Original Article

Polysomnographic Outcomes Before and After Modified Uvulopalatopharyngoplasty Alone or With Minimally Invasive Surgery for Patients with Obstructive Sleep Apnea

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Objective: To evaluate the polysomnographic (PSG) outcomes before and after modified uvulopalatopharyngoplasty (Mod UPPP) alone or with minimally invasive surgery (MIS) for patients with obstructive sleep apnea (OSA).

Materials and Methods: The present study was a retrospective study included OSA patients aged 18 years or older who underwent Mod UPPP alone or with MIS as radiofrequency (RF) ablation of the nose and tongue base, at Siriraj Hospital between January 2014 and October 2019. Those with incomplete PSG data or sleep efficiency of less than 50% were excluded. The primary outcome was the apnea-hypopnea index (AHI). Secondary outcomes were the sleep stages' proportions, lowest oxygen saturation (LSAT), oxygen desaturation index (ODI), time with oxygen saturation of less than 90% (T90), surgical success and response rates, and postoperative complications.

Results: Seventy-five 75 patients including 59 males and 16 females, with a mean age of 41.6±10.8 years old and body mass index (BMI) of 30±6 kg/m^2 were included in the study. The mean follow-up time of PSG was 11.5±10.2 months. The postoperative results showed mean reductions of AHI from 42.3 to 19.2 events/hour ($p<0.001$), ODI of 4% or less from 39 to 17.4 events/hour ($p<0.001$), T90 from 16% to 6.1% ($p<0.001$), and an increase in LSAT from 74.1% to 81.9% ($p<0.001$). Overall, the surgical success and response rates for Mod UPPP alone and with MIS were 33.3% and 49.3%, respectively. However, no statistical reduction of AHI was found between these groups. Secondary bleeding was found postoperatively in three patients or 4%, in which two of them required intervention for hemostasis. No serious complications, such as respiratory distress or death, were found.

Conclusion: Mod UPPP alone or with MIS significantly improved the PSG outcomes with a low complication rate, suggesting it may be considered an alternative treatment for Thai patients with OSA.

Keywords: Obstructive sleep apnea; Palatal surgery; Minimally invasive surgery; Modified UPPP; Anterior palatoplasty; Thai

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Obstructive sleep apnea (OSA) is a common disorder characterized by repetitive upper airway pharyngeal collapse during sleep, which results in hypoxemia-hypercapnia and an increased sympathetic overdrive from frequent arousals. Its clinical presentations include snoring, daytime somnolence, poor concentration, depression, marital discord, and cardiovascular consequences. Generally, continuous positive airway pressure (CPAP) providing pneumatic splinting of the upper airway is accepted as the first-line treatment for OSA due to its high efficacy in reducing the apnea-hypopnea index (AHI) and improving various clinical symptoms[1]. However, patients' poor compliance remains a significant limitation to its use and this frequently leads to suboptimal therapeutic effectiveness[2]. To improve outcomes especially in this group, upper airway

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surgery has been introduced as an alternative treatment for OSA[3,4]. Among the surgery options, uvulopalatopharyngoplasty (UPPP) is a popular operation used to correct retropalatal obstruction, which is the type most commonly found, at 84.1%, during drug-induced sleep endoscopy (DISE) in OSA patients, as reported in a meta-analysis[5].

Traditional UPPP, which involves resection and reconstruction of the uvula, soft palate, tonsils, and pharyngeal wall, was first reported by Fujita et al in 1981[6]. Thereafter, various modifications of this procedural technique, the so-called modified UPPP (Mod UPPP), have been introduced for achieving better outcomes and fewer complications such as bleeding or respiratory disturbances[4,7,8-10]. Nowadays, these interventions have gained more popularity worldwide, and indeed are routinely used as an alternative treatment to CPAP for OSA patients in the present study otolaryngologic and sleep center. However, due to multilevel upper airway obstruction being found in several OSA patients, minimally invasive surgery (MIS), especially radiofrequency (RF) ablation of the nasal turbinate and tongue base, may frequently be added to the Mod UPPP for achieving better results[11]. Although, there are reports on UPPP in the literature, their results are still heterogenous and limited in a Thai population[12-18]. The objectives of the present study were to evaluate the polysomnographic (PSG) outcomes and complications of the Mod UPPP alone or with MIS in Thai patients with OSA.

Materials and Methods

This retrospective review of medical records was approved by the Siriraj Institutional Review Board (SIRB), Ethics approval No.933/2561(EC3) COA no.SI 214/2019. It was conducted at the Department of Otorhinolaryngology, Faculty of Medicine Siriraj Hospital, Mahidol University, Bangkok, Thailand. The inclusion criteria were patients aged 18 years or older with OSA diagnosed by PSG underwent Mod UPPP alone or with MIS between January 2014 and October 2019. The exclusion criteria were patients who did not have postoperative PSG or whose PSG showed very poor sleep efficiency (SE) or less than 50%.

Treatment selection

The patients who refused CPAP therapy routinely had a comprehensive assessment undertaken, including otolaryngologic examination, Friedman system staging, and lateral cephalometric analysis to select the proper surgical candidates. In patients who did not show obvious upper airway abnormalities, DISE was also performed using the VOTE classification to determine the potential site(s) of their upper airway obstruction during sleep. Patients who had a low-lying soft palate, elongated uvula, or tonsils grade 3 or 4 were recommended to undergo Mod UPPP as an alternative therapy to CPAP. If they had a nasal obstruction with inferior turbinate hypertrophy or relative macroglossia, RF nose or RF tongue base was advised as an adjunctive treatment performed simultaneously with the Mod UPPP. For those who were classified as Friedman stage 3 or 4, or who had significant craniofacial abnormalities, other modalities, such as oral appliance, jaw surgery, positional therapy, were advised instead.

Figure 1. Postoperative wound in modified uvulopalatopharyngoplasty.

There are surgical scars particularly at the midline of the soft palate and some remnants of uvula.

Surgical intervention

The Mod UPPP in the present study was performed with tonsillectomy. Its operative procedures included partial uvulectomy or uvuloplasty, anterior palatoplasty or removal of the soft palate mucosa at the midline in a rectangular or diamond shape, and pharyngoplasty or suturing of the anterior and posterior tonsillar pillars together. All the tissues were then reconstructed by absorbable sutures using vicryl No.3/0 or 4/0. An example postoperative surgical wound is presented in Figure 1. The processes for RF nose included nasal endoscopy, injection of local anesthesia with 0.5% lidocaine with adrenaline 1:400,000, penetration of a bipolar probe into the submucosa of the anterior and inferomedial aspects of the bilateral inferior turbinates, and the release of RF energy (using a CURIS® 4 MHz radiofrequency generator, Freiburg, Germany) using a power setting of 6 Watts for approximately 6 to 8 points each side. In addition, out-fracture or lateralization of the

Table 1. Comparison of the data of the two surgical groups

Parameters	Mod UPPP alone (n=21)	Mod UPPP with MIS (n=54)	p-value
Age (year); mean±SD	42.3±11.8	41.3±10.5	0.711
BMI (kg/m^2); mean±SD	28.4±5.9	30.6±6.0	0.158
Neck circumferences (cm^2); mean±SD	37.8±4.0	39.9±4.1	0.075
Pre-op AHI (events/hour); mean±SD	24.4±27.5	49.3±31.2	0.02
Post-op PSG (months); mean±SD	10.2±6.2	12±11.4	0.496
Response rate (%)	52.4	48.1	0.742
Surgical success rate (%)	42.9	29.6	0.275

BMI=body mass index; Mod UPPP=modified uvulopalatopharyngoplasty; MIS=minimally invasive surgery; Pre-op=preoperative; Post-op=postoperative; AHI=apnea-hypopnea index; SD=standard deviation

bilateral inferior turbinates was done. These were performed before or after Mod UPPP in the same setting. The processes for RF tongue base included applying an oral retractor, suturing around the tongue tip for traction, injection of local anesthesia with 1% lidocaine with adrenaline 1:200,000, around the circumvallate papillae, bipolar RF probe penetration deep into the midline tongue muscles, and the release of RF energy using a CURIS® 4 MHz radiofrequency generator, Freiburg, Germany, and using a power setting of 12 Watts for 4 to 5 points at 0.5 cm intervals.

Polysomnographic outcomes

Both diagnostic and postoperative PSG in the present study were level 1 as scored by qualified sleep technicians and interpreted by sleep specialists according to the standard criteria recommended by the American Academy of Sleep Medicine (AASM) version 2012. The primary outcome was AHI, and the secondary outcomes were the apnea index (AI), hypopnea index (HI), SE (%), sleep stages proportion (%), lowest oxygen saturation (LSAT), 4% oxygen desaturation index (ODI), percentage of time spent with SpO_2 at less than 90% (T90), and postoperative complications. Hypopnea was defined as a 30% or greater reduction of the airflow from baseline for 10 seconds or longer, plus an oxygen desaturation of 4% or more (criteria 1B). The surgical response in the present study was defined if there were postoperative AHI of less than 20 events/hour, which decreased from a baseline of 50% or more (Sher's criteria) or postoperative AHI of less than 5 events/hour. The surgical success was defined if patients had postoperative AHI of less than 5 events/hour.

Statistical analysis

Continuous data were presented as the mean ± standard deviation (SD). Categorical data were presented as numbers and percentages. The t-test was used to compare the means of two groups, such as pre- and postoperative results (paired test) and between two distinct groups (unpaired test). A p-value of less than 0.05 was considered statistically significant. Data were analyzed using PASW Statistics, version 18.0 (SPSS Inc., Chicago, IL, USA).

Results

Medical records of 75 patients including 59 males and 16 females with a mean age of 41.6±10.8 and a range of 21 to 64 years old, were reviewed. The mean preoperative AHI was 42.2±32 events/hour, ranging from 5.3 to 117.2 events/hour. The mean duration of follow-up PSG was 11.5±10.2 months, ranging from 1 to 72 months, and the mean body mass index (BMI) was 30±6 kg/m² ranging from 20.6 to 50.3 kg/m² and included 32 patients that had a BMI of 30 kg/m² or more. Overall, 21 patients underwent Mod UPPP alone, 12 patients underwent Mod UPPP with RF nose, 25 patients underwent Mod UPPP with RF tongue base, and 17 patients underwent all the procedures. Overall surgical response and success were found in 37 patients or 49.3%, and 25 patients or 33.3%, respectively. Comparison data between Mod UPPP alone and Mod UPPP with MIS is presented in Table 1.

The PSG outcomes of surgery overall, Mod UPPP alone, and Mod UPPP with MIS are separately presented in Table 2, 3, and 4, respectively. Major postoperative complications were found in 3 out of 75 patients or 4%. All were secondary hemorrhage or delayed bleeding, which happen approximately one week later, of which two needed re-operation for hemostasis. Other complications such as pain, swallowing difficulty, and velopharyngeal insufficiency were not well documented, but none were irreversible. However, no serious complications, such as respiratory distress, nasopharyngeal stenosis, or death, were found.

Table 2. Polysomnographic outcomes of the overall surgery (n=75)

PSG parameters	Pre-op; mean±SD	Post-op; mean±SD	p-value
AHI (events/hour)	42.3±32	19.2±22.2	<0.001
Apnea index (events/hour)	25.7±28.5	8.1±14.3	<0.001
Hypopnea index (events/hour)	16.6±17.2	11.1±14.4	0.03
Sleep efficiency (%)	86.2±9.3	86±8.6	0.89
Stage N1 (%)	30±18.9	16.2±11.3	<0.001
Stage N2 (%)	42.7±12.8	54±11.7	<0.001
Stage N3 (%)	13.2±12.7	12.2±9.2	0.5
Stage REM (%)	13.8±10.1	16.4±7	0.04
LSAT (%)	74.1±15.3	81.9±9.9	<0.001
4% ODI	39±32.3	17.4±21.3	<0.001
T90 (%)	16±23.3	6.1±15.7	0.001

Pre-op=preoperative; Post-op=postoperative; AHI=apnea-hypopnea index; LSAT=lowest oxygen saturation; ODI=oxygen desaturation index; T90=percentage of recording time with SaO_2 <90%; SD=standard deviation

Table 3. Polysomnographic outcomes of modified uvulopalato-pharyngoplasty alone (n=21)

Parameters	Pre-op; mean±SD	Post-op; mean±SD	p-value
AHI (events/hour)	24.4±27.5	11.8±18	0.04
Apnea index (events/hour)	10.5±16.6	6.6±15.3	0.08
Hypopnea index (events/hour)	13.9±22.4	5.2±6	0.1
Sleep efficiency (%)	85.5±9.5	88.7±7.5	0.22
Stage N1 (%)	25.2±15.6	14.2±9	0.002
Stage N2 (%)	46.9±10.8	56.7±11.9	0.001
Stage N3 (%)	15.2±13.4	11.1±8.1	0.15
Stage REM (%)	12.4±7.3	16.6±7.6	0.06
LSAT (%)	81.4±8.9	83.1±6.9	0.5
4% ODI	22.1±28.2	10.9±18.1	0.08
T90 (%)	4.4±15.2	3.1±8.7	0.7

Pre-op=preoperative; Post-op=postoperative; AHI=apnea-hypopnea index; LSAT=lowest oxygen saturation; ODI=oxygen desaturation index; T90=percentage of recording time with SaO_2 <90%; SD=standard deviation

Table 4. Polysomnographic outcomes of modified uvulopalato-pharyngoplasty with minimally invasive surgery (n=54)

PSG parameters	Pre-op; mean±SD	Post-op; mean±SD	p-value
AHI (events/hour)	49.3±31.2	22.1±23.1	<0.001
Apnea index (events/hour)	31.6±30	8.7±14	<0.001
Hypopnea index (events/hour)	17.7±14.9	13.4±16	0.14
Sleep efficiency (%)	86.5±9.3	85±8.9	0.345
Stage N1 (%)	31.8±19.8	17±12.1	<0.001
Stage N2 (%)	41.1±13.2	53±11.5	<0.001
Stage N3 (%)	12.4±12.5	12.6±9.7	0.9
Stage REM (%)	14.4±11.1	16.3±6.9	0.21
LSAT (%)	71.2±16.5	81.4±10.8	<0.001
4% ODI	45.6±31.7	19.9±22	<0.001
T90 (%)	20.5±24.4	7.4±17.6	<0.001

Pre-op=preoperative; Post-op=postoperative; AHI=apnea-hypopnea index; LSAT=lowest oxygen saturation; ODI=oxygen desaturation index; T90=percentage of recording time with SaO_2 <90%; SD=standard deviation

Discussion

Since UPPP was first reported by Fujita et al[6] in 1981, modification and various types of MIS have been introduced to clinical practice as an alternative therapy to CPAP for OSA patients. The outcomes of these procedures are heterogeneously reported and typically insufficient, especially in Thai patients[16,18]. The results of the present study in 75 patients that underwent Mod UPPP alone or combined with MIS showed statistically significant reduction of AHI after surgery from 42.3 to 19.2 events/hour ($p<0.001$). Based on 21 patients that underwent Mod UPPP alone, the present study results showed AHI was significantly decreased from 24.4 to 11.8 events/hour, or a 51.6% reduction. This corresponded to the results reported by Browaldh et al[7], who noted a 60% AHI reduction after surgery, and the results of a systematic review and meta-analysis performed by He et al[19] that reported a 46.1% AHI reduction. The present study results for Mod UPPP combined with MIS in 54 patients showed a significant decrease in AHI from 49.3 to 22.1 events/hour or a 55.2% reduction. This is similar to the results of Struat et al[20] who repoted a 56.5% reduction. However, the AHI reductions reported in the present study were higher than those in the study of Friedman et al[21] done in 143 patients, which showed non-significant changes in AHI by UPPP alone with a 26% reduction and a 36.3% reduction of AHI by UPPP with RF tongue base. The heterogeneity of the surgical results in the literature may be due to differences in the patients' characteristics, the interventional techniques, or research methodology aspects[14,20,21].

The secondary PSG outcomes of overall surgery in the present study also showed significant improvements of parameters, including AI, 4% ODI, T90, and LSAT, ($p\leq0.001$). However, there were almost no significant improvement in the proportion of sleep stage N3 and REM, which was slightly below the authors expectation but showed a similar outcome by Browaldh et al[7]. The surgical response and success rate in the present study were 49.3% and 33.3%, respectively, which were similar to those of He et al[19] at 48.3% and 32.5%, respectively. However, when comparing between the two groups, the patients

who underwent Mod UPPP alone achieved a higher surgical response rate at 52.4% versus 48.1% and success rate at 41.9% versus 29.6% than those with Mod UPPP and MIS. This was not much of a surprise because patients who underwent multilevel surgery initially have a higher preoperative AHI and BMI. One of the authors' hypotheses is that Mod UPPP does not dramatically reduce AHI because apneic events or a complete absence of airflow may have transformed into hypopneic events or a partial reduction of the airflow instead. Therefore, the total number of respiratory events was not changed.

Regarding surgical complications, postoperative bleeding was found in 4.1% of the patients, which was an acceptable percentage and close to that previously reported in the literature, including in the studies of Kandasamy et al[9] and Stuart et al[20]. Although common side effects such as pain, swallowing difficulty, and velopharyngeal insufficiency are not well documented, significant complaints of irreversible side effects or serious complications, such as respiratory distress, nasopharyngeal stenosis, or death, were not found.

There were limitations of the present study to note. First, this was a retrospective review, which potentially led to incomplete data. For example, evaluation of the upper airway characteristics was not well recorded and DISE was not routinely performed in all cases. Hence, it could not be assessed whether these findings were related to the response or failure of the operations. Second, patients who could not afford the PSG expense or who were lost to follow-up were not included and follow-up PSG was performed approximately one year after the operation, thus it did not represent all the postoperative results or the outcomes of longer periods. Last, the study had a small sample size and no control group to compare. The authors propose that future prospective studies should be performed with a larger sample size, more comprehensive data, and longer-term follow-up.

Conclusion

Mod UPPP alone or with MIS significantly improved several PSG parameters with few major complications. Consequently, these may be considered alternative treatments in Thai patients with OSA, particularly for those who could not tolerate CPAP. However, long-term postoperative follow-up is required.

What is already known on this topic?

The main stay treatment of moderate to severe OSA consisted of using CPAP apart from other conservative treatment such as weight loss. However not every people can tolerate CPAP use. Thus, alternative methods of treatment were introduced such as mandibular advancement device or surgery for sleep apnea. In various literatures, sleep apnea surgery was mentioned with satisfied outcome. However, the data were still scarce in Thai population.

What this study adds?

This study showed the outcome from sleep apnea surgery for those who are intolerant to CPAP treatment for Thai patient. Surgery can significantly improve several PSG parameters with few major complications. These may be considered alternative treatments in Thai patients with OSA.

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Conflicts of interest

The authors declare that there were no conflicts of interest in this study.

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