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Comparative study between single-stage multilevel surgery and staged surgery for management of snoring and/or obstructive sleep apnea

Hazem Abdel-Latif Gafar[1], Alaa El-Din Ali Abdulla[1], Youssef Yehia Ghanem[2] and Ahmed Yassin Bahgat[3*]

Abstract

Background: When the nasal obstruction is identified in cases of snoring and/or OSA with suspected oropharyngeal and nasal obstruction, the combination of nasal and palate surgeries is suggested to be conducted in either a single-staged or multi-staged manner. This study aimed to assess the efficacy and safety of combined nasal-palatopharyngeal surgery in a staged versus a single-stage multilevel procedure.

Methods: Prospective randomized comparative study included 60 patients with combined nasal and retropalatal obstruction, > 18 years old, BMI < 40, with snoring and/or mild to moderate OSA (AHI ˂ 30) and ASA < 3. Patients were randomly allocated into three groups (every 20 patients); groups 1 and 2 patients underwent a staged procedure, where group 1 had a nasal surgery as a first step for management of nasal obstruction, followed by a BRP after 3 months and vice versa for group 2 patients, while group 3 patients had a single-stage combined nasal surgery and (BRP). Preoperative and 6 months post-operative SOS, SBPS, ESS scores, and polysomnography data (AHI, ODI) were recorded. Post-operative complications, pain (VAS), and duration of hospital stay were monitored.

Results: Post-operative improvement in SOS, SBPS, EES, AHI, and ODI were similar after a staged or a single-stage multilevel procedure with no significant intergroup differences. Total operative time for single-stage multilevel surgery (80 ± 25 min) was significantly shorter than that for the staged procedure (135 ± 30 min). Post-operative complications were temporary and not severe in both surgical procedures and included wound infection (11.67%) and nasal bleeding (11.67%), which were resolved immediately by firm pressure and nasal packing and suture extrusion (5%). However, it didn't appear to alter anatomical and functional outcomes. Post-operative pain by VAS was significantly higher after a single-stage multilevel procedure (5.8 ± 1.4) compared to (2.8 ± 0.6 and 3.7 ± 0.7, respectively) in groups 1 and 2 that underwent a staged surgery.

Conclusion: Combined nasal surgery and BRP, either staged or single-stage multilevel procedure in the treatment of snoring and/or mild and moderate OSA with nasal obstruction, provide similar successful improvement in subjective and objective findings. A single-stage procedure was safer because of a significantly shorter total operative time, and repeated hospitalization and need for anesthesia were avoided.

Keywords: Snoring, OSA, Nasal-palatopharyngeal, Staged surgery, Combined surgery

*Correspondence: ahmedyassinbahgat@gmail.com

[3] Department of Otorhinolaryngology, Alexandria University, Elazaritta, Alexandria 00203, Egypt
Full list of author information is available at the end of the article

Background

Snoring and/or obstructive sleep apnea (OSA) are worldwide common chronic disorders that affect virtually every organ system and are associated with impaired

quality of life and increased risk of morbidities and mortality [1].

Many factors contribute to snoring and OSA at the same time. Differing levels of obstruction, and personal characteristics (BMI and age), play an essential role in defining the line of treatment [2].

Published data suggested that when a nasal obstruction is identified in cases of OSA with suspected oropharyngeal and nasal obstruction, the combination of nasal and palate surgeries should be conducted in either a single-staged or multi-staged manner [3].

Outcomes of a staged or a single-stage multilevel surgery remain a matter of discussion; it is unclear whether oropharyngeal and nasal surgery should be performed simultaneously or separately because research addressing this issue is scarce [4, 5].

This study aimed to assess the safety, efficacy, and surgical success of the combined nasal-palatopharyngeal surgery when performed in a staged versus a single-stage multilevel procedure.

Methods

This study was conducted in the Otorhinolaryngology-Head and Neck Surgery Department at the Alexandria Main University Hospital. To fulfill the objectives of this study, a prospective randomized comparative approach was adopted.

The target population was confined to 60 patients with combined nasal and retropalatal obstruction, > 18 years old, BMI < 40, with snoring and/or mild to moderate OSA (AHI ˂ 30) and ASA < 3. Patients were randomly allocated into three groups. Group 1 patients ($n = 20$) underwent nasal surgery as a first step for management of nasal obstruction, followed by a BRP after 3 months. Group 2 patients ($n = 20$) underwent a BRP as a first step, then followed by a nasal surgery after 3 months, and group 3; patients ($n = 20$) had a single-stage multilevel surgery, where combined nasal and palate (BRP) surgeries were done at the same sitting.

After obtaining informed written consent, all patients were subjected to a preoperative evaluation (age, sex, BMI, complete otorhinolaryngological examination including awake endoscopy with Muller maneuver, subjective SOS, SBPS, ESS scores, and polysomnography: AHI, ODI events/h). According to the patient's assigned group, they underwent nasal surgery and a BRP in a staged or single-stage multilevel procedure.

The intra-operative evaluation included total operative time and intraoperative bleeding. Post-operative evaluation after 6 months had post-operative data of SOS, SBPS, ESS, AHI, ODI, post-operative complications, post-operative pain (VAS), post-operative hospital stay, and surgical success). Outcomes of the combined nasal-palatopharyngeal surgery, when performed in a staged or single-stage multilevel procedure, were compared using suitable statistical tests, and significance was accepted when $p < 0.05$.

Results

Most of the study patients were males (68.3%); their ages ranged from 23 to 60 years, with a mean age of 42.7 ± 8.7 years and a mean BMI of 33.1 ± 1.6 kg/m^2. Intergroup differences in age, sex, and BMI were not significant (Table 1).

Nasal surgeries done along with BRP in the staged or single-stage procedures depended on the endoscopic findings to treat the nasal component of obstruction. Nasal surgeries included endoscopic septoplasty and endoscopic submucosal diathermy ESD of the inferior turbinate (Table 2).

SOS and SBPS scores improved significantly after 6 months ($p < 0.001$) in patients who underwent staged or single-stage nasal and BRP surgery. ESS score decreased in the 3 study groups from 12.9 ± 2.05, 11.7 ± 4.5, and 12.1 ± 3.8, respectively to 5.5 ± 2.6, 4.9 ± 2, and 5.04 ± 2.2, respectively, this reduction was statistically significant ($p < 0.001$). Intergroup differences for improvements in SOS, SBPS, and ESS scores were not significant (Table 3).

Preoperative AHI events/h. Decreased significantly in the 3 study groups from 24 ± 6, 22 ± 6, and 23.8 ± 5.9, respectively to 11.5 ± 4.2, 9.1 ± 5.8, and 7.7 ± 4.8, respectively, ($p < 0.001$) and intergroup differences were not significant (Table 4).

Intraoperative bleeding and complications were not noticed in staged or single-stage procedures. Total operative time for single-stage multilevel surgery ranged from 60 to 110 min with a mean of 80 ± 25 min; it was significantly less than the whole operative time for the staged procedure, which ranged from 120 to 155 min with a mean of 135 ± 30 min ($p < 0.001$) (Table 5).

Post-operative complications were relatively rare and not severe. In the first two post-operative days, seven patients (11.67%) needed antibiotic treatment for wound infection, and seven (11.67%) developed nasal bleeding, resolved immediately by firm pressure and nasal packing. Suture extrusion was encountered in 3 patients (5%), but it did not appear to alter anatomical and functional outcomes (Table 5). After 6 months follow-up period, post-operative complications were not reported.

Post-operative pain was evaluated using the visual analog scale (VAS).

In the first two post-operative days, we found that VAS ranged from 1 to 7, and the mean VAS score was significantly higher after a single-stage multilevel procedure (5.8 ± 1.4) compared to 2.8 ± 0.6 and 3.7 ± 0.7 respectively in group 1 and 2 patients who underwent

Table 1 Personal characteristics of patients in the 3 study groups

	Surgical procedures			Test of Sig	*P*
	Group 1 Staged nasal then BRP (*n* = 20)	**Group 2 Staged BRP then nasal (*n* = 20)**	**Group 3 Single stage nasal + BRP (*n* = 20)**		
Age (years)					
20–	1 (5%)	0 (0%)	1 (5%)	$\chi^2 = 2.242$	$^{MC}p = 0.960$
30–	8 (40%)	6 (30%)	6 (30%)		
40–	7 (35%)	8 (40%)	8 (40%)		
50 +	4 (20%)	6 (30%)	5 (25%)		
Mean ± SD	40.8 ± 9	44.8 ± 7.7	42.4 ± 9.4	*F* = 1.062	0.352
Median (min.–max.)	40 (23–55)	44.5 (34–60)	42 (23–56)		
Sex					
Female	7 (35%)	8 (40%)	4 (20%)	$\chi^2 = 2.003$	0.367
Male	13 (65%)	12 (60%)	16 (80%)		
Preoperative BMI kg/m^2					
Mean ± SD	32.8 ± 1.8	33.3 ± 1.4	33.4 ± 1.5	*F* = 0.841	0.437
Median (min.–max.)	33 (30–35)	33 (30–35)	33 (30–35)		

SD standard deviation, χ^2 chi-square test, *MC* Monte Carlo,

F F for one-way ANOVA test, pairwise comparison bet. Each 2 groups was done using post hoc test (Tukey)

Table 2 Nasal surgeries done with BRP in OSA patients undergoing staged and single-stage multilevel procedures

Nasal surgery	Freq	Percent
Septoplasty	22	36.67
Septoplasty and inferior turbinate reduction	36	60.00
Bilateral turbinate reduction	2	3.33
Total	60	100

Table 3 Pre- and post-operative SOS, SBPS, and ESS scores in OSA patients who underwent staged and single-stage multilevel surgery

Parameters	Group 1 Staged nasal then BRP (*n* = 20) Mean ± SD	Group 2 Staged BRP then nasal (*n* = 20) Mean ± SD	Group 3 Single stage nasal + BRP (*n* = 20) Mean ± SD	*F* test	*p* value
Pre-SOS	32.8 ± 11.5	34 ± 10.2	33.4 ± 12.1	0.056	0.94
Post-SOS	62.4 ± 12.3	61.7 ± 11.8	62.5 ± 12.04	0.026	0.96
t(p)	*7.86(< 0.001)*	*7.94(< 0.001)*	*7.62(< 0.001)*		
% Change	47.4 ± 9.2	44.8 ± 7.7	46.5 ± 9.4	0.041	0.95
Pre-SBPS	25.2 ± 11.5	23.5 ± 11.4	25 ± 10.01	0.143	0.86
Post-SBPS	60.8 ± 19.2	60.2 ± 17.5	61.04 ± 15.9	0.012	0.98
t(p)	*7.11(< 0.001)*	*7.85(< 0.001)*	*8.57(< 0.001)*		
% Change	58.5 ± 8.2	60.9 ± 9.6	59 ± 9.5	0.05	0.93
Pre-ESS	12.9 ± 2.05	11.7 ± 4.5	12.1 ± 3.8	0.575	0.56
Post-ESS	5.5 ± 2.6	4.9 ± 2	5.04 ± 2.2	0.379	0.68
t(p)	*9.9(< 0.001)*	*6.17(< 0.001)*	*7.49(< 0.001)*		
% Change	50.8 ± 9	54.8 ± 7.7	52.4 ± 9.4	0.011	0.98

F F for one-way ANOVA test, pairwise comparison bet. Each 2 groups was done using post hoc test (Tukey),

t(p) paired *t* test for comparing between pre and post in each group

a staged surgery (Table 6), nevertheless pain subsided in all patients by the end of the first week (VAS < 3) (Table 5). Hospital stay showed no significant intergroup differences.

Surgical success was defined as a ≥ 50% reduction in preoperative AHI with a post-operative AHI < 20, and surgical cure was recorded when AHI events/h. Decreased to < 5 and ESS score < 10, and both were reduced by > 50% after surgery. Surgical cure in the three study groups was 5%, 15%, and 25%, respectively, and surgical success was 80%,80%, and 75%, respectively; on the other hand, surgical failure was 15%, 55%, and 0% respectively. Intergroup differences were not statistically significant ($p = 0.18$) (Table 6).

Discussion

It is now generally accepted that snoring and/or OSA commonly results from narrowing in multiple areas of the upper airway, including the soft palate, lateral pharyngeal walls, and tongue base. Rarely is OSA caused by a single isolated site of obstruction [3]. Nose and soft palate were described as critical anatomic components of obstruction in OSA and, therefore, should be treated as

Table 4 Pre- and post-operative PSG findings (AHI, ODI events/h) in OSA patients who underwent staged and single-stage multilevel surgery

PSG findings	Group 1 Staged nasal then BRP (*n* = 20) Mean ± SD	Group 2 Staged BRP then nasal (*n* = 20) Mean ± SD	Group 3 Single-stage nasal + BRP (*n* = 20) Mean ± SD	*F* test	*p* value
Pre-AHI	24 ± 6	22 ± 6	23.8 ± 5.9	0.682	0.509
Post-AHI	11.5 ± 4.2	9.1 ± 5.8	7.7 ± 4.8	2.98	0.058
t(p)	*7.6(< 0.001)*	*6.91(< 0.001)*	*9.5(< 0.001)*		
% Change	52.8 ± 15.7	56.5 ± 25.4	67.3 ± 15.9	2.79	0.059
Pre-ODI	23.2 ± 5.6	21.7 ± 6	23.5 ± 5.5	0.64	0.58
Post-ODI	10.8 ± 1.4	10 ± 1.5	8.5 ± 2.2	2.86	0.517
t(p)	*9.6(< 0.001)*	*8.46(< 0.001)*	*11.2(< 0.001)*		
% Change	50.7 ± 12.2	52.4 ± 11.5	55.2 ± 12.5	2.66	0.54

F F for one-way ANOVA test, pairwise comparison bet. Each 2 groups was done using post hoc test (Tukey)

t(p) paired *t* test for comparing between pre and post in each group

far as possible as a single-staged or multi-staged procedure [6].

In this study, two types of combined nasal-palatopharyngeal surgery (staged and single-stage multilevel procedures) for snoring and/or mild to moderate obstructive sleep apnea (OSA) were compared for efficacy, safety, and surgical success. Clinically, several case–control studies have shown that nasal obstruction was associated with snoring and mild OSA. However, there was not a linear correlation between the degree of nasal obstruction and the severity of OSA, as the nasal obstruction is not the only contributing factor in the majority of patients with mild or moderate OSA [7].

The baseline characteristics (age, gender, BMI, preoperative subjective, and objective parameters) of patients in the three study groups (who underwent a staged or a single-stage nasal and BRP surgery) were not significantly different. This suggests that the initial characteristics of patients did not influence between-group differences in outcomes. Therefore, it was appropriate to compare the post-operative results of the three groups.

The main complaints of patients before surgery were snoring, daytime sleepiness, nocturnal arousals, and fatigue. Not accepting the CPAP mask as a treatment for OSA.

Table 5 Total operative time, postoperative complications, and pain (VAS) in OSA patients who underwent staged and single-stage multilevel surgery

Operative and postoperative data	Surgical procedures			Test of Sig	(*P*)
	Staged nasal thenpalate (*n* = 20)	Staged palate then nasal (*n* = 20)	Single-stage multilevel (*n* = 20)		
Total operative time (min)	120–155	110–157	60–110	*H* = 42	
Min–max	135 ± 30	130 ± 28	80 ± 25	76	
Mean ± SD	$p_{1=}$ 0.09, $p_2 < 0.001$, $p_{3<}$ 0.001				
Complications					
No complications	15 (75%)	16 (80%)	12 (60%)	$\chi^2 = 7.65$	$^{MC}p = 0.220$
Infection	4 (20%)	1 (5%)	2 (10%)		
Bleeding	1 (5%)	3 (15%)	3 (15%)		
Suture extrusion	0 (0%)	0 (0%)	3 (15%)		
Postoperative pain VAS					
Mean ± SD	2.8 ± 0.6	3.7 ± 0.7	5.8 ± 1.4	*H* = 45.40	< 0.001
Median (min.–max.)	2 (1–3)	3.5 (3–5)	6 (3–7)		
Sig. bet. grps	$p_{1=}$ 0.06, $p_2 < 0.001$, $p_3 = 0.003$				

SD standard deviation, χ^2 chi-square test, *MC* Monte Carlo,

H H for Kruskal–Wallis test, pairwise comparison bet. Each 2 groups was done using post hoc test (Dunn's for multiple comparisons test)

p p value for comparing between the studied groups

p_1 *p* value for comparing between group 1 and group 2

p_2 *p* value for comparing between group 1 and group 3

p_3 *p* value for comparing between group 2 and group 3

Table 6 Surgical success in OSA patients who underwent staged and single-stage multilevel surgery

Surgical success	Group 1 Staged nasal then BRP ($n=20$)		Group 2 Staged BRP then nasal ($n=20$)		Group 3 Single-stage nasal + BRP ($n=20$)		χ^2	^{MC}p
	No	%	No	%	No	%		
Cured	1	5	3	15	5	25		
Success	16	80	16	80	15	75	6.21	0.18
Failure	3	15	1	5	0	0		

χ^2, $p\,\chi^2$ and p values for chi-square test for comparing between the two groups,

^{MC}p p value for Monte Carlo for chi-square test for comparing between the three groups

Although CPAP has been proven to be the most effective non-invasive form of therapy for OSA, unfortunately, previously published research studies have shown that patient compliance with CPAP therapy can be as low as 40 to 50%, and the rate of refusal of CPAP therapy once a patient has been diagnosed can be as high as 24%. Surgical treatment may be an essential alternative option for patients who are not compliant or cannot tolerate CPAP [8–10].

Careful preoperative assessment, including nasopharyngoscopy in an awake state, was conducted to identify septal deviation, enlarged turbinates, inflamed nasal mucosa, and/or adenoid hypertrophy. Muller maneuver [11] was performed in erect and supine positions to ascertain the level of collapse, help determine a targeted approach for the treatment, and exclude patients with tongue base hypertrophy. Muller Maneuver scoring is a reliable method in assessing the site and degree of collapse of the upper airway and has comparable efficacy as with DISE [12].

Subjective surveys (SOS, SBPS, and ESS) for snoring and/or OSA were used in this study. The SOS is a valid, reliable, and disease-specific outcome measure for sleep disturbed breathing (SDB) treatment [13]. The mean preoperative SOS score for our patients was 34.2 ± 12.8.

The subjective SBPS questionnaire was also included because it is usually the sleeping partner's perception of the snoring that motivates the patient to seek treatment [14]. The mean preoperative SBPS score for the studied patients was 27.5 ± 15.6.

The mean preoperative ESS score for our patients was 11.5 ± 4.6, which was a favorable finding because it was reported that sleepy patients were good candidates for surgery. Otherwise, non-sleepy, asymptomatic subjects may focus on the minimal side effects and do not appreciate the good surgical outcomes [15].

Polysomnography was performed, being the gold standard for a definite diagnosis of OSAS. Our patients' apnea/hypopnea index (AHI) ranged from 10 to 29, with a mean of 22.9 ± 6.1. According to the American Academy of Sleep Medicine, based on AHI events/h, the severity of OSA was mild in 15 patients (25%) and moderated in 45 patients (75%). Recently, Camacho et al. [16] showed that AHI was the only factor that independently remained significant in multivariate analysis for both surgical cure and surgical success in OSAS patients.

In this study, *nasal surgery* (endoscopic septoplasty and endoscopic submucosal diathermy ESD of the inferior turbinate) was performed under general anesthesia as a first or second step with *BRP* in staged surgery and combined with BRP in the single-staged procedure.

Nasal surgery appeared to be an excellent therapeutic option as other studies mentioned that it may help OSA patients who do not tolerate CPAP therapy when there is an obstructive factor in the nose. It was also noted that surgical procedures that improve nasal patency have a role in relieving symptoms of simple snoring and multiple-level surgery in patients with OSA [17]. Morrow. et al. found that nasal surgeries were adjuncts that improve breathing in OSA patients [18]. Moreover, a review by Carvalho B et al. stated that the goal of nasal surgery in snoring and/or OSA is to improve nasal airflow by correcting the obstructing structures, such as a deviated septum or enlarged turbinates. Thus far, the literature has shown that nasal surgery alone rarely successfully treats OSA. However, studies did indicate that nasal surgery improved sleep quality. It also helped improve CPAP adherence and compliance by reducing the necessary pressure and increasing hours of use [19].

Li et al. recently addressed the role of nasal surgery in patients with snoring and OSA; they found that complete relief of snoring was achieved in only 12% of patients [20]. Conversely, a significant improvement was observed in the quality-of-life parameters [21].

Furthermore, two meta-analyses investigated the role of nasal surgery in treating patients with snoring and

OSA, and they concluded that ESS improved significantly after isolated nasal surgery, but AHI did not significantly improve [22, 23].

Barbed reposition pharyngoplasty (BRP) was selected for this study as an easy, quick, safe, and effective new palatopharyngeal procedure that can be used in a single level surgery or as a part of multilevel procedures [24, 25]. In addition, Iannella G et al., in a systemic review, concluded that BRP was superior to other traditional techniques (UPPP or ESP), for the management of palatal/oropharyngeal obstruction [26].

Compared to other techniques, BRP guarantees a more significant and stable retraction of the pharyngeal soft tissue due to the latero-lateral traction and the anchorage to the pterygomandibular raphe, an enlargement of the anteroposterior space, and better preservation of the mucosa and muscle tissue [27]. In addition, the minimal muscle and mucosa resection and the absence of knots in the pharynx are well accepted by the patients in terms of invasiveness [6].

Subjective SOS, SBPS, and ESS scores improved significantly after 6 months, whereas confounding influences mainly change in BMI in the three study groups was not different at the time of the post-operative sleep study. The mean % improvement in the 3 study groups was 47.4 ± 9.2, 44.8 ± 7.7, and 46.5 ± 9.4, respectively for SOS scores and 58.5 ± 8.2, 60.9 ± 9.6, and 59 ± 9.5 respectively, for SBPS score. The mean % reduction of ESS score in the 3 study groups was 50.8 ± 9, 54.8 ± 7.7, and 52.4 ± 9.4, respectively.

Objective parameters AHI and ODI events/h dropped significantly after 6 months. Preoperative AHI events/h in the 3 study groups decreased significantly from 24 ± 6, 22 ± 6, and 23.8 ± 5.9, respectively to 11.5 ± 4.2, 9.1 ± 5.8, and 7.7 ± 4.8, respectively.

There was no significant difference between staged and single-stage multilevel procedures regarding the subjective and objective surgical outcomes. In addition, there was no significant association between the mean % reduction in AHI and the preoperative severity grade of OSA.

Coinciding with our results, Li et al., in their retrospective study that compared the outcomes of two types of combined nasal-palatopharyngeal surgery (simultaneous and staged) for the treatment of OSA, found that collected data indicate that surgical results in a concurrent surgery group were equivalent to those in a staged surgery group [28].

Other studies stated that nasal surgery performed in staged or single-stage multilevel procedures improved ESS scores [22, 29].

A study by Madkikar N et al. found that single-stage nasal surgery along with BRP caused a reduction of the AHI to mean value from 40.6 to 10.2 ($p < 0.001$), ODI from 42.7 to 12.6 ($p < 0.001$) and a 10 points reduction on ESS score [6].

In a recent systematic review, four studies reported results of BRP in a multilevel surgery setting where authors observed that BRP improved post-operative AHI values and caused a higher surgical success rate in a multilevel surgery than in other traditional palate surgeries [26].

In the preliminary study of Vicini et al., they described and assessed the BRP and an objective clinical improvement was confirmed by polysomnography 6 months post-operative with a significant decrease in mean AHI from 43.65 ± 26.83 to 13.57 ± 15.41 ($p = 0.007$), daytime sleepiness assessed by Epworth Sleepiness Scale from 11.6 ± 4.86 to 4.3 ± 2 ($p = 0.01$), ODI from 44.7 ± 27.3 to 12.9 ± 16.3 ($p = 0.004$) [30].

The effectiveness of BRP has also been tested using a randomized clinical trial, where a linear regression showed that higher baseline AHI predicts more significant post-operative absolute AHI reduction [25]. Moreover, Bahgat YS et al. assessed BRP as a step in a single multilevel procedure and indicated that the more severe the preoperative OSA, the more benefit gained from the technique [31]. Also, Camacho et al. registered a significant effect for AHI (< 30 events/h vs. > 30 events/h) on the likelihood of surgical cure [16]. On the contrary, this study did not find an association between OSA severity and surgical outcomes. This may be attributed to the fact that patients with severe OSA were not included in this study.

Total operative time in this study was significantly longer in staged surgery compared with the single-stage multilevel procedure. In agreement with our results, a systematic review found that BRP was the quickest palatal technique and was recommended in multilevel single-stage procedures [26]. Madkikar N et al. mentioned that multilevel single-stage procedures reduced operative time and the risk and economic burden on the patients by avoiding repeated hospitalization and the need for anesthesia [6].

Intra and post-operative complications in this study were relatively rare and not severe. In the first two post-operative days, seven patients (11.67%) needed antibiotic treatment for wound infection, and seven (11.67%) developed nasal bleeding, resolved immediately by firm pressure and nasal packing. Suture extrusion was encountered in 3 patients (5%), but it did not appear to alter anatomical and functional outcomes. In the last follow-up visit (6 months), post-operative complications were not reported. Moreover, no significant association was found between the occurrence of complications and the surgical procedure adopted.

This study's results are consistent with previous studies showing that BRP in a staged or single-stage multilevel procedure did not carry additional risk. A recent study by El-Bassiouny stated that after a single-stage multilevel BRP and nasal surgery, a few minor complications were observed, but they were temporary and resolved without sequelae. No recorded cases of immediate post-operative respiratory compromise or cardiovascular complications.

A systematic review of the current literature, which analyzed the last 10 years of literature on barbed palate surgery (15 studies), stated that there were no significant intraoperative or post-operative complications in all patients (1061) who underwent a BRP [26].

Montevecchi et al., in a multicentric prospective study of 111 patients who underwent BRP, reported 93% of patients without intraoperative complications (103 pts); partial extrusion was found in 3 cases, intra operative self-limited bleeding in 3 cases, a suture rupture in 1 case, and a needle rupture in 1 patient were observed [24].

Gulotta et al. studied 488 patients treated with BRP and/or multilevel TORS. Extrusion suture rate was suture-type sensitive (V-Loc > Stratafix) and more frequent when BRP has performed alone than BRP-TORS and occurred in 76.7% within 2 months after the discharge [32]. Bahgat YS et al. found that the most crucial early complication in BRP was suture extrusion. Dysphagia developed in 45% of patients but didn't persist beyond one week. It was attributed to either suture extrusion, or the tongue base procedure performed simultaneously [31].

Busaba NY retrospectively compared post-operative complications between same-stage nasal palatopharyngeal and staged-surgery groups and concluded that same-stage nasal palatopharyngeal surgery was safe for OSAS patients with nasal obstruction [33].

In a randomized clinical trial by Vicini C et al. in 2020 to detect the effectiveness of BRP in treating OSA, no significant complications (e.g., bleedings and severe dysphagia) were recorded [25].

On the other hand, post-operative complications were recorded by other researchers. Iannella et al. studied post-operative outcomes of 140 patients who underwent barbed reposition pharyngoplasty (BRP) and were evaluated in a short- and long-term follow-up (average 26 months). 51% of patients complained of swallowing problems after surgery. In 91% of cases, the problem cleared up spontaneously. During the last follow-up, rhinolalia was observed in 8% of patients, whereas nose regurgitation was present in 2% of patients, and in 20% of patients, the foreign body sensation was present [34].

In addition, Li HY et al., in their retrospective study, found that simultaneous nasal–palatopharyngeal surgery had a few disadvantages. One of the significant disadvantages was the risk of severe complications such as respiratory and cardiovascular complications [28].

Moreover, Hsu PP had the impression that performing staged procedures is a safer option in the surgical management of patients with moderate to severe OSA, as nasal packing with a blood clot after nasal surgery will further compromise the narrow, obstructed upper airway of patients with mild to severe OSA if nasal surgery is performed first or concurrently [35].

Post-operative pain in this study was evaluated using the visual analog scale (VAS). In the first two post-operative days, we found that VAS was significantly higher after a single-stage multilevel procedure (5.8 ± 1.4) compared to 2.8 ± 0.6 and 3.7 ± 0.7, respectively) in groups 1 and 2 patients who underwent a staged surgery. At the end of the first week, the pain subsided in all patients (VAS < 3).

In agreement with other studies, when pain profile was monitored, they found that pain was significantly higher in multilevel procedures [3, 36]. Moreover, Bahgat YS et al. stated that after BRP, the mean visual analog scale was 4 in the first 2 days, increasing to 7 on the fourth day, then decreased to 1 on the sixth and seventh day. The pain completely subsided after the first week [31].

Post-operative hospital stay in this study lasted for one or 2 days. It showed no significant difference between patients who underwent a staged or a single-stage multilevel surgery similarly in a multicentric study evaluating clinical outcomes and complications of BRP. The average hospitalization period was 2.5 ± 0.5 days [24].

Contrary to our results, Li et al. 2005, in their retrospective study, concluded that single-stage multilevel surgery could lower the total hospitalization time and expenses when compared to multi-staged surgery [37], and Holly JE et al. stated that surgical techniques for treating snoring and/or OSA were challenging and time-consuming. Dysphagia was the primary post-operative concern of all patients, ranging from 8 to 70 days post-operatively (mean, 20.4 days), requiring more extended hospital stay to receive parenteral nutrition [38].

Surgical success, cure, and failure showed no significant differences between staged or single-stage multilevel surgery. Surgical treatment in the three study groups was 5%, 15%, and 25%, respectively, and surgical success was 80%, 80%, and 75%, respectively on the other hand, surgical failure was 15%, 55% and 0% respectively.

Similarly, a systematic review by Iannella G et al. reported that post-operative surgical success rate of BRP alone or in a multilevel single-stage procedure ranged between 64.5 and 93% [26]. In another study by Bahgat YS et al., the surgical success of BRP with or without

concomitant procedures was 70%, and it increased to 90% in severe OSA patients [31]. In addition, Li HY et al., in their retrospective study, found that simultaneous nasal–palatopharyngeal surgery was as effective and satisfactory as staged surgery [28].

Limitations

Our study had certain limitations; the small sample size, long-term outcomes, and complications could not be examined because of the short follow-up period, and being a staged or a single-stage multilevel procedure, it was difficult to quantify the contribution of surgical procedures to the outcome on snoring, daytime sleepiness, and polysomnography parameters.

Conclusion

Combined nasal surgery and BRP, either staged or single-stage multilevel procedures for treating mild and moderate OSA, showed equivalent efficacy and surgical success. In addition, single-stage multilevel surgery (nasal surgery and BRP) was safer than a staged procedure since total operative time was significantly shorter and repeated hospitalization and need for anesthesia were avoided.

Further studies with a significant number of patients, possibly in a multicenter setting, and a more extended follow-up period are strongly recommended in the future.

Abbreviations

OSA: Obstructive sleep apnea; BMI: Body mass index; AHI: Apnea hypopnea index; ASA: American Society of Anesthesiologists; BRP: Barbed reposition pharyngoplasty; ODI: Oxygen desaturation index; SOS: Snore outcome survey; SBPS: Spouse/Bed Partner Survey; ESS: Epworth sleepiness scale; VAS: Visual analog scale; CPAP: Continuous positive airway pressure; DISE: Drug-induced sleep endoscopy; UPPP: Uvulopalatopharyngoplasty; TORS: Transoral robotic surgery.

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Authors' contributions

AB performed surgeries on patients, and designed the work. YG acquired, analyzed, and interpreted data of the work. AA involved in drafting the work and revising it critically for important intellectual content. HG had major role in final approval of the version to be published. All authors read and approved the final manuscript.

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Availability of data and materials

The datasets used and/or analyzed during the current study available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

This study was approved by the ethics committee of Alexandria University. Informed written consent was obtained from all individual participants included in the study.

Consent for publication

Not applicable.

Competing interests

All authors declare that they have no competing interests.

Author details

[1]Faculty of Medicine, Alexandria University, Elazaritta, Alexandria 00203, Egypt. [2]Specialist of Otorhinolaryngology, Borg-El Arab University Hospital, Borg-El Arab, Egypt. [3]Department of Otorhinolaryngology, Alexandria University, Elazaritta, Alexandria 00203, Egypt.

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