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Original Article

Five-Year Subjective Outcomes of Obstructive Sleep Apnea Surgery: A Multiinstitutional Study

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Objectives. To evaluate the effect of obstructive sleep apnea (OSA) surgery on long-term (5-year) subjective outcomes, including sleep disordered breathing (SDB) symptoms and other complications, in patients with OSA.

Methods. We enrolled patients who underwent diagnostic polysomnography for OSA between January 2006 and December 2006 in ten hospitals. Patients either were treated for OSA or were not treated for OSA. All patients completed a brief telephone survey regarding their SDB signs and symptoms (e.g., snoring, apnea, nocturnal arousals, and daytime sleepiness), positive airway pressure (PAP) compliance, and any adverse effects of either the surgery or PAP. A positive subjective outcome for either surgery or no treatment was taken to be the alleviation of apnea, defined as a ≥50% increase in score. A positive subjective outcome (compliance) for PAP was defined as a PAP usage of ≥4 hours per night and ≥5 days per week.

Results. A total of 229 patients were included in this study. Patients were divided into three groups: a surgery group (n=87), a PAP group (n=68), and a control (untreated) group (n=74). The surgery group exhibited significant improvement in all SDB symptoms compared with the control group. The long-term subjective outcomes of the surgery (52.9%) and PAP (54.4%) groups were significantly better than those of the control group (25.0%). The subjective outcome of the surgery group was not significantly different from that of the PAP group. The overall surgical complication rate was 23.0% (20 of 87) in the surgery group, and 55.0% (22 of 40) of all patients with PAP experienced adverse effects.

Conclusion. The extent of SDB symptoms was consistently improved in patients with OSA at 5 years postsurgery. Information about the potential long-term subjective outcomes should be provided to patients when considering surgery.

Keywords. *Obstructive Sleep Apnea; Surgery; Signs and Symptoms; Treatment Outcome*

INTRODUCTION

Obstructive sleep apnea (OSA) is a relatively common chronic sleep disorder characterized by repeated episodes of narrowing or collapse of the upper airway [1]. Several pathophysiological mechanisms have been associated with OSA [2-4]. If left untreated, OSA can be manifested by many symptoms and com-

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plications [2,5]. To prevent these symptoms and complications, the early detection and effective management of OSA are both extremely important.

Primary therapeutic options for OSA include the application of positive airway pressure (PAP) and surgical modifications of the upper airway [2]. Currently, PAP is recommended for the cardinal management of OSA; this therapy has been shown to be highly effective when used during sleep [6,7]. However, some patients are intolerant to PAP due to its various side effects, including mask leakage, nasal obstructions, and pressure intolerance [7,8]. Upper airway surgery can be considered in patients who have a surgically-correctable obstructing structure (primary indication) or who fail nonsurgical treatments such as PAP (secondary indication) [2,8]. However, surgical procedures also have several limitations, including relatively low success rates in unselected patients, unpredictable results, and the possibility of perioperative or postoperative complications [2,9].

Numerous studies have indicated that OSA surgery can alleviate many subjective sleep-disordered breathing (SDB) symptoms [10,11]. However, few studies have examined the long-term (greater than 5 years) effects of OSA surgery on subjective outcomes, such as SDB symptoms and adverse effects [12]. Furthermore, comparative analyses of subjective outcomes between surgery, PAP, and control groups have been insufficient [13]. Therefore, the objectives of this study were: (1) to investigate the effectiveness of surgery for adult patients with OSA on long-term (5-year) subjective outcomes, including SDB symptoms and complications; and (2) to compare subjective treatment outcomes among the surgery, PAP, and control (untreated) groups.

MATERIALS AND METHODS

Study protocol

This study was comprised of a multi-institutional retrospective chart review and a telephone survey. The study protocol was reviewed and approved by the Institutional Review Board of each of the ten participating hospitals (Asan Medical Center, Busan St. Mary's Medical Center, Konkuk University Hospital, Korea University Ansan Hospital, Kyung Hee University Medical Center, Pusan National University Hospital, Samsung Medical Center, Seoul National University Bundang Hospital, Seoul National University Hospital, and Severance Hospital), as well as the Korean Rhinologic Society Sleep and Sleep Physiology Study Group.

Subjects

Adults meeting the following inclusion criteria were included in the study: (1) underwent diagnostic polysomnography and had been diagnosed with OSA; (2) had undergone upper airway surgery to treat OSA (surgery group), had been treated with PAP (PAP group), or had not received any treatment (control group) between January 2006 and December 2006. The following exclusion criteria were applied to the adult patients: (1) had received any other therapeutic treatment (e.g., oral appliance, positional therapy, etc.) during the same period; (2) lack of available medical records; (3) could not be contacted by telephone; and (4) refused to participate in the present study.

Surgical procedures

All patients in the surgery group underwent surgical modifications of the upper airway to treat OSA. Surgical procedures include the following: (1) palatal surgery (e.g., uvulopalatopharyngoplasty [UPPP], uvulopalatal flap, etc.) and/or nasal surgery (e.g., turbinoplasty, septoplasty, etc.); and (2) palatal surgery combined with tongue base surgery (e.g., radiofrequency tongue base ablation, genioglossus advancement, etc.) and/or nasal surgery. All surgical managements were performed at the operating surgeon's discretion, based on the suspected level of obstruction.

Questionnaire

Surgery group

Each patient completed a brief telephone survey regarding the presence of SDB symptoms (e.g., snoring, apnea, nocturnal arousals, and daytime sleepiness) and adverse effects related to surgery (e.g., foreign body sensations, velopharyngeal incompetence, dry throat, voice changes, speech alterations, etc.). To evaluate the SDB symptoms before (5 years ago) and after surgery (at present), a 6-point Likert scale ranging from 0 (none of the time) to 5 (all of the time) was used. In addition, yes or no questions were used to determine the presence of adverse effects after surgery (at present). Improvement was defined as a symptom score at present that was decreased by at least one point compared with its value 5 years ago. A positive subjective outcome in the surgery group was taken to be the alleviation of apnea, defined as a score difference of $\geq$50% between 5 years ago and the present time.

PAP group

Each subject completed a brief telephone survey regarding subjective PAP compliance (defined as a PAP usage of $\geq$4 hours per night and $\geq$5 days per week) and the presence of adverse effects related to PAP (e.g., mouth leakage, mask problems, noise, nasal obstructions, pressure intolerance, etc.). To investigate subjective PAP compliance (at present), a yes or no question was asked. In addition, yes or no questions were used to identify adverse effects associated with PAP (at present). The subjective outcome in the PAP group was defined as the subjective compliance rate.

Control group

Each subject completed a brief telephone survey regarding SDB symptoms (e.g., snoring, apnea, nocturnal arousals, and daytime sleepiness) and reasons for avoiding treatment (e.g., discomfort, improvement of symptoms, a busy lifestyle, financial reasons, no

familial support, etc.). To assess differences in SDB symptoms between 5 years ago and the present, a 6-point Likert scale ranging from 0 (none of the time) to 5 (all of the time) was used. In addition, yes or no questions were used to examine the reasons for which treatment was not sought. As described above, improvement was defined as the alleviation of symptoms, defined as a score at present at least one point lower than its value 5 years ago. The subjective outcome in the control group was designated as the alleviation of apnea, defined as a ≥50% difference in the score from 5 years ago from the present score.

Statistical analysis

Continuous data are presented as mean±SD, and categorical data are expressed as frequencies (percent). One-way analysis of variance tests were used to compare the average age, body mass index (BMI), and apnea-hypopnea index (AHI) among the surgery, PAP, and control groups. Chi-square tests were used to compare the sex and subjective outcomes among the three groups, and also to compare the extent of SDB symptoms (e.g., snoring, apnea, nocturnal arousals, and daytime sleepiness) between the surgery and control groups. In this study, multiple comparisons were performed with Bonferroni *post hoc* tests. Binary logistic regression analysis (method=Enter) models were used to evaluate the impact of potential variables (e.g., age, sex, BMI 5 years ago, BMI at present, and AHI 5 years ago) on symptom improvement and subjective outcome. Statistical analyses were performed with the IBM SPSS ver. 20.0 (IBM Co., Armonk, NY, USA). Values of $P<0.05$ were considered to be statistically significant.

RESULTS

Subjects

A total of 229 patients were included in this study; their baseline data are shown in Table 1. The mean patient age (±SD) was 48.2±14.2 years, and the male:female ratio was 200:29. The mean BMI 5 years ago was 26.3±3.4 kg/m^2, and the mean BMI at present was 26.2±2.9 kg/m^2. The mean AHI 5 years ago (events/hour) was 36.6±22.2. The subjects were divided into three groups: (1) the surgery group (n=87); (2) the PAP group

Table 1. Patient baseline data (n=229)

Variable	Surgery (n=87)	PAP (n=68)	Control (n=74)	*P*-value
Age (year)	44.1±13.4[a)]	54.1±12.1[b)]	47.5±15.0[a)]	<0.001*
Sex (male:female)	78:9	59:9	63:11	0.681
Body mass index (kg/m^2)				
5 Years ago	26.5±3.1	26.8±3.6	25.6±3.6	0.074
Present	26.3±2.7	26.3±3.2	25.9±2.9	0.681
AHI 5 years ago	33.2±20.5[a)]	46.7±21.0[b)]	31.3±22.3[a)]	<0.001*

Values are presented as mean±SD.
PAP, positive airway pressure; AHI, apnea-hypopnea index.
*$P<0.05$, statistically significant difference between the groups ([a)] and [b)]).

Table 2. Comparisons of improvements in subjective symptoms between the surgery and control groups

Variable	Surgery	Control	*P*-value
Snoring			0.004*
Improvement	58 (66.7)	32 (43.2)	
No improvement	29 (33.3)	42 (56.8)	
Apnea			0.001*
Improvement	60 (70.6)	31 (43.7)	
No improvement	25 (29.4)	40 (56.3)	
Nocturnal arousals			0.046*
Improvement	33 (64.7)	22 (43.1)	
No improvement	18 (35.3)	29 (56.9)	
Daytime sleepiness			<0.001*
Improvement	49 (66.2)	17 (27.0)	
No improvement	25 (33.8)	46 (73.0)	

Values are presented as number (%). Improvement was defined as the alleviation of the symptom, which was taken to be a score improvement by one point or more from 5 years ago to the present.
*$P<0.05$, statistically significant difference between surgery and control groups.

Table 3. Subjective symptoms in the surgery group compared to control group after adjustment for potential variables

Variable	Odds ratio	95% CI	*P*-value
Snoring improvement			
Control	Reference		
Surgery	3.304	1.624–6.722	0.001*
Apnea improvement			
Control	Reference		
Surgery	3.744	1.784–7.858	<0.001*
Nocturnal arousals improvement			
Control	Reference		
Surgery	3.598	1.451–8.923	0.006*
Daytime sleepiness improvement			
Control	Reference		
Surgery	5.860	2.648–12.969	<0.001*

Improvement was defined as the alleviation of the symptom, which was taken to be a score improvement by one point or more from 5 years ago to the present.
CI, confidence interval.
*$P<0.05$, statistically significant difference.

Table 4. Comparisons of subjective outcomes in the surgery, PAP, and control groups

	Surgery	PAP	Control	*P*-value
Subjective outcome	45/85 (52.9)[a)]	37/68 (54.4)[a)]	18/72 (25.0)[b)]	<0.001*
No. of patients with favorable outcome	45	37	18	
No. of patients without favorable outcome	40	31	54	

Values are presented as number (%). The subjective outcome in the surgery and control groups was designated as the alleviation of apnea, defined as a difference in score ≥50% from 5 years ago to the present. The subjective outcome in the PAP group was defined as the subjective compliance rate.
PAP, positive airway pressure.
*P<0.05, statistically significant difference between the groups ([a)] and [b)]).

Table 5. Subjective outcomes in the surgery and PAP groups compared to control group after adjustment for potential variables

Favorable subjective outcome	Odds ratio	95% CI	*P*-value
Control	Reference		
Surgery	3.245	1.624–6.484	0.001*
PAP	3.642	1.705–7.779	0.001*

The subjective outcome in the surgery and control groups was designated as the alleviation of apnea, defined as a difference in score ≥50% from 5 years ago to the present. The subjective outcome in the PAP group was defined as the subjective compliance rate.
PAP, positive airway pressure; CI, confidence Interval.
*P<0.05, statistically significant difference.

(n=68); and (3) the control (untreated) group (n=74).

The mean ages and AHI 5 years ago were significantly different between the surgery group and the PAP group and between the control group and the PAP group. No significant differences in sex or BMI were found.

Symptoms

The extents of improvement in subjective symptoms between the surgery and control groups are compared in Table 2. The surgery and control groups exhibited significantly different extents of various symptoms such as snoring (P=0.004), apnea (P=0.001), nocturnal arousals (P=0.046), and daytime sleepiness (P<0.001). Compared to the control group, the surgery group had better results related with improvements of symptoms including snoring (P=0.001), apnea (P<0.001), nocturnal arousals (P=0.006), and daytime sleepiness (P<0.001) after adjustment for age, sex, BMI 5 years ago, BMI at present, and AHI 5 years ago (Table 3).

Subjective outcomes

The subjective outcomes in the surgery, PAP, and control groups are compared in Table 4. The subjective outcomes were significantly different between the surgery group and the control group and between the PAP group and the control group (P<0.001). Compared to control group, surgery (P=0.001) and PAP (P=0.001) groups have better subjective outcomes after adjustment for age, sex, BMI 5 years ago, and AHI 5 years ago (Table 5).

Adverse effects

In the surgery group, 20 out of 87 patients (23.0%) experienced adverse effects. The most common adverse effect was a foreign body sensation (n=9), followed by velopharyngeal incompetence (n=4), dry throat (n=3), voice changes (n=2), speech alterations (n=1), and hyposmia (n=1).

In the PAP group, 22 out of 40 patients (55.0%) experienced adverse effects. Mouth leakage (n=13) was the most common complaint, followed by mask problems (n=9), noise (n=4), nasal obstructions (n=4), pressure intolerance (n=4), and skin problems (n=3).

Untreated reasons

In the control group, the most common reason for avoiding treatment for 5 years was discomfort (n=21), followed by an improvement in symptoms (n=19), a busy lifestyle (n=18), financial reasons (n=17), and a lack of familial support (n=2).

DISCUSSION

The current study was designed to determine the effects of surgical treatment for OSA on patient long-term subjective outcomes. The two aims of this study were to compare (1) the extent of improvement in subjective symptoms between the surgery and control groups; (2) the subjective outcomes of the surgery, PAP, and control groups. The data presented here indicate that: (1) the surgery group exhibited significant improvements in various SDB symptoms, including snoring, apnea, nocturnal arousals, and daytime sleepiness, compared with the control group; (2) the long-term subjective outcomes of the surgery and the PAP groups were more favorable than those of the control group; however, no significant differences were observed between the subjective outcomes of the surgery and the PAP groups.

Upper airway surgery is well known to improve diverse subjective symptoms in patients with OSA [10,11]. For instance, Weaver et al. [10] reported that isolated UPPP favorably influenced many subjective outcomes such as physical symptoms (e.g., snoring, sleep apnea, morning headaches, and excessive daytime sleepiness) and the sleep-related quality of life (as assessed by the Functional Outcomes of Sleep Questionnaire) at 3 and 6 months in patients with OSA. Most studies have focused

on the short-term outcomes of OSA surgery. However, some studies have also investigated the long-term effects of surgical therapy for OSA [12]. For instance, Goh et al. [12] investigated the long-term (more than 17 years) effects of UPPP on multiple subjective outcomes, including clinical benefits (e.g., snoring, excessive daytime sleepiness, and nocturnal arousals) and late complications (e.g., dry throat, velopharyngeal incompetence, foreign body sensations, speech alterations, and swallowing abnormalities) in unselected OSA patients. This study found that UPPP was associated with the alleviation of various SDB symptoms; however, UPPP was also associated with a higher risk of long-term unfavorable effects, such as a loss of the favorable effects of surgery over time and more common postoperative complications than generally predicted [12].

In the present study, both upper airway surgery and PAP yielded better results compared with the absence of any treatment [14]. Lojander et al. [14] carried out a randomized 1-year follow-up study to estimate the therapeutic and side effects of surgery or PAP compared with conservative management in patients with OSA. This study found that both surgery and PAP were more effective than conservative management; however, each treatment was accompanied by specific problems such as postoperative complications (e.g., velopharyngeal insufficiency and infection), or side effects related to PAP (e.g., rhinorrhea, mask discomfort, dry nose and throat, and disturbances resulting from machine noise) [14]. The postoperative complication rate in this study (22%) was quite similar to that found in the present study (23%). In our study, no major complications were found at 5 years postsurgery.

According to the recent clinical guidelines for adult OSA, the majority of upper airway surgeries are not curative, based on the polysomnographic findings from unselected patients [2]. However, the objective effects of maxillomandibular advancement are consistent with those of PAP in the majority of patients [2,15]. Although it is very difficult to measure the efficacy of surgery against the efficacy of PAP, some strategies have been used to do so [16]. To determine whether the objective outcomes of a surgical protocol were comparable to those of PAP therapy, Riley et al. [16] compared the posttreatment polysomnographic data from patients who underwent maxillofacial surgery and those who underwent PAP. This study found no significant differences in sleep quality (e.g., amount of deep sleep, amount of rapid eye movement sleep, and wake after sleep onset) or any of the respiratory parameters examined (e.g., respiratory disturbance index, lowest SaO_2, and number of SaO_2 measurements below 90%) between the two treatments [16]. Robinson et al. [13] compared the extents of snoring and excessive daytime sleepiness using the Epworth Sleepiness Scale (ESS) and the long-term qualities of life using the Glasgow Benefit Inventory (GBI) between surgery and PAP groups. This study found no significant differences between the extents of snoring, the ESS scores, or the GBI scores between the two groups.

One of the strengths of the present study was that it included 229 subjects from ten hospitals. However, this clinical research study did have some limitations. First, this study was not a prospective randomized controlled study; rather, it consisted of a multi-institutional retrospective chart review and a telephone survey. Second, this study only assessed subjective outcomes via telephone surveys. Further studies are needed to determine the effects of surgery on other long-term objective outcomes, such as polysomnographic data. Third, the subjective outcome criteria in the surgery group differed from those in the PAP group. To the best of our knowledge, this is the first study to compare subjective outcomes using subjective criteria between surgery and PAP groups. We made every attempt to make adequate comparisons by establishing the appropriate criteria for the subjective outcomes based on the objective criteria in each group before the study began. Fourth, 5 years ago the mean ages and AHIs were higher in the PAP group than in the surgery and control groups. Thus, the results of our study may not be representative of the general population with SDB.

In conclusion, this study found that SDB symptoms were effectively alleviated with upper airway surgery; and although no serious complications were observed, persistent adverse effects can occur in some patients with OSA who undergo surgery. Therefore, when considering surgical treatments for OSA, patients should be provided with adequate information regarding the long-term subjective outcomes of such treatments, including their effects on symptoms and their adverse effects.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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