Received: 18 August 2021 | Revised: 9 December 2021 | Accepted: 11 December 2021

DOI: 10.1002/lio2.718

ORIGINAL RESEARCH

Laryngoscope Investigative Otolaryngology

Changes in laryngopharyngeal reflux after uvulopalatopharyngoplasty for obstructive sleep apnea: An observational study

Xiaojun Tang MM | Qinglai Tang MD | Shisheng Li MD | Xinming Yang MD | Ying Zhang MD | Shiying Zeng MM | Peiying Huang MM | Mengmeng Li MM

Department of Otolaryngology Head and Neck Surgery, The Second Xiangya Hospital, Central South University, Changsha, Hunan, China

Correspondence
Shisheng Li, Department of Otolaryngology Head and Neck Surgery, The Second Xiangya Hospital, Central South University, Changsha, Hunan 410000, China.
Email: lissdoctor@csu.edu.cn

Funding information
National Natural Science Foundation of China, Grant/Award Numbers: 81870711, 82002895

Abstract

Purpose: To estimate laryngopharyngeal reflux (LPR) changes after uvulopalatopharyngoplasty (UPPP) for obstructive sleep apnea (OSA) using the reflux symptom index (RSI) and reflux finding score (RFS) questionnaires.

Methods: A total of 91 participants were recruited and divided into three groups: control (n = 27), OSA mild to moderate (n = 29), and OSA severe (n = 35) groups according to polysomnography. All participants completed the preoperative RSI, and underwent blinded evaluation on videolaryngoscopy using the RFS questionnaire. Thirty-four OSA patients who underwent UPPP surgery completed postoperative polysomnography and questionnaires again after a 6-month follow-up.

Results: The RSI score and RFS were higher in patients with OSA than in those without OSA. Patients with severe OSA also had a higher RSI score and RFS than those with mild to moderate OSA. Apnea and hypopnea index degree and percentage of recording time for <90% oxygen saturation showed positive correlation with LPR symptoms. But the lowest blood oxygen saturation during the recording time was negatively correlated with LPR symptoms. The mean RSI score and RFS before UPPP surgery were 15.88 ± 4.85 and 13.18 ± 4.80, after surgery decreasing to 9.53 ± 4.16 and 8.65 ± 4.87, respectively (*P* <.05). In 25 patients where surgery was successful, RSI scores, RFSs and individual RSI variables decreased after surgery.

Conclusions: LPR symptoms are common among OSA patients, and the coexistence of OSA and LPR cannot be ignored. Successful UPPP surgery potentially reduces LPR symptoms and improves laryngoscopic signs by alleviating sleep respiratory disorders.

Level of Evidence: 3.

KEYWORDS
laryngopharyngeal reflux, obstructive sleep apnea, reflux finding score, reflux symptom index

1 | INTRODUCTION

Obstructive sleep apnea (OSA) is a growing health concern. Approximately 2%–4% of middle-aged people suffer from OSA.[1] OSA is characterized by repetitive collapse and reopening of the upper airway during sleep resulting in intermittent hypoxia and sleep fragmentation.[2] Intermittent hypoxia is a condition when apnea/hypopnea occurs, and oxygen supply to the blood is reduced. Intermittent hypoxia results in systemic inflammation and oxidative stress and may induce airway inflammation.[3] To alleviate this symptoms, continuous positive airway pressure (CPAP) or surgery are common treatments applied to OSA.

CPAP reduces reflux events and improves clinical symptoms of gastroesophageal reflux disease (GERD) and laryngopharyngeal reflux (LPR) in patients with OSA, like heartburn complaints.[4–6] As an effective and noninvasive treatment for OSA, CPAP maintains a certain positive pressure in the upper airway to improve upper airway collapse. Research has shown that CPAP decreases both GERD and LPR attacks by increasing esophageal internal pressure,[4,7] and reflex contraction of the lower esophageal sphincter (LES),[8] limiting reflux duration and reducing esophageal acidification. OSA and LPR are two conditions that cause chronic upper airway inflammation. In OSA patients, coexistence with LPR is very frequent, being found in 20%–67% of patients.[9,10] Although the association between OSA and LPR has been recently investigated, it still remains controversial. While some studies have demonstrated that CPAP treatment significantly improves reflux symptoms in OSA patients,[11] only few have investigated the effect of surgery treatment for OSA on reflux disease.

Uvulopalatopharyngoplasty (UPPP) is a widely accepted surgery for OSA[12] and first suggested by Fujita et al.[13] It has been recently improved[14] with the goal of reducing the oropharyngeal obstruction by eliminating redundant mucosal folds, hypertrophic tonsils, and an excessively thickened and elongated soft palate.[15] UPPP may relieve the severity of OSA in patients whose obstruction site is located at the palatopharyngeal level.

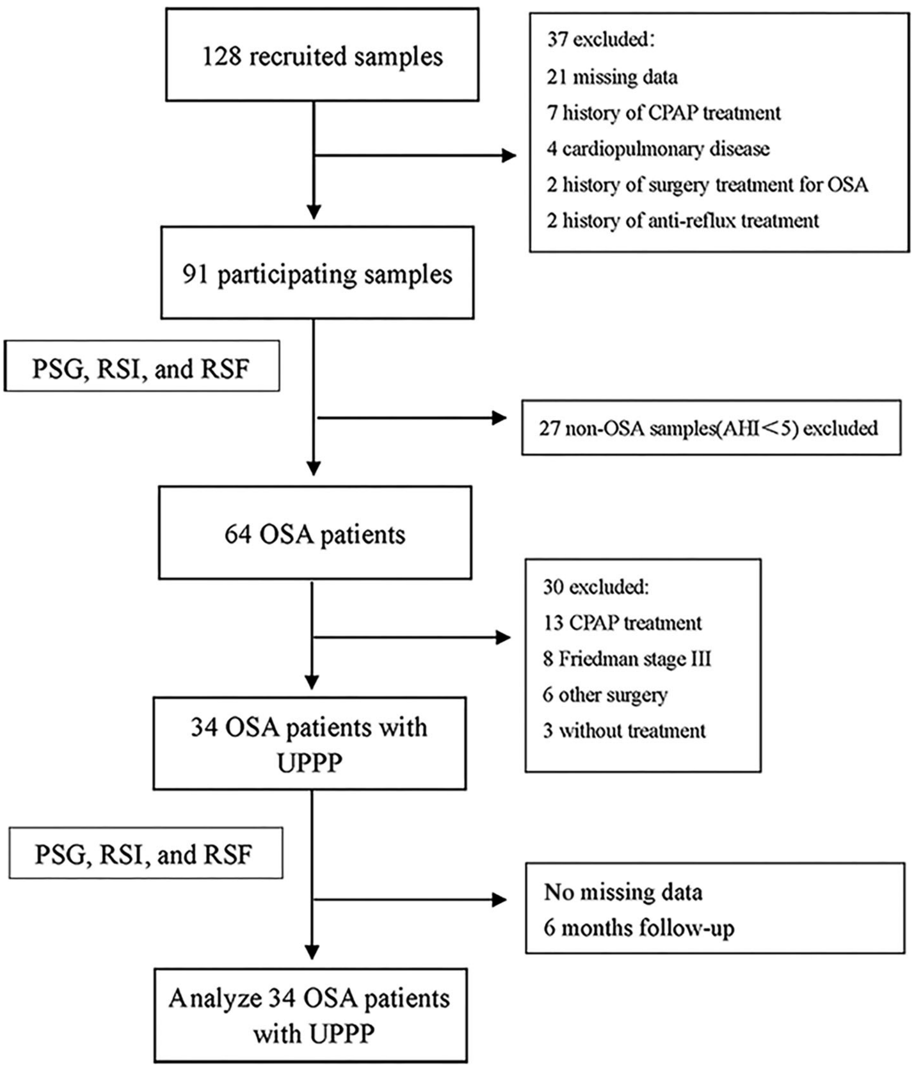

FIGURE 1 Flow diagram of participates. AHI, apnea hypopnea index; CPAP, continuous positive airway pressure; PSG, polysomnography; RFS, reflux finding score; RSI, reflux symptom index; UPPP, uvulopalatopharyngoplasty surgery

LPR is defined as gastric content reflux to the laryngopharynx; it is characterized by laryngeal mucosal inflammation and damage,[16] and a common disease in otolaryngology outpatient clinics.[9] Although 24 h pH monitoring is the gold standard for diagnosing LPR, the reflux symptom index (RSI) and reflux finding score (RFS) are more commonly used for routine clinical practice and to quantify the severity of LPR symptoms.[9,17]

The aim of this study was to evaluate the changes in LPR symptoms and signs after UPPP for OSA based on patients' responses to the RSI and RFS questionnaires.

2 | METHODS

2.1 | Procedure and participants

Adult participants were recruited from patients at the Sleep Laboratory of the Second Xiangya Hospital, Central South University, between January 2016 and January 2017. Of the 128 participants, 21 (16%) declined to participate and 16 (13%) were ineligible, leaving 91 (71%) participants in the present study. The study included patients newly diagnosed with OSA as confirmed by Polysomnography (PSG). Controls were selected among patients without OSA as confirmed by PSG. According to the Apnea and hypopnea index (AHI), participants were classified into non-OSA (AHI <5) and OSA group (AHI ≥5). The OSA group was assigned as follows: mild to moderate, AHI >5 and ≤30; or severe, AHI >30. Participants with OSA were diagnosed with LPR if both RSI scores >13 and RFS >7. The study design is shown in Figure 1.

The inclusion criteria were as follows: (1) clinical symptoms and signs compatible with clinical OSA suspicion,[18] (2) aged between 18 and 60 years, (3) no central sleep apnoea, (4) no disease of the nasal cavity and nasopharynx, (5) no history of taking anti-reflux drugs, and (6) provided informed consent. Clinical suspicion was defined as snoring and ≥1 of the following symptoms: witnessed apnoea, nonrestful sleep, or daytime sleepiness. Participants were excluded if they had NYHA grade IV heart failure, chronic renal failure (stage 4–5), degenerative cerebrovascular disease, or severe lung disease. The Epworth Sleepiness Scale (ESS) questionnaire, which is widely used to assess daytime sleepiness, was also completed by the patients at the same visit. Demographic data including sex, age, body mass index (BMI), AHI, minimum oxygen saturation, and oxygen saturation <90% were also obtained.

2.2 | Approval by the Human Research Ethics Committee

The study was approved by the ethics committee of the Second Xiangya Hospital, Central South University in China (LYF2020014), and all participants provided written informed consent.

2.3 | LPR assessment

LPR was defined as both the RSI score >13 and RFS >7.[19] The RSI was developed by Belafsky et al.[17] As a validated quality-of-life instrument, the RSI is a 9-item questionnaire administered to document the presence and severity of LPR characteristic signs and symptoms. It is a useful instrument in diagnosing LPR, along with other measures, such as that of the composite pH score, and for devising the appropriate potential therapies. The questionnaire included hoarseness, throat clearing, postnasal drip, swallowing difficulty, coughing, breathing difficulty, annoying cough, lump sensation, and heartburn. During the initial visit, all patients were asked to complete the RSI questionnaire to assess the severity of LPR-related symptoms. They were asked if they had a specific set of symptoms indicating LPR. Each item is scored from 0 (no problem) to 5 (severe problem), with a maximum score of 45. A score ≥13 was not normal and supported a diagnosis of LPR.

The RFS contains an 8-item clinical severity scale for judging laryngoscopy findings and is a useful tool to assess and follow-up LPR patients. To identify the most specific laryngoscopic signs of LPR, Belafsky et al.[16] developed the RFS based on the findings of video laryngoscopy. The laryngoscopic findings used for the diagnosis of LPR are nonspecific signs of laryngeal irritation and inflammation, including subglottic edema, ventricular obliteration, erythema, vocal fold edema, diffuse laryngeal edema, vocal fold edema, posterior commissure hypertrophy, granulation tissue, and thick endolaryngeal mucus. Laryngoscopy was reviewed by an otolaryngologist blinded to patient RSI and PSG information. They rated eight LPR-associated findings on a variably weighted scale from 0 to 4, and the results ranged from 0 (normal) to 26 (worst possible score). According to their analysis, a patient with a score ≥7 has LPR with 95% certainty.

TABLE 1 Initial characteristics of study participants

Characteristic	Controls (n = 27)	OSA (n = 64)	*P* value
Age (years)	43.85 ± 10.95	42.98 ± 10.21	.718
BMI (kg/m^2)	26.73 ± 3.74	27.19 ± 3.46	.576
AHI (events/h)	3.00 ± 1.20	34.62 ± 14.8	<.05
ESS	4.33 ± 1.88	11.31 ± 6.14	<.05
L-SpO$_2$ (%)	85.78 ± 3.70	70.16 ± 11.09	<.05
CT90 (%)	1.14 ± 1.51	29.29 ± 21.75	<.05
RSI	7.59 ± 4.70	13.70 ± 5.56	<.05
>13	n = 6	n = 33	<.05
≤13	n = 21	n = 31	
RFS	6.04 ± 3.55	10.45 ± 5.03	<.05
>7	n = 8	n = 43	<.05
≤7	n = 19	n = 21	

Note: Data are presented as median ± SD.
Abbreviations: AHI: apnea/hypopnea index; BMI: body mass index; CT90%: percentage of recording time when oxygen saturation of arterial blood<90%; ESS: Epworth Sleepiness Scale (range 0–24); L-SpO$_2$: lowest blood oxygen saturation during recording time; RFS: reflux finding score; RSI: reflux symptom index.

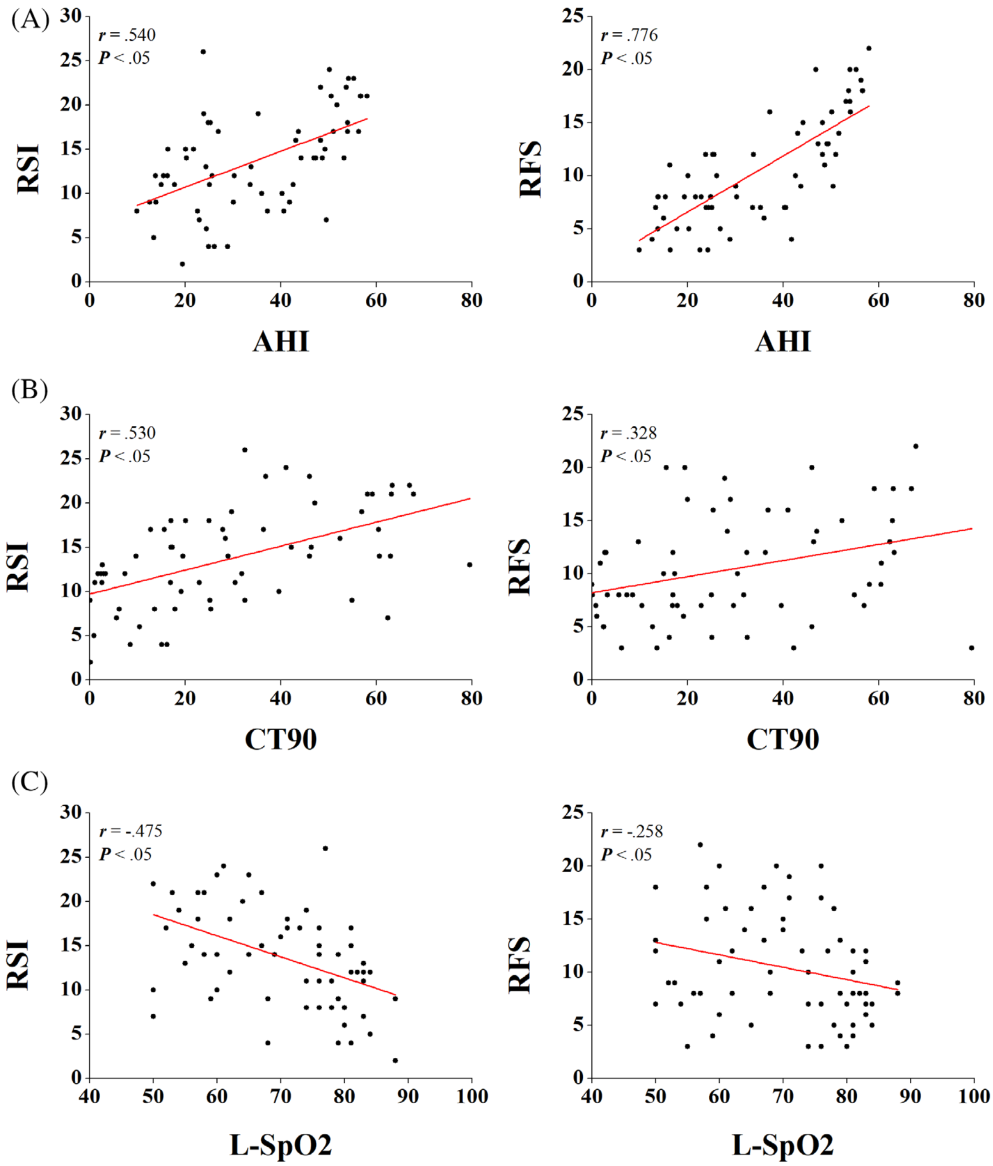

FIGURE 2 Correlation of laryngopharyngeal reflux and sleep parameters. AHI, apnea hypopnea index; CT90, percentage of recording time when oxygen saturation <90%; L-SpO_2, lowest SpO_2 during sleep; RFS, reflux finding score; RSI, reflux symptom index

TABLE 2 Reflux symptom index and reflux finding score between mild-moderate obstructive sleep apnea (OSA) and severe OSA patients before uvulopalatopharyngoplasty

	Mild-moderate OSA (n = 29)	Severe OSA (n = 35)	*P* value
RSI	11.34 ± 5.40	15.66 ± 4.96	<.05
>13	n = 9	n = 24	<.05
≤13	n = 20	n = 11	
RFS	7.07 ± 2.78	13.26 ± 4.75	<.05
>7	n = 14	n = 29	<.05
≤7	n = 15	n = 6	

Note: Data are presented as median ± SD.
Abbreviations: RFS: reflux finding score; RSI: reflux symptom index.

2.4 | UPPP surgery

UPPP relieves airway obstruction at the palate level by eliminating redundant mucosal folds, hypertrophic tonsils, and excessively thickened and elongated soft palates. We performed a revised UPPP with uvular preservation. Bilateral tonsillectomy was performed. Then, the redundant bilateral mucosa and submucosal tissue were resected to enlarge the oropharyngeal lumen. Two inverted U-shaped incisions were performed on the surface of the soft palate along both sides of the uvula. Mucosal membrane and surplus submembranous adipose tissue in the U-shaped incisions were removed. The soft palate length to remove was determined preoperatively according to the anatomy of the patient's pharynx and sleep apnoea severity. The incision was higher in severe patients and lower in mild patients. The dorsal surface of the soft palate was incised, and the levator palatini muscle and tensor palatini muscle were preserved. The dorsal and ventral margins of the preserved mucosal membrane of the uvula were closed with interrupted sutures forming a long new uvula. The new uvula was shortened when considered too long. The palatoglossal arch, the soft tissue of the tonsillar fossa, and the palatopharyngeal arch were also closed with interrupted sutures, thus enlarging the oropharyngeal cavity.

Patients who underwent UPPP surgery met the following inclusion criteria: (1) observed loud snoring, sleep apnoea, daytime sleepiness, and arousal from sleep; (2) AHI ≥5 events/hour of sleep (from PSG); (3) thickened and elongated soft palate; (4) Friedman stage I or II; (5) nonadherence with CPAP treatment or rejecting CPAP treatment. The exclusion criteria included (1) serious psychiatric, cardiopulmonary, or neurological disease or an American Society of Anesthesiologists (ASA) classification >3; (2) severe nasal congestion; (3) BMI≥40 kg/m^2; (3) history of surgical therapy for OSA (for example, tonsillectomy); (4) Friedman stage III; and (5) anti-reflux treatment before or after surgery. A surgeon (L. S. S.) performed all UPPP surgeries. Surgical success was defined as ≥50% reduction in preoperative AHI and a postoperative AHI <20 per hour.[20]

TABLE 3 Various factors before and after uvulopalatopharyngoplasty surgery

Characteristic	Before surgery	After surgery	*P* value
BMI (kg/m^2)	27.33 ± 3.98	26.64 ± 3.45	.370
AHI (events/h)	46.73 ± 8.00	19.94 ± 11.30	<.05
ESS	15.15 ± 5.29	9.59 ± 3.89	<.05
L-SpO$_2$ (%)	65.56 ± 10.16	81.28 ± 7.22	<.05
CT90 (%)	38.18 ± 19.70	11.65 ± 13.80	<.05
RSI	15.88 ± 4.85	9.53 ± 4.16	<.05
>13	n = 24	n = 6	<.05
≤13	n = 10	n = 28	
RFS	13.18 ± 4.80	8.65 ± 4.87	<.05
>7	n = 28	n = 11	<.05
≤7	n = 6	n = 23	

Note: Data are presented as median ± SD.
Abbreviations: AHI, apnea/hypopnea index; BMI, body mass index; CT90%, percentage of recording time when oxygen saturation of arterial blood<90%; ESS, Epworth Sleepiness Scale (range 0–24); L-SpO$_2$, lowest blood oxygen saturation during recording time; RFS, reflux finding score; RSI: reflux symptom index.

2.5 | Follow-up

All patients were re-evaluated at our sleep disorder centre at follow-up visits 6 months after UPPP surgery. PSG, RSI, RFS, and ESS questionnaire were obtained from each patient. The investigator (L. S. S.) was not involved in the care of any patient.

2.6 | Statistical analysis

Data were analyzed using a SPSS (version 24.0; SPSS Inc., Chicago, IL). A Chi-square test was used for categorical variables and a t-test or Mann–Whitney *U* test for continuous variables. Regression analysis was performed to show the effect of different variables on the outcome data. Statistical significance was set at *P* <.05.

3 | RESULTS

3.1 | Population characteristics

The characteristics of the 64 patients with OSA (AHI ≥5 events/h) and 27 controls are presented in Table 1. There were no significant differences in age or BMI between groups. Patients with OSA had lower blood oxygen saturation, higher AHI and epworth sleepiness scores. As anticipated, the RSI score and RFS of patients with OSA were higher than those of the controls.

3.2 | Relationship between OSA and LPR

In 64 OSA patients, both AHI and CT90 were positively correlated with the RSI score and RFS, indicating that the degree of OSA is associated with LPR severity (Figure 2A,B). Lowest blood oxygen

TABLE 4 Changes between reflux symptom index and reflux finding score in patients with uvulopalatopharyngoplasty surgery

	Successful(n = 25)			Unsuccessful (n = 9)		
	Before surgery	After surgery	*P* value	Before surgery	After surgery	*P* value
RSI	16.04 ± 4.48	8.60 ± 3.50	<.05	15.44 ± 6.06	12.11 ± 4.94	<.05
>13	n = 18	n = 3	<.05	n = 6	n = 3	.347
≤13	n = 7	n = 22		n = 3	n = 6	
RFS	13.44 ± 4.87	7.92 ± 4.52	<.05	12.44 ± 4.80	10.67 ± 5.52	.150
>7	n = 22	n = 7	<.05	n = 6	n = 4	.341
≤7	n = 3	n = 18		n = 3	n = 5	

Note: Data are presented as median ± SD.
Abbreviations: RFS: reflux finding score; RSI: reflux symptom index.

Laryngoscope Investigative Otolaryngology

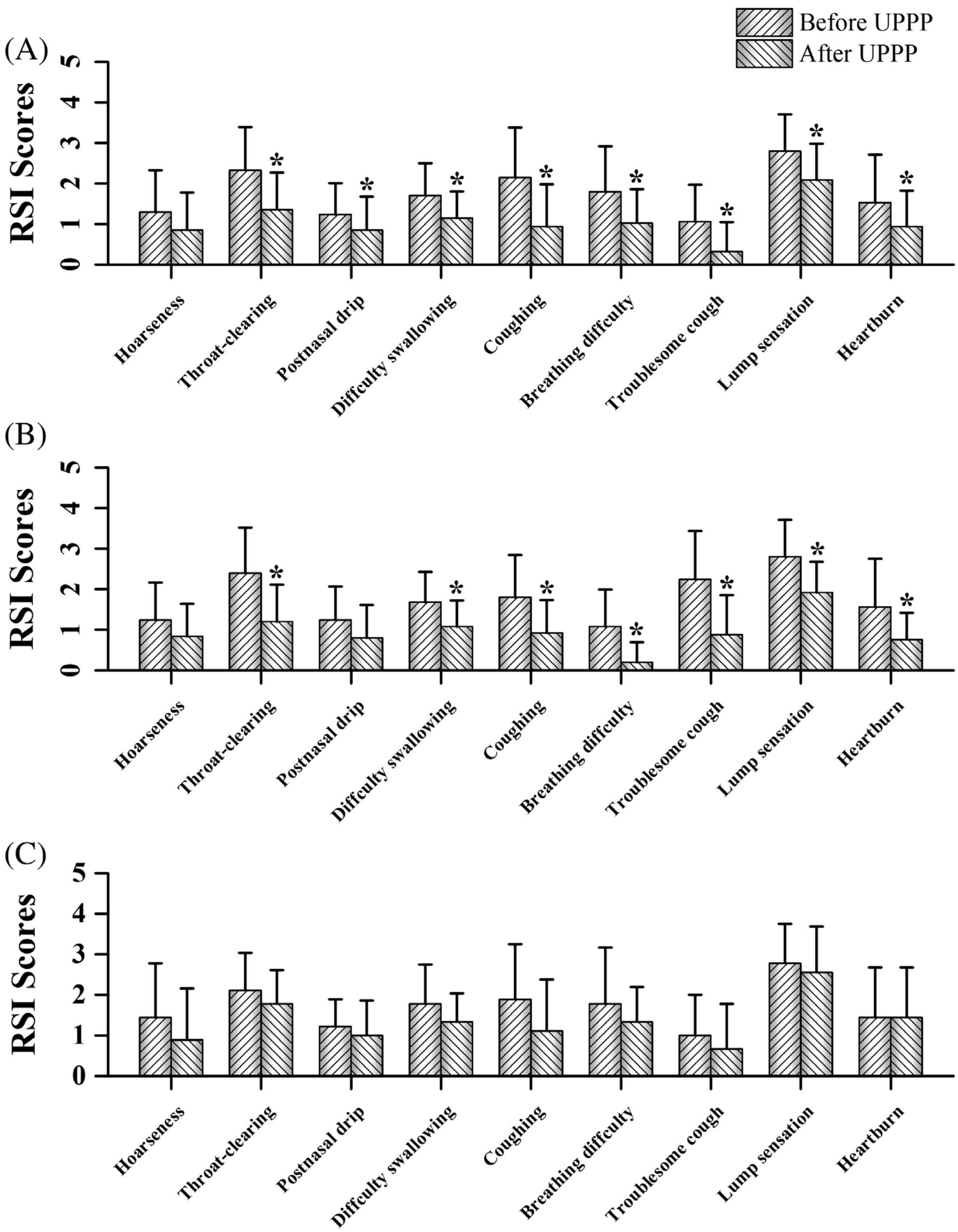

FIGURE 3 Reflux symptom index scores before and after UPPP surgery in different groups. * P <.05 compared with before uvulopalatopharyngoplasty group

saturation during the recording time (L-SpO_2) was negatively correlated with the RSI score and RFS (Figure 2C). In addition, the RSI score and RFS of patients with severe OSA were higher than those of patients with mild to moderate OSA (Table 2).

3.3 | Surgical outcomes

Table 3 shows that postoperative AHI, night-time SpO_2 (CT90 and L-SpO_2), and ESS scores decreased after UPPP surgery in 34 OSA patients. Moreover, both the RSI score and RFS decreased after treatment with UPPP.

Patients whose AHI decreased by 50% from baseline and AHI <20 per hour after surgery were considered as surgical success.[20] The surgical success rate was 73.53% (25/34). In 25 successful surgery patients, the RSI score and RFS were lower than before surgery, and the LPR prevalence changed immediately after successful UPPP surgery (Table 4).

Figure 3A shows that all individual RSI variables improved significantly after surgery (P <.05), except for hoarseness (P = .054). When we compared the pre- and postsurgery individual RSI variables in patients in the successful or unsuccessful surgery group, all RSI variables improved significantly after successful surgery (P <.05, Figure 3B), except for hoarseness and postnasal drip (P = .117 and P = .052, respectively), but no RSI variables significantly changed after unsuccessful surgery (Figure 3C).

4 | DISCUSSION

This study investigated the effect of UPPP surgery for OSA on LPR symptoms based on patient responses to the RSI and RFS questionnaires. We found: (1) a close correlation between OSA and LPR: LPR is more prevalent in OSA patients than in the general population, and AHI and CT90 were positively and L-SpO_2 negatively correlated with LPR symptoms, and (2) UPPP surgery, especially when successful, significantly lowered the mean RSI score and RFS but also individual RSI variables.

The coexistence of OSA with LPR has been reported to have a prevalence of 20%–67%.[21,22] Although previous studies could not demonstrate a direct relationship between them, they suggested a possible causative relationship.[23] Our results indicate that the degree of OSA is associated with LPR severity, and that there is a close correlation between OSA and LPR. An interaction between them could explain our results, namely, OSA causes inflammatory injury, low intrathoracic pressure, and leakage of the lower esophageal sphincter; in turn, LPR (Acid reflux) results in injury to the esophagus, larynx, and pharynx mucosa as well as laryngopharyngeal symptoms.

Anti-reflux therapy may improve the symptoms and PSG parameters of OSA.[24] Simultaneously, other studies report that CPAP can reduce GER events and improve nocturnal GER symptoms in OSA patients.[20,21] However, few studies report on the effect of surgical treatment for OSA on LPR.[25] UPPP is usually not the first choice of treatment in most patients with OSA compared to CPAP. If CPAP is refused or the obstructive plane is defined, surgery can be considered as a treatment for OSA, especially multilevel surgery. UPPP is indicated in patients who only have airway collapse at the level behind the palate, and our study included participants whose level of collapse was presumed to be in the oropharynx was in the oropharynx. The present study demonstrated that postoperative AHI, night-time SpO_2 (CT90 and L-SpO_2), the RSI score, and the RFS were greatly improved after surgery. Interestingly, when we compared the pre- and post-surgery changes in the mean RSI score and mean RFS among patients in the successful and unsuccessful surgery groups, the successful surgery group experienced a significant decrease in the RSI score and RFS, but there was only one significant difference (mean RFS) in the unsuccessful group. We proposed that successful UPPP surgery lowered RSI scores and RFSs, and unsuccessful surgery improved the RFS only.

In our study, we presumed that effective UPPP surgery could improve LPR symptoms and signs in three ways. First, published studies have proposed that mouth breathing and snoring aggravate pharyngeal inflammation and LPR, and chronic intermittent hypoxia can lead to systemic inflammation of the whole body and respiration in OSA.[24,26,27] UPPP solves the problem of OSA-induced inflammatory injury by reducing airflow obstruction and increasing nocturnal blood oxygen saturation. Second, successful UPPP lowers OSA-induced esophageal changes. It has been postulated that OSA causes lower intrathoracic pressure and leakage of the lower esophageal sphincter[28]: (1) when either apnoea or hypopnea occur, OSA patients overcome hypoxia by sleep breathing effort, which produces increased transdiaphragmatic pressure and decreased intrathoracic pressure, exacerbating the LES pressure gradient and favoring acid reflux into the esophagus, resulting in laryngeal mucosal injury.[29–31] (2) the inflammation accompanying OSA may predispose the patient to dysphagia by hypoxia-reoxygenation, promoting upper airway narrowing.[32,33] Additionally, the hypoxia inducible factor (HIF)-2α may play an important role in reflux esophagitis, indicating that low nocturnal oxygen saturation may aggravate LPR symptoms.[34,35] (3) OSA-induced airway resistance causes reflux events coexisting with transient LES pressure relaxation.[35,36] Third, LPR-induced inflammation cannot be ignored in the cycle between OSA and LPR. Previous studies have proposed that LPR results in esophagus, larynx, and pharynx mucosal injury and promote: (1) tissue thickening and hypertrophy caused by chronic inflammation which can directly narrow upper airways and (2) increased sensitivity of the laryngopharyngeal mucosa, inflammation-mediated tissue damage, and sensory impairment contributing to upper respiratory collapse.[23] UPPP improves LPR in two aspects mentioned above, breaking the OSA and LPR cycle.

Patients often have postoperative complaints after UPPP surgery, including pharyngeal pain, swallowing difficulty, and lump sensation, which might result from surgical wound scarification. Most of these symptoms were similar to those reported in the RSI questionnaire. However, our study found that most symptoms improved significantly after UPPP surgery, probably resulting from removal of the upper airway obstruction.

Our study had several limitations. First, a more objective and easy measure to evaluate the effects of UPPP on LPR is needed to clarify our results and evaluate the obstruction level. There are several reasons we chose the RSI score and RFS instead of 24 h pH monitoring to diagnose LPR and evaluate UPPP effects: (1) RSI and RFS questionnaires are not only easy to conduct for both patients and doctors, but also convenient for follow-up; (2) twenty-four hour pH monitoring is difficult for patients to accept, leading to poor adherence. Second, OSA patients often complain of similar symptoms (lump sensation, throat clearing, and difficulty swallowing) in the RSI questionnaire after surgery treatment, which are difficult to distinguish. Further studies are needed to compare the preoperative and postoperative states of each item in the RSI and RFS questionnaires. Third, UPPP can solve intermittent hypoxia or upper airway resistance in patients with OSA, but future studies including more cases are necessary to explore whether removing intermittent hypoxia or upper airway resistance can improve LPR.

5 | CONCLUSION

In summary, LPR symptoms are prevalent in OSA patients, and the coexistence of OSA and LPR cannot be ignored. Successful UPPP surgery against OSA potentially reduces laryngeal reflux symptoms and improves laryngoscopic signs by alleviating sleep respiratory disorders.

CONFLICT OF INTEREST

The authors declared that there is no other funding, financial relationships, or conflicts of interest to disclose.

ORCID

Shisheng Li https://orcid.org/0000-0001-5874-6049
Peiying Huang https://orcid.org/0000-0001-8415-7432

REFERENCES

1. Young T, Palta M, Dempsey J, Skatrud J, Badr S. The occurrence of sleep-disordered breathing among middle-aged adults. *N Engl J Med*. 1993;328(17):1230-1235.
2. Kapur VK. Obstructive sleep apnea: diagnosis, epidemiology, and economics. *Respir Care*. 2010;55(9):1155-1167.
3. Bikov A, Hull JH, Kunos L. Exhaled breath analysis, a simple tool to study the pathophysiology of obstructive sleep apnoea. *Sleep Med Rev*. 2016;27:1-8.
4. Tawk M, Goodrich S, Kinasewitz G, Orr W. The effect of 1 week of continuous positive airway pressure treatment in obstructive sleep apnea patients with concomitant gastroesophageal reflux. *Chest*. 2006;130(4):1003-1008.
5. Fournier MR, Kerr PD, Shoenut JP, Yaffe CS. Effect of nasal continuous positive airway pressure on esophageal function. *J Otolaryngol*. 1999;28(3):142-144.
6. Lei WA, Hh A, Gang W, et al. Relationship between reflux diseases and obstructive sleep apnea together with continuous positive airway pressure treatment efficiency analysis. *Sleep Med*. 2020;75:151-155.
7. Green BT, Broughton WA, O'Connor JB. Marked improvement in nocturnal gastroesophageal reflux in a large cohort of patients with obstructive sleep apnea treated with continuous positive airway pressure. *Arch Intern Med*. 2003;163(1):41-45.
8. Shepherd KL, Holloway RH, Hillman DR, Eastwood PR. The impact of continuous positive airway pressure on the lower esophageal sphincter. *Am J Physiol Gastrointest Liver Physiol*. 2007;292(5):G1200-G1205.
9. Koufman JA, Aviv JE, Casiano RR, Shaw GY. Laryngopharyngeal reflux: position statement of the committee on speech, voice, and swallowing disorders of the American Academy of Otolaryngology-Head and Neck Surgery. *Otolaryngol Head Neck Surg*. 2002;127(1):32-35.
10. Wise SK, Wise JC, Delgaudio JM. Gastroesophageal reflux and laryngopharyngeal reflux in patients with sleep-disordered breathing. *Otolaryngol Head Neck Surg*. 2006;135(2):253-257.
11. Eryılmaz A, Erişen L, Demir UL, et al. Management of patients with coexisting obstructive sleep apnea and laryngopharyngeal reflux disease. *Eur Arch Otorhinolaryngol*. 2012;269(12):2575-2580.
12. Li KK. Sleep apnea surgery: putting it all together. *Oral Maxillofac Surg Clin North Am*. 2009;21(4):421-423.
13. Fujita S, Conway WA, Zorick FJ, et al. Evaluation of the effectiveness of uvulopalatopharyngoplasty. *Laryngoscope*. 1985;95(1):70-74.
14. Sheen D, Abdulateef S. Uvulopalatopharyngoplasty. *Oral Maxillofac Surg Clin North Am*. 2021;33(2):295-303.
15. Choi JH, Jun YJ, Kim TH, et al. Effect of isolated uvulopalatopharyngoplasty on subjective obstructive sleep apnea symptoms. *Clin Exp Otorhinolaryngol*. 2013;6(3):161-165.
16. Belafsky PC, Postma GN, Koufman JA. The validity and reliability of the reflux finding score (RFS). *Laryngoscope*. 2001;111(8):1313-1317.
17. Belafsky PC, Postma GN, Koufman JA. Validity and reliability of the reflux symptom index (RSI). *J Voice*. 2002;16(2):274-277.
18. Iber C, Ancoli-Israel S, Chesson AL, Quan SF. *The AASM Manual for the Scoring of Sleep and Associated Events: Rules, Terminology and Technical Specifications*. American Academy of Sleep Medicine; 2015.
19. Lechien JR, Camille F, Kathy H, et al. Impact of laryngopharyngeal reflux on subjective, aerodynamic, and acoustic voice assessments of responder and nonresponder patients. *J Voice*. 2019;33(6):929-939.
20. Sher AE, Schechtman KB, Piccirillo JF. The efficacy of surgical modifications of the upper airway in adults with obstructive sleep apnea syndrome. *Sleep*. 1996;19(2):156-177.
21. Zanation AM, Senior BA. The relationship between extraesophageal reflux (EER) and obstructive sleep apnea (OSA). *Sleep Med Rev*. 2005;9(6):453-458.
22. Garrigues V, Gisbert L, Bastida G, et al. Manifestations of gastroesophageal reflux and response to omeprazole therapy in patients with chronic posterior laryngitis: an evaluation based on clinical practice. *Dig Dis Sci*. 2003;48(11):2117-2123.
23. Eskiizmir G, Kezirian E. Is there a vicious cycle between obstructive sleep apnea and laryngopharyngeal reflux disease? *Med Hypotheses*. 2009;73(5):706-708.
24. Steward DL. Pantoprazole for sleepiness associated with acid reflux and obstructive sleep disordered breathing. *Laryngoscope*. 2004;114(9):1525-1528.
25. Kim SJ, Kim HY, Jeong JI, Hong SD, Chung SK, Dhong HJ. Changes in the reflux symptom index after multilevel surgery for obstructive sleep apnea. *Clin Exp Otorhinolaryngol*. 2017;10(3):259-264.
26. Payne RJ, Kost KM, Frenkiel S, et al. Laryngeal inflammation assessed using the reflux finding score in obstructive sleep apnea. *Otolaryngol—Head Neck Surg*. 2006;134(5):836-842.
27. Bergeron C, Kimoff J, Hamid Q. Obstructive sleep apnea syndrome and inflammation. *J Allergy Clin Immunol*. 2005;116(6):1393-1396.
28. Miller LS, Vegesna AK, Brasseur JG, Braverman AS, Ruggieri MR. The esophagogastric junction. *N Engl J Med*. 2011;1232(1):323-330.
29. Ing AJ, Meng CN, Breslin A. Obstructive sleep apnea and gastroesophageal reflux. *Am J Med*. 2000;108 Supplement 4a(4-supp-S1):120S-125S.
30. Berg S, Hybbinette JC, Gislasson T, Ovesen J. Intrathoracic pressure variations in obese habitual snorers. *J Otolaryngol*. 1995;24(4):238-241.
31. Kerr P, Shoenut JP, Steens RD, Millar T, Micflikier AB, Kryger MH. Nasal continuous positive airway pressure. A new treatment for nocturnal gastroesophageal reflux? *J Clin Gastroenterol*. 1993;17(4):276-280.
32. Boyd JH, Petrof BJ, Hamid Q, Fraser R, Kimoff RJ. Upper airway muscle inflammation and denervation changes in obstructive sleep apnea. *Am J Respir Crit Care Med*. 2004;170(5):541-546.
33. Barrera JE, Pau CY, Forest VL, Holbrook AB, Popelka GR. Anatomic measures of upper airway structures in obstructive sleep apnea. *World J Otorhinolaryngol Head Neck Surg*. 2017;3(002):85-91.
34. Souza RF, Bayeh L, Spechler SJ, Tambar UK, Bruick RK. A new paradigm for GERD pathogenesis. Not acid injury, but cytokine-mediated inflammation driven by HIF-2α: a potential role for targeting HIF-2α to prevent and treat reflux esophagitis. *Curr Opin Pharmacol*. 2017;37:93-99.
35. Huo X, Agoston AT, Dunbar KB, et al. Hypoxia-inducible factor-2α plays a role in mediating oesophagitis in GORD. *Gut*. 2017;66(9):1542-1554.
36. Shaheen NJ, Madanick RD, Alattar M, Morgan DR, Vaughn BV. Gastroesophageal reflux disease as an etiology of sleep disturbance in subjects with insomnia and minimal reflux symptoms: a pilot study of prevalence and response to therapy. *Dig Dis Sci*. 2008;53(6):1493-1499.

How to cite this article: Tang X, Tang Q, Li S, et al. Changes in laryngopharyngeal reflux after uvulopalatopharyngoplasty for obstructive sleep apnea: An observational study. *Laryngoscope Investigative Otolaryngology*. 2022;7(1):266-273. doi:10.1002/lio2.718