


AHI Outcomes Are Superior after Upper Airway Reconstructive Surgery in Adult CPAP Failure Patients

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Abstract

Objective. This study aims to evaluate Apnea-Hypopnea Index (AHI) outcomes of upper airway adult obstructive sleep apnea (OSA) reconstructive surgery, as compared with outcomes of suboptimal continuous positive airway pressure (CPAP) therapy, in response to reviews claiming unreliable surgical AHI reduction.

Study Design. Prospective cohort study.

Setting. Single-surgeon series at medical centers within Wollongong, Australia.

Subjects and Methods. Adult patients with OSA who were partial device users or who refused CPAP were considered candidates for upper airway surgery (N = 48). Subjects underwent physical examination and polysomnography before and after surgery. Three groups were delineated on the nature of their suboptimal CPAP therapy: group 1, partially using CPAP or refusing long-term CPAP despite adherence (with available download data); group 2, unable or refusing to use CPAP with 2 sleep studies over time; group 3, unable or refusing to use CPAP with 1 sleep study over time. Collected data included demographics and AHI outcomes.

Results. Average AHI across all 3 groups with suboptimal CPAP therapy before surgery was 30.24 ± 17.17 events per hour sleep, as compared with the average postoperative AHI of 7.65 ± 6.59 events per hour sleep. This decrease was shown to be statistically significant with Wilcoxon signed-rank test ($P < .0001$).

Conclusions. AHI outcomes are superior with surgery in untreated or suboptimally treated adult OSA patients prescribed CPAP.

Keywords

upper airway reconstructive surgery, obstructive sleep apnea, continuous positive airways pressure, Apnea-Hypopnea Index, polysomnography

Upper airway reconstructive surgery for patients with obstructive sleep apnea (OSA) who cannot utilize devices has been criticized for not reliably reducing polysomnographic parameters of disease.^{1,2} Continuous positive airway pressure (CPAP) is currently the primary treatment modality for adult patients with moderate to severe OSA. CPAP is highly efficacious in the laboratory, as reflected by a reduction in Apnea-Hypopnea Index (AHI). Although less than ideal, compliant use is generally defined as ≥ 4 hours on $>70\%$ of nights.³ CPAP adherence is highly variable (30%-60%),⁴ depending on various patient and device factors despite technological advancements and efforts to improve the interface and usability.⁵

When CPAP is refused or used suboptimally, upper airway reconstructive surgery is a second-line treatment modality that is not dependent on patient adherence for improved AHI outcomes. Successful surgery has traditionally been defined as $>50\%$ reduction in AHI and AHI <20 .^{5,6} Polysomnographic resolution of OSA with surgery is often difficult to achieve, despite improvements in quality of life and reduction in motor vehicle accidents, cardiovascular risk, and all causes of mortality.⁷⁻¹⁰ Surgery reduces AHI continuously and achieves a relatively consistent AHI throughout the night, as compared with suboptimal use or refusal (untreated) of CPAP therapy.^{3,5} However, a recent systematic review by Caples et al¹ found that surgery does not reliably reduce the AHI, and the purpose

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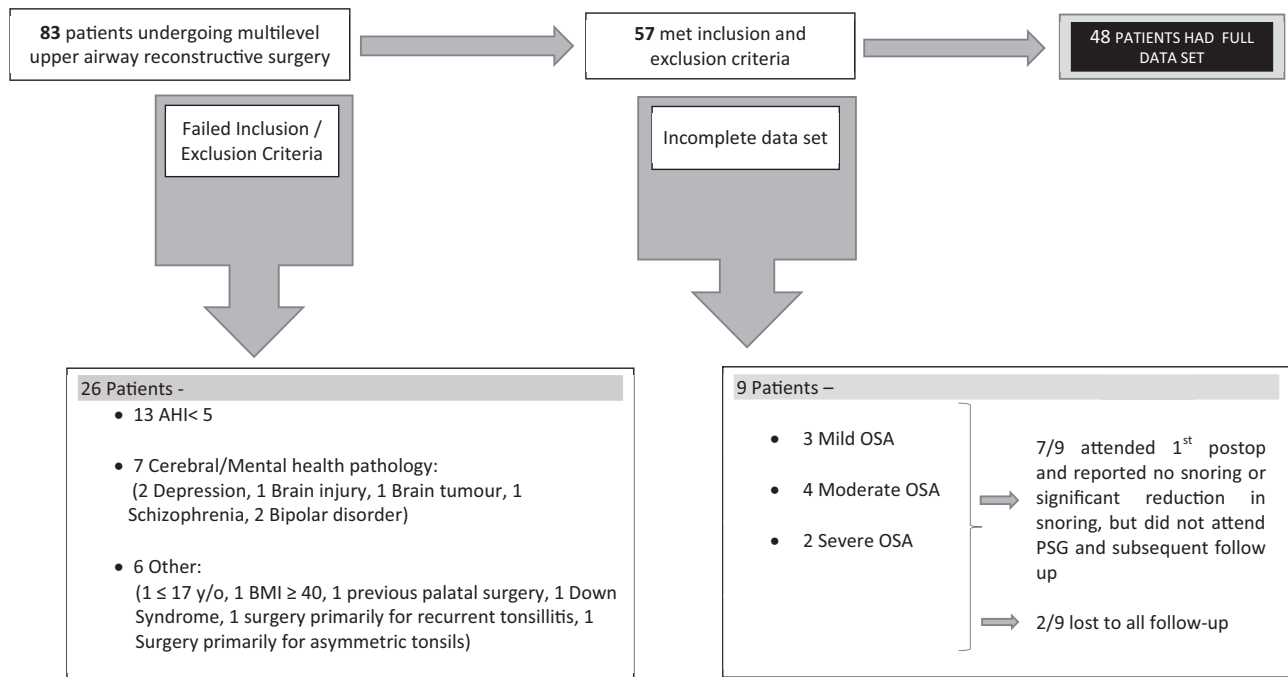


Figure 1. Patient selection and inclusion pathway. AHI, Apnea-Hypopnea Index; BMI, body mass index; OSA, obstructive sleep apnea.

of this article is to provide efficacy (AHI) data following surgery that refute that assertion.

Upper airway reconstructive surgery is favored over ablative or traditional techniques, as recent advancements in reconstructive surgery have seen improvements in patient outcomes and a decrease in complication rates.^{7,11} This study aims to evaluate outcomes of such reconstructive adult OSA surgery, as compared with outcomes of suboptimal CPAP therapy.

Materials and Methods

Study Design

Patients with suboptimal CPAP use or outright refusal who presented to a sleep surgeon with expertise in upper airway reconstructive surgery for OSA between 2010 and 2014 (S.G.M.) were considered for inclusion (**Figure 1**). Ethics approval was obtained from the Human Research Ethics Committee at the University of Wollongong.

Patient Recruitment and Stratification

Patients who consented with complete data sets were included and delineated as follows, according to suboptimal CPAP use:

Group 1: partially using CPAP or refusing long-term CPAP despite adherence (allowing patients to act, in effect, as their “own” controls—ie, control group on CPAP and case group, surgery)

Group 2: unable or refusing to use CPAP with 2 sleep studies over time (allowing patients to act, in effect, as their “own” controls between the first and second study)

Group 3: unable or refusing to use CPAP with 1 sleep study over time (allowing patients to act, in effect, as their “own” controls presuming, conservatively, that there is no change in their disease as measured by AHI from the time of sleep study to surgery)

Pre- and postoperative AHI, age, sex, and body mass index (BMI) data were recorded. Patients were excluded if they had previous airway surgery, were <17 or >75 years of age, had psychiatric illness, or had a BMI >35.

Selection for Surgery

Referred patients underwent comprehensive history and thorough awake clinical evaluation as previously detailed by S.G.M.¹² Polysomnography (PSG) was reviewed and surgical procedure selected in accordance with staged surgical protocol.^{7,12}

Polysomnography

Attended PSG was performed on all patients preoperatively (17.24 ± 23.95 months; median, 8.03 months) and postoperatively (5.87 ± 7.83 months; median, 3.52 months).

Data Analysis and Statistics

For group 1, the average AHI per night while using CPAP was calculated from downloadable data by applying the Ravesloot and de Vries calculation.³ Data were analyzed with XLSTAT and presented as medians and ranges for groups 1, 2, and 3. Wilcoxon signed-rank test assessed the differences between pre- and postoperative variables AHI and BMI, with Cohen's *d* a measure of effect size. *P* value <.05 was considered statistically significant.

Table 1. Patient Demographics: Suboptimal Groups.

Demographics	Group 1 (n = 9)	Group 2 (n = 8)	Group 3 (n = 31)	All (N = 48)
Male, n (%)	6 (66.66)	7 (87.50)	21 (67.74)	34 (70.83)
Age, y, mean ± SD	36 ± 8.1	53 ± 11.5	39 ± 12.4	41 ± 12.7
Body mass index, mean ± SD				
Preoperative	27.4 ± 4.23	27.4 ± 3.00	28.3 ± 4.15	27.9 ± 3.90
Postoperative	26.9 ± 3.04	27.1 ± 2.39	28.5 ± 3.90	27.9 ± 3.49

Table 2. Number and Type of Procedures Performed.

Procedures	n
Modified uvulopalatopharyngoplasty ¹¹	48
Transpalatal advancement pharyngoplasty	21
Coblation channeling tongue ¹¹	47
Inferior turbinoplasties	6
Lingual tonsillectomy	11
Coblation-assisted Lewis and Mackay operation ¹⁶	3
Coblation-assisted uvuloplasty	1
Submucosal lingualplasty ¹⁷	1
Uvulopalatal flap	1

Results and Analysis

Sample size for all 3 groups combined was 48 patients (34 men and 14 women), and the average age was 39 ± 12.9 years (range, 67-17; **Table 1**). **Table 2** indicates the type and total number of each procedure used in a staged surgical protocol. Forty-eight patients had a total of 139 operations, for a mean of 2.9, either concurrently or in a staged manner. One patient out of 48 in this study developed a palatal fistula requiring surgical correction with no further complications. Another patient returned to theater to control a secondary hemorrhage at day 13.

Group 1 (n = 9) had a formal PSG at a median of 7.8 months prior to surgery and showed a statistically significant reduction in mean AHI (37.03 ± 28.25 to 6.09 ± 5.18, *P* = .024; point 1 to point 3, **Figure 2**) postoperatively (*d* = 1.1). Average AHI per night computed during CPAP usage by applying the AHI calculator was 13.67 ± 14.85 (point 2, **Figure 1**). Over half (55%) the patients had a drop in AHI postoperatively (point 2 to point 3, **Figure 1**).

Group 2 (n = 8) had 2 preoperative PSGs performed: one at initial presentation for diagnosis and CPAP treatment and another after intolerance of the device resulted in a period of untreated OSA and further intervention was eventually sought. The first preoperative PSG, performed at a median of 17.5 months preoperatively, had a calculated mean AHI of 31.65 ± 15.44 (**Figure 3**). The second preoperative PSG, performed at a median of 10.6 months preoperatively, had a calculated mean AHI of 33.68 ± 11.83. The follow-up

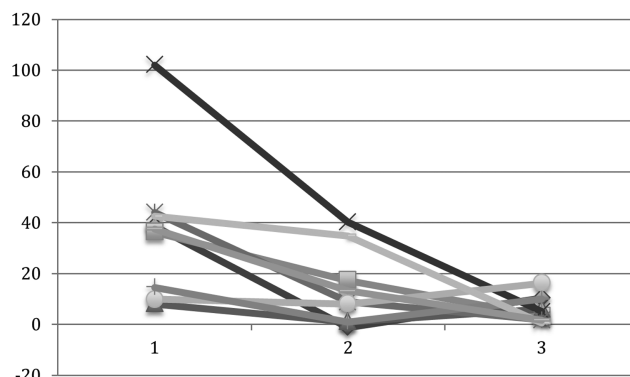


Figure 2. Group 1 (n = 9). Point 1 represents Apnea-Hypopnea Index (AHI) on formal polysomnography. Point 2 represents calculated AHI with continuous positive airway pressure (Ravesloot/de Vries calculation).³ Point 3 represents postoperative AHI.

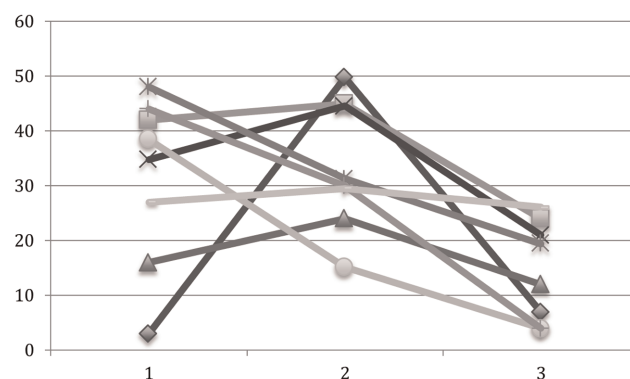


Figure 3. Group 2, suboptimal (n = 8). Point 1 represents Apnea-Hypopnea Index on formal polysomnography. Point 2 represents second polysomnography over time. Point 3 represents postoperative Apnea-Hypopnea Index.

PSG, performed at a median of 4 months postoperation, had a significant reduction in AHI to 14.69 ± 9.05 (*P* = .014).

Group 3 (n = 31) underwent preoperative PSG at a median of 8.1 months and postoperative PSG at a median of 3.5 months after surgery (**Figure 4**). There is a statistically significant reduction in mean AHI from 27.39 ± 13.82 to 6.29 ± 5.09 events per hour sleep (*P* < .0001). These patients refused CPAP outright, and it is assumed that their AHI did not rise from time of diagnosis to time of surgery.

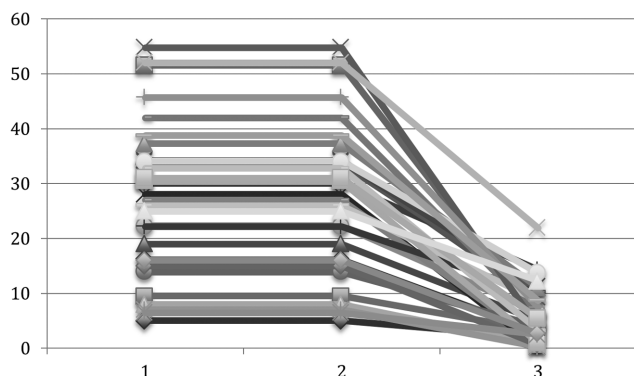


Figure 4. Group 3 suboptimal ($n = 31$): Point 1 represents Apnea-Hypopnea Index (AHI) on formal polysomnography. Point 2 represents presumed stable AHI. Point 3 represents postoperative AHI.

Cumulatively, all patients show a statistically significant reduction in mean AHI from 30.24 ± 17.17 at point 1 to 7.65 ± 6.59 events per hour sleep at point 3 ($P < .0001$), which approaches standard clinical values for a large effect size ($d = 1.32$).

Discussion

The overall findings reveal a statistically significant reduction in mean AHI from 30.24 at point 1 to 7.65 events per hour sleep at point 3 ($P < .0001$). Group 1 was referred for surgery due to partial CPAP adherence, poor tolerance, or long-term refusal. Judging the clinical success of upper airway reconstructive surgery for OSA depends on imposed AHI criteria, so too the effectiveness of CPAP must likewise be measured. To that end, Ravesloot and de Vries generated a formula to estimate the effect that treatment modalities have on AHI respective of compliance.³ It must be emphasized that this is purely an attempt by Ravesloot and de Vries to provide a “mean disease alleviation” concept—it is not to be considered “absolute.”

Six group 1 patients (66.67%) had a calculated average AHI that was consistent with residual disease (AHI >5 per night), despite being on CPAP (point 2, **Figure 2**), with 5 of these patients having a reduction in AHI postoperatively. This finding raises the question of whether some partially compliant CPAP patients remain untreated and monitored less frequently than desirable. The formulas are based on a number of assumptions: (1) AHI reverts to baseline once CPAP is not in use; (2) this value matches the initial diagnostic laboratory sleep study; (3) AHI stays uniform across the night; and (4) 8 hours of sleep represents an average sleeper.³

Group 1 also includes a subset of patients who appeared to achieve their target AHI through initial CPAP use but, due to subsequent partial adherence, were referred for surgery. These patients achieved postoperative outcomes in AHI comparable to their initial CPAP use. CPAP pressures that are titrated to consistently reduce AHI to <5 events per hour with compliant use are ideal.¹³ However, as severity of OSA increases, the required hours of CPAP must also

increase to achieve an adequate decrease in AHI across the night.³ Arbitrary compliance rates may in fact hide insufficient reductions in AHI during sleep time; thus, certain CPAP users may not be receiving effective therapy with >4 hours of CPAP.^{3,4} Five (62.5%) patients in group 2 had a rise in AHI between their 2 preoperative PSGs over an 8-month period, which was not statistically significant. All 5 patients had a subsequent decrease in AHI following surgery.

Currently, the recommendation is for close follow-up during the first few weeks to establish CPAP therapy, then annually thereafter for long-term follow-up.^{13,14} CPAP may be poorly tolerated, which is a significant limitation of treatment. Noncompliance is reportedly between 30% and 60% and is usually established within the first week of therapy, with up to 40% discontinuing treatment after 3 months.^{4,5} Nonadherence is multifactorial due to disease and patient characteristics, treatment titration procedures, technological device factors, and side effects, as well as psychological and social factors, all of which reduce the effectiveness of treatment.⁴ In contrast, surgery has a continuous effect, and patients experience a relatively consistent AHI during sleep.³ When CPAP therapy is refused, fails, or is adhered to partially, contemporary upper airway surgery represents an effective alternative treatment option, as demonstrated in this patient cohort.

Advancements in surgical techniques, such as modification of uvulopalatopharyngoplasty aiming to avoid scarring and inconsistent outcomes,^{11,15} as well as newer technology, have decreased the frequency of complication rates with the added ability for failures to return to CPAP without air leak or complication.^{1,11} A recent systematic review describes a complication profile of between 0% and 16%, with lower complication rates reported in recent years.¹

Changes in BMI have been shown to influence AHI.¹³ The average BMI preoperatively herein was 27.9 ± 3.70 , which remained unchanged postoperatively (27.9 ± 3.49) and did not have an impact on AHI.

This study has several weaknesses. First, the small sample size reduces statistical power, albeit the outcomes are significant. Second, follow-up PSGs were performed at approximately 3 to 6 months postoperatively. Annual and 3-year follow-up is ideal to assess the long-term efficacy of salvage surgery. However, long-term cohort studies demonstrate surgical benefit in relation to quality of life,⁷ less mortality,¹⁰ reduced motor vehicle accident risk,⁸ and lower risk of cardiovascular events,⁹ without describing AHI outcomes specifically.

This study demonstrates that patients partially using CPAP or not at all achieve a better AHI outcome following surgery. Outcomes were not influenced by weight loss, as the average pre- and postoperative BMI remained unchanged.

Conclusion

In our study, AHI outcomes are superior with surgery in untreated or suboptimally treated adult OSA patients prescribed CPAP. Longer-term follow-up is warranted to evaluate the sustainability of these outcomes.

Author Contributions

Samuel Stewart, writing, manuscript preparation, drafting, approval, and agreement; **June Huang**, data collection, statistical analysis, drafting, approval, agreement; **Alok Mohorikar**, data collection, statistical analysis, drafting, approval, agreement; **Andrew Jones**, clinical assessment, revision, approval, agreement; **SueEllen Holmes**, writing, revision, statistical analysis, data collection, manuscript preparation, agreement; **Stuart G. MacKay**, writing, revision, provision of patients, surgery, manuscript preparation, approval and agreement.

Disclosures

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