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MISCELLANEOUS

Pterygomandibular suspension suture: a simple modification of uvulopalatopharyngoplasty for severe obstructive sleep apnea

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Abstract
Backgrounds The aim of this study is to introduce pterygomandibular suspension suture as a simple modification of uvulopalatopharyngoplasty for severe obstructive sleep apnea in dealing with lateral pharyngeal wall and retropalatal space collapse.
Methods This retrospective study was conducted at Taipei Veterans General Hospital, Taiwan. Ten adult patients underwent modified uvulopalatopharyngoplasty with pterygomandibular suspension suture according to following inclusion criteria: severe obstructive sleep apnea (apnea–hypopnea index [AHI] > 30 events/h), type I Fujita with lateral pharyngeal wall collapse, and failure for continuous positive airway pressure (CPAP) therapy. The philosophy of this modification technique is to create a firm anterolateral suspension of the lateral pharyngeal wall and soft palate by sutures.
Results The mean operative time of modified uvulopalatopharyngoplasty with pterygomandibular suspension suture was 60 min. The mean AHI decreased significantly from 77.2 ± 25.0 preoperatively to 28.7 ± 18.8 postoperatively ($P = 0.005$) and the lowest oxygen saturation increased from 69.9 ± 11.4 to $81.1 \pm 7.19\%$ ($P = 0.005$). No major perioperative complication such as massive bleeding or respiratory distress was noted. No patient experienced a swallowing disturbance, taste change, or voice change 6 months postoperatively. The mean period for resuming a normal diet was 15 days.
Conclusion Modified uvulopalatopharyngoplasty with pterygomandibular suspension suture is a simplified and effective surgical approach with satisfactory functional recovery for selective patients with severe obstructive sleep apnea.

Keywords Obstructive sleep apnea · Pterygomandibular suspension suture · Uvulopalatopharyngoplasty · Apnea–hypopnea index · Surgery

Introduction

Uvulopalatopharyngoplasty (UPPP), described by Fujita et al. in 1981, had been the most widely performed pharyngeal surgery for obstructive sleep apnea (OSA) [1]. However, the relatively low success rate and high morbidities limited the clinical use of UPPP since 1990s [2]. The causes of failure of UPPP are multifactorial, but one of the most important factors is persistent collapse over the upper pharynx after the operation [3]. Consequently, many UPPP modifications were developed, such as Cahali's lateral pharyngoplasty, Pang's expansion sphincter pharyngoplasty, Li's relocation pharyngoplasty, and Woodson's transpalatal advancement pharyngoplasty, which all have shown promising results [2, 4–6]. However, these modifications are relatively complex as compared with conventional UPPP. Herein, we describe a

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simplified UPPP modification using the pterygomandibular (PM) suspension suture, which is designed to offer reliable support to suspend the lateral pharyngeal wall (LPW) and soft palate for effectively widening the upper airway.

The purpose of this study is to describe the surgical technique and preliminary results of our modified UPPP procedure using PM suspension suture in the treatment of severe OSA.

Methods

A retrospective study was performed at Taipei Veterans General Hospital with approval of the institutional review board. From March 2010 to March 2013, 10 adult patients (9 men and 1 woman) underwent modified UPPP with PM suspension suture. Inclusion criteria were as follows: severe obstructive sleep apnea syndrome (apnea–hypopnea index [AHI] > 30 events/h), unable to tolerate or fail continuous positive airway pressure (CPAP) therapy, and anatomic features as type I Fujita (retropalatal obstruction) [7] with lateral pharyngeal wall collapse, diagnosed by flexible fiberoptic nasopharyngoscopy with Muller's maneuver. Friedman staging system was used to describe the anatomic characters of patients [8]. Polysomnography was arranged 6 months after the operation.

Surgical technique

Under general anesthesia with oral endotracheal intubation, patients were placed in a supine position with their heads extended. A Dingman mouth gag was applied to obtain adequate exposure of the oropharynx. The pterygomandibular (PM) sling, which comprised the pterygomandibular raphe and medial pterygoid muscle tendon, was identified with palpation as a submucosal fibrotic band that extended from the pterygoid hamulus to the mandible (Fig. 1a). The pterygomandibular raphe is a ligamentous band of buccopharyngeal fascia, attached superiorly to the hamulus of the medial pterygoid plate and inferiorly to the posterior end of the

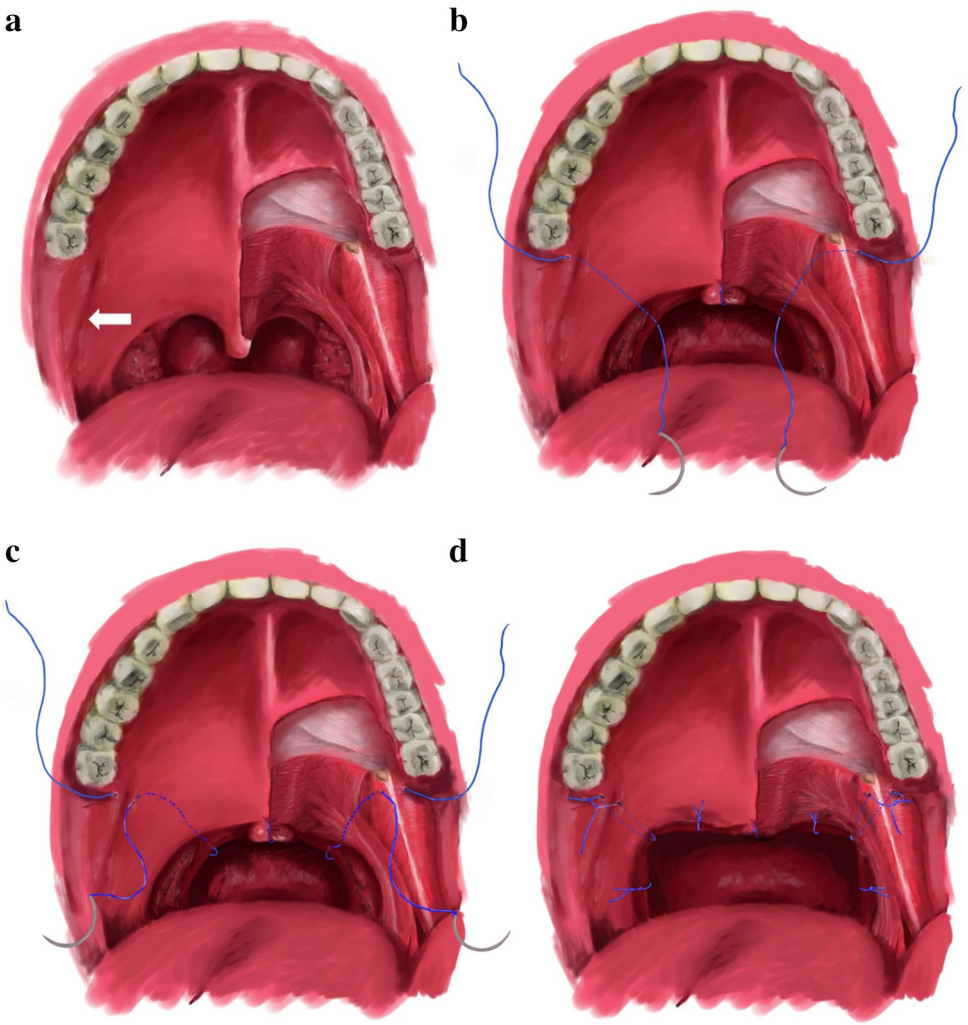

Fig. 1 Procedures of pterygomandibular (PM) suspension suture. **a** Pterygomandibular raphe and medial pterygoid muscle tendon serve as a submucosal palpable pterygomandibular (PM) sling (arrow) with high tensile strength that extends from the pterygoid hamulus to the mandible. **b** After bilateral tonsillectomy and partial amputation of uvula, the PM suspension suture started from a point lateral to the PM sling near the pterygoid hamulus, piercing through the posterior tonsillar pillar. **c** Then, the suture line grasps and suspends the palatopharyngeal muscle and posterior pillar flap, returns back to tonsillar fossa, and finishes from a point medial to the PM sling. **d** Additional simple sutures are used to approximate the palatal mucosa. After PM suspension suture, velopharyngeal space is widened by the anterolateral traction on the soft palate and lateral pharyngeal wall

mylohyoid line of the mandible (Fig. 1a). Deep to the pterygomandibular raphe is a tendon from the medial pterygoid muscle that originates from the lateral pterygoid plate to the mandibular angle (Fig. 1a). These two structures provided the high tensile strength required to support our modified UPPP procedure.

Similar to the conventional UPPP, bilateral tonsillectomy was first carried out, followed by partial amputation of the uvula 0.5–1 cm below the velopharyngeal sphincter. With 3-0 Vicryl suture (Ethicon, Somerville, NJ), bilateral PM suspension sutures were commenced from a point lateral to the PM sling near the pterygoid hamulus (the distance between insertion point and hamulus was less than 5 mm) through the tonsillar fossa that suspended the palatopharyngeal muscle and posterior pillar flap and then back to a point medial to the PM sling (Fig. 1b, c). With appropriate tension applied to the two PM suspension sutures, the velopharyngeal space was effectively widened using anterolateral traction force on the soft palate and lateral pharyngeal wall (Fig. 1d). Additional simple sutures near the PM suspension sutures were added for reinforcement. The palatal mucosa was approximated. Complete or partial closure of the tonsillar fossa was also performed, based on appropriate tension on the final pharyngeal wounds (Fig. 1d).

Results

The mean age of these ten patients was 45.6 years (range 27–64), with a mean body weight index (BMI) of 29.6 kg/m^2 (range 23.0–39.8). Four of the ten patients were Friedman stage III obstructive sleep apnea. Preoperative polysomnographic data showed that mean AHI was 77.2 events/h (range 40.1–123.0).

The mean operative time was 60 min (range 45–80). With anchorage over the PM sling, the bilateral suspension sutures effectively exerted anterolateral traction force to successfully widen the velopharyngeal space by suspending the collapsed posterior and anterior pillar flap, as compared with a simple approximation of the mucosa that occurs in a conventional UPPP (Fig. 2). Two of ten cases (20%) showed the breakdown of suture within 2 weeks, and minor dehiscence of the wound at pharyngeal mucosa ensued. In spite of minor dehiscence, the traction force on the soft palate and lateral pharyngeal wall could be kept towards pterygomandibular sling eventually because of inflammation and scar formation along suture.

Extubation in the operation room was successful for all patients, and none experienced respiratory distress. There was also no major wound bleeding. No nasal regurgitation during swallowing, alternation in speech (including hyponasality and hypernasality), or taste disturbance developed in the period of 6 months postoperatively.

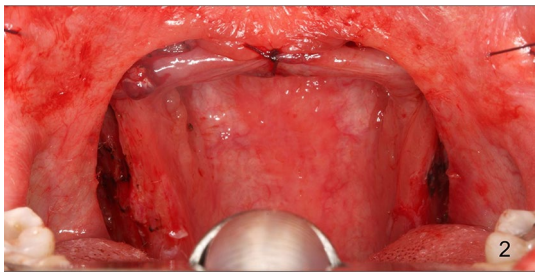

Fig. 2 Operative views of the pterygomandibular suspension suture. The bilateral PM suspension sutures can be adjusted to exert appropriate tension for anterolateral traction and widening the previous collapsed velopharyngeal space

The postoperative polysomnographic data demonstrated significant improvement in AHI (77.2 ± 25.–28.7 ± 18.8 events/hour; $P = 0.005$), mean arterial oxygen saturation (SaO_2) (91.9 ± 2.96 to 94.8 ± 1.87%; $P = 0.015$), and lowest SaO_2 (69.9 ± 11.4 to 81.1 ± 7.19%; $P = 0.005$) (Table 1). The percentage of time spent in stages 3 and 4 of sleep (1.46–5.63%; $P = 0.069$) showed a trend to increase after the operation (Table 1). There was no significant change in pre- or postoperative BMI (29.6–29.6; $P = 0.859$) (Table 1).

Discussion

OSA is a common medical disorder accompanied with relatively high tendency for cardiovascular disease, neurocognitive dysfunction, and premature death [9]. The primary treatment policy for OSA is CPAP. However, the compliance rate was often low, and many patients cannot tolerate or adhere to long-term nightly use of this device [10]. Therefore, surgery becomes another main option for these patients.

UPPP was the most popular palatopharyngeal surgical technique for OSA since 1981 [1]. However, the success rate of UPPP was not as good as expected and high side effects rate occurred [2]. In the literature review, long-term success rate was only 33% reported by Conway et al. [11], and Harget et al. addressed that the rate of long-standing side effects was up to 62% [12]. One of the most important causes related to above unfavorable outcomes is continuous collapse of the upper pharynx postoperatively [13], because, in conventional UPPP, no anchorage can serve as a strong and effective support for lateral pharyngeal wall and retropalatal space. Therefore, several modified UPPP techniques have been developed [2, 4–6].

In 1993, Woodson et al. described transpalatal advancement pharyngoplasty for forward advancing the palate and enlarging the retropalatal and velopharyngeal space [5]. This technique successfully created bony support by performing palatal flap elevation, palatal osteotomy, tendon lysis, and suturing of the soft palate to the palatal bone. However,

Table 1 Preoperative and postoperative polysomnographic and BMI results among the 10 patients

Patient no.	AHI (events/h)		Mean SaO_2 (%)		Lowest SaO_2 (%)		Stage III + IV (%)		BMI	
	Pre-	Post-	Pre-	Post-	Pre-	Post-	Pre-	Post-	Pre-	Post-
1	103.0	58.0	89.0	94.0	51.2	65.0	0.0	3.2	39.8	43.3
2	62.4	40.0	92.0	95.0	76.0	83.0	4.8	1.4	27.9	27.5
3	40.1	25.9	89.0	93.0	74.0	78.0	0.0	0.0	24.8	23.7
4	62.0	14.6	95.0	96.0	86.0	88.0	0.4	11.8	31.6	31.6
5	86.9	9.6	93.0	94.0	77.0	89.0	0.5	4.9	31.1	30.0
6	123.0	22.2	89.0	95.0	59.0	80.0	8.0	29.0	30.7	31.4
7	79.8	49.7	95.0	95.0	67.0	81.0	0.3	2.5	30.7	29.7
8	95.0	9.3	88.0	95.0	59.0	86.0	0.0	3.5	25.7	28.7
9	57.5	9.2	96.0	99.0	84.0	89.0	0.6	0.0	31.2	26.2
10	62.7	48.5	93.0	92.0	66.0	80.0	0.0	0.0	23.0	24.0
Median	77.2	28.7	91.9	94.8	69.9	81.1	1.46	5.63	29.6	29.6
P	0.005*		0.015*		0.005*		0.069		0.859	

AHI Apnea–Hypopnea Index; *SaO_2* arterial oxygen saturation, *BMI* body mass index, *Pre* preoperative, *Post* postoperative

*Two-tail *P* value < 0.05 with the Wilcoxon signed rank test

comparing with conventional UPPP, the procedures of transpalatal advancement pharyngoplasty were relatively complicated.

We herein designed PM suspension suture technique to create an anchorage point to suspend the soft tissue and prevent further collapse as the philosophy of Woodson's transpalatal advancement pharyngoplasty [5]. Our technique is simplified using PM sling to replace palatal flap elevation and osteotomy (Fig. 1b–d). Starting from this anchorage point, the PM suspension suture can exert appropriate tension to widen and support the LPW and retropalatal space (Fig. 2a).

Another modification of PM suspension suture technique is to simplify the step of dissection over the lateral pharyngeal muscle. In PM suspension suture technique, we use 3-0 Vicryl to grasp and suspend posterior tonsillar pillar mucosa and palatopharyngeal muscle to PM sling instead of muscle dissection and suture. Without the violation of superior constrictor muscle and palatopharyngeal muscle, the possibility of damaging neurovascular structures over parapharyngeal space can be lowered. Therefore, PM suspension suture technique can be done without operative microscope which is necessary in the procedure of lateral pharyngoplasty [4]. The operation becomes safer and less time-consuming.

In addition to offering a simplified surgical procedure, PM suspension suture is an effective technical modification for UPPP indicated by the objective improvements of AHI by follow-up polysomnography. Although there are conflicted results in the previous literatures about the application of pharyngeal cavity reconstruction in UPPP [14, 15], in our study, the postoperative polysomnographic data demonstrated significant improvement in AHI (77.2 ± 25.0 to 28.7 ± 18.8 events/hour; $P = 0.005$), mean arterial oxygen saturation (SaO_2) ($91.9 \pm 2.96\%$ to $94.8 \pm 1.87\%$; $P = 0.015$), and lowest SaO_2 (69.9 ± 11.4 to $81.1 \pm 7.19\%$; $P = 0.005$) (Table 1). However, there were still two main patients' factors that affected the success rate of PM suspension suture in this study. First, all patients were diagnosed as severe OSA who initially treated with CPAP, but failed or cannot tolerate such device. Second, a great majority of patients had unfavorable anatomic features for UPPP (four of the ten patients classified as Friedman stage III) [16]. These two factors could lead to poor prognosis of surgery, but the success rate (using a threshold of > 50% reduction in AHI and an AHI of < 20) of PM suspension suture in our series can be still up to 60%. Due to the above results, preoperative Friedman staging could be an important selection criteria for OSA patients who plan to undergo modified UPPP with PM suspension suture technique.

A major limitation of the present study is the small patient population and no control group. In the future, more patients, the establishment of control group, longer follow-up periods, and additional research on measuring the enlargement of LPW space following PM suspension suture is warranted. Sutures with longer needles and longer absorbable periods could also be applied to maintain stronger PM suspension.

Conclusion

Modified UPPP with PM suspension suture is a simplified surgical technique to effectively enlarge the pharyngeal airway lumen by anterolateral suspension of soft palate and LPW. In appropriately selected patients, this technique can

be a favorable alternative to conventional UPPP in patients with OSA.

Author contributions TLL and SKT contributed equally to this study. SKT designed the procedure of pterygomandibular suspension suture and reviewed the manuscript. TLL and SKT performed the surgery. TLL and YTL collected clinical data and wrote the manuscript. The authors also express their gratitude to Dr. FHW for the contributions to the figures.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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Ethical approval This article does not contain any studies with human participants or animals performed by any of the authors.

Informed consent Non-informed consent was required in this retrospective study which was approved by Taipei Veterans General Hospital's institutional review board.

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