operation results Table 2.

There is a statistically significant relation between outcome and pre-operative snoring index, minimal SpO_2, baseline SpO_2, AHI, and Stop Bang score. Failure is associated with a higher pre-operative snoring index, AHI, and Stop Bang score. It is also associated with lower minimal and baseline SpO_2. There is a statistically significant association between outcome and OSA grades. Severe degrees were associated with failure. There is a statistically non-significant relation between outcome and age, BMI, operation time, or complications Table 3.

Multivariate analysis of factors associated with operation failure among the studied patients by binary logistic

Table 4 Multivariate analysis of factors associated with operation failure among the studied patients

	β	p	AOR	95% CI	
				Lower	Upper
Snoring index pre	0.135	0.008*	1.145	1.035	1.265
Minimal SpO_2 pre	0.483	0.050	1.622	1.000	2.629

AOR adjusted odds ratio, *CI* confidence interval

*$p < 0.05$ is statistically significant

Table 3 Comparing some pre-operative variables, operation time, and complications between success and failure groups

	Successful ($n = 32$) $N = 32$	Failed ($n = 14$) $N = 12$	T	p value
Age (year)			0.215	0.831
Mean $\pm$ SD	39.19 $\pm$ 6.67	38.71 $\pm$ 7.33		
Range	(25–52)	(29–54)		
BMI			1.507	0.139
Mean $\pm$ SD	30.89 $\pm$ 3.91	32.717 $\pm$ 3.67		
Range	(25–39.1)	(27–37.4)		
Stop Bang Pre			− 2.295	0.027*
Mean $\pm$ SD	3.81 $\pm$ 1.09	4.64 $\pm$ 1.22		
Range	(2–7)	(2–6)		
AHI pre			− 2.812	0.007*
Mean $\pm$ SD	30.89 $\pm$ 12.81	41.27 $\pm$ 9.78		
Range	(12–62.7)	(29–63.1)		
Snoring index			− 4.897	< 0.001**
Mean $\pm$ SD	145.84 $\pm$ 34.14	184.93 $\pm$ 19.72		
Range	(70–213)	(154–211)		
Min SpO_2			2.709	0.01*
Mean $\pm$ SD	80.0 $\pm$ 6.02	76.7 $\pm$ 3.69		
Range	(69–91)	(69–81)		
Baseline SpO_2			− 3.11	0.004*
Mean $\pm$ SD	96.44 $\pm$ 0.91	95.64 $\pm$ 0.63		
Range	(95–98)	(95–97)		
Operation time			1.326	0.192
Mean $\pm$ SD	42.66 $\pm$ 6.6	40.71 $\pm$ 3.32		
Range	(35–60)	(35–45)		
	Frequency (%)	Frequency (%)	χ^2	P value
Complications				
No	29 (90.6%)	14 (100%)	1.404	0.694
Bleeding	2 (6.2%)	0		
VPI	1 (3.1%)	0		
OSA degree				
Mild	3 (9.4%)	0 (0%)	4.526	0.033*
Moderate	11 (34.4%)	1 (7.1%)		
Severe	18 (56.2%)	11 (92.9%)		

regression showed that a higher snoring index and lower minimal SpO_2 increases the risk of operation failure by 1.145- and 1.622-folds, respectively Table 4.

There were no patients with the previous tonsillectomy enrolled in this study. However, there was a statistically significant positive relationship between tonsil grade and operation success, where success rate increase with high grades (3, 4). Comparing results of low grades (1, 2) and high grades (3, 4), we found that tonsil grades 1 and 2 increased the risk of failure of operation by 4.77-folds, Table 5.

Bleeding in two patients (4.3%) and velopharyngeal insufficiency (VPI) in one patient (2.22%) were announced as complications Table 3.

Discussion

The updated lateral pharyngoplasty procedure was performed for all patients independent of their sleep endoscopy results. Patients were always counseled about the availability of non-surgical option before proceeding to surgery, and we recommend surgery in case of CPAP refusal or failure as CPAP orientation is mandatory.

The results of the study based on *Sher's success criteria* [22] reported that the success rate was 69.6% (32 cases) and 30.4% failure rate (14 cases). The cure rate (19.6%) is low but taking in consideration that reaching AHI less than 5 as a cure rate is extremely difficult especially most of our cases were severe OSAS (more than 30 event/hour) which were 29 cases in our study, so we depend mainly on success criteria than cure rate [23, 26]. Park et al. [24] showed a surgical response in 11 of 12 patients (91.7%) in the lateral pharyngoplasty group, and eight out of 12 patients achieved success (66.7%). Mean AHI improved significantly from 36.3 ± 28.6 to 14.8 ± 17.9, reducing approximately 60%.

Even with higher grade tonsillar hypertrophy, we prefer to do lateral pharyngoplasty and not isolated tonsillectomy because the burden of isolated adult tonsillectomy remains a significant issue. Moreover, if velar collapse persisted after tonsillectomy dissection of the palatopharyngeus will be more difficult and less successful. Best chance is to operate upon a virgin lateral pharyngeal wall.

The procedure substantially decreases the Stop Bang score, AHI, and snoring index (p value < 0.001). Likewise, it substantially increases minimal SpO_2 and baseline SpO_2 dramatically (p value < 0.001), with significant postoperative AHI degree improvement. Cahali et al. [21] reported a substantial reduction of AHI with 60% of the patients over 50%, a reduction in AHI in contrast with pre-operative one where the median AHI decreased from 41.2 to 9.5. Likewise, Dizdar et al. [25] reported a significant reduction in the mean AHI from 23.4 to 11.3 postoperative to lateral pharyngoplasty ($p < 0.05$). Parameters such as RDI, lowest O_2 saturation, oxygen desaturation index (ODI), mean O_2 saturation, supine AHI, and ESS also significantly improved after surgery in Park et al.'s work [24].

Correlation of DISE results to the success of the operation, we found that lateral wall, tongue, and laryngeal collapses, significantly predict failure operation outcomes. However, the palatal collapse had no significant prediction in operation outcome. All patients with lateral wall-collapse at hypopharynx (LH) level, high tongue base (TH), laryngeal collapse (L1), and tongue palate interaction had failure outcomes. Although other levels had successful outcomes, they were not significant predictors.

Missale et al. [26] had a success rate of 89% with a cure rate of 20%. But, it depends on the criteria chosen, which influence the success rate, as they include patients with obstruction at the palatal or lateral pharyngeal wall, according to the NOHL classification. They excluded patients with complete base-tongue, hypopharyngeal, or laryngeal collapse.

A second DISE was repeated for failed cases; it showed that four patients still had persistent collapse at lateral wall hypopharynx; five patients still had high tongue base collapse; three patients still had a persistent laryngeal collapse; and two patients still had a palatal collapse. Postoperative DISE of cases showed the same findings except tongue palate interaction which showed a stiff palate with high tongue collapse, so the interaction seems to disappear, and they needed further procedure according to the level of collapse [19].

Green et al. [27] reported that any oropharyngeal lateral wall-collapse or obstruction was related to a 50% reduction in the surgery outcome's odds. Poorer results may be explained by non-easily handled oropharyngeal lateral walls in surgery.

Table 5 Relation between tonsil grade and operation success

Tonsil grade	Failure		Success		χ^2	p	COR (95% CI)
	$N=14$	(%)	$N=32$ (%)	(%)			
1 and 2	10	71.4%	11	34.4%	Fisher	0.027*	4.77 (1.21–18.78)
3 and 4	4	28.6%	21	65.6%			

COR crude odds ratio, *CI* confidence interval, χ^2 Chi-squared test

*$p < 0.05$ is statistically significant

In the Chi et al. [28] study, patients with moderate OSAS can be benefited more from lateral pharyngoplasty than those with severe OSAS. As in patients suffering from severe OSAS, the lateral pharyngeal space and the retroglossal space should be evaluated.

We performed transoral DISE to understand the tongue's role more deeply. We evaluated the degree of tongue retraction, interaction with the palate, and position from the oral cavity and the nasopharynx, highlighting a secondary anteroposterior soft palate collapse, due to the tongue position [29].

In this research, there were three successful cases with isolated lateral pharyngoplasty that had low tongue base collapse (6.5%) with an improvement of AHI, the usage of (LwPTL) classification could explain why we had only three successful cases with low tongue base collapse as we did not consider the partial collapse of a given structure favorable. Genta PR et al. [30] announced that no significant data of physiological meaning could be given for partial visual collapses. Likewise, Katsantonis et al. [31] had 4 (20%) cases of tongue collapse using VOTE classification.

So, the updated Cahali lateral pharyngoplasty technique could not be used as an independent procedure in all OSA patients. It can be used in most OSA patients except in patients who had a collapse of the lateral wall at the hypopharynx level (LH), high tongue base collapse (TH), laryngeal collapse (L1), and tongue palate interaction.

This study utilized a multivariate analysis of operation failure factors among the studied patients by binary logistic regression. This showed that a higher snoring index and lower minimal SpO_2 increase the risk of operation failure by 1.145- and 1.622-folds, respectively.

In this research, there were no patients with previous tonsillectomy enrolled in this study. However, there is a statistically significant positive relationship between tonsil grade and operation success (65.6% % success rate in grades 3, 4). Comparing results of low grades (1, 2) and high grades (3, 4), we found that tonsil grades 1 and 2 (low grades) increased the risk of failure of operation by 4.77-folds. These findings are only valid if tonsillectomy was a part of the procedure. Green et al. [27] did a univariate analysis and reported an increase in the odds of healing response ($p = 0.008$) with increasing tonsil size: 31% (32 of 102) with 0 tonsils, 41% (43 of 104) with 1 + tonsils, and 55% (38 of 69) with 2 + tonsils with no significant difference in surgical outcome in OSA severity subgroup ($p = 0.78$) or center ($p = 0.50$).

No significant intra-operative complications are documented. However, minimal postoperative complications were announced with no substantial long-term morbidity as; secondary hemorrhage in 2 (4.3%) patients and velopharyngeal insufficiency (VPI) in one (2.2%) patient. Park and his colleague's [24] announced postoperative hemorrhage in

9.8% (four cases) of the patients, which stopped spontaneously without intervention, but there were no complaints of VPI. Operative time ranged from 35 to 60 min.

Conclusions

The updated Cahali lateral pharyngoplasty technique could not be used as an independent procedure in all OSA patients. It can be used in most OSA patients except in the collapse of a lateral wall at the hypopharynx level (LH), high tongue base collapse (TH), laryngeal collapse (L1), and tongue palate interaction patients. The absence of laryngeal collapse (L0) is a significantly predict success of the procedure. The pre-operative high snoring index and low grades tonsils (1, 2) predict the surgery's failure.

Declarations

Conflict of interest There is no conflict of interest.

Ethical approval All procedures performed in this study involving human participants were in accordance with the ethical standards of the institutional research editorial boards and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Consent for publication Formal consent was signed by the patients to share and to publish their data in this research.

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