Immediate and Medium-Term Follow-Up of Patients with Obstructive Sleep Apnea Undergoing Pharyngeal and Nasal Surgery: A Pilot Study

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Abstract

Objectives To evaluate the evolution of obstructive sleep apnea (OSA), comparing data from preoperative, immediate postoperative and late postoperative, in patients undergoing pharyngeal surgery associated with nasal surgery, and to compare the findings of arterial tonometry and type 1 polysomnography in the late postoperative period.

Methods Seventeen adults with moderate or severe OSA were included in the study. They underwent clinical evaluation, surgical intervention, and sleep study preoperatively, on the 1st night after surgery, and after a minimum period of 3 months. The data for the three moments were compared.

Results The mean age was 38.1 ± 12.5 years old (22 to 59 years old), and 82.3% were male. Body mass index (BMI) ranged from 25.6 to 45.1 kg/m2 (mean = 33.1 ± 5.8 kg/m^2). Fifteen patients (88.2%) were diagnosed with severe OSA. There was a progressive improvement, with a decrease in the indexes (AHI and RDI) and in the percentage of time with peripheral oxyhemoglobin saturation below 90% (tSpO < 90%), and an increase in nadir of SpO2. In the comparison between the 2 methods used in the late postoperative period – arterial tonometry and polysomnography – there was no difference in the indexes and in the tSpO < 90%.

Discussion There was a progressive and favorable impact of pharyngeal surgery on the improvement of polysomnographic and clinical respiratory parameters; however, many patients maintained residual OSA, suggesting the need for a new sleep study in the postoperative period. The arterial tonometry showed similar findings to polysomnography, which can be considered as an option in postoperative follow-up of patients.

Keywords
- sleep apnea
- obstructive/surgery
- postoperative period
- polysomnography
- adult

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Introduction

Obstructive sleep apnea (OSA) is a multifactorial syndrome characterized by recurrent episodes of partial or total upper airway obstruction during sleep.[1] Obstructive sleep apnea is a very prevalent disease. A classic study conducted by Young et al.,[2] in 1993, in adults aged between 30 and 60 years old, showed a prevalence of 9% in women and 24% in men, considering the apnea and hypopnea index (AHI) $\geq$ 5 events/hour and 2% in women and 4% in men when considering the presence of excessive daytime sleepiness associated with AHI $\geq$ 5 events/hour. In an epidemiological study conducted in the city of São Paulo, in adults between 20 and 80 years old, the prevalence of OSA was 32.9% in the general population, 40.6% in men and 26.1% in women.[3] In 2015, in an epidemiological study carried out in Switzerland, in adults aged between 40 and 85 years old, the prevalence of moderate-severe OSA (AHI $>$ 15 events/hour) was 23.4% in women and 49.7% in men.[4] In a systematic review of the literature published in 2017, the authors found a prevalence of 9 to 38% in the general population, considering AHI $\geq$ 5 events/hour.[5]

There are several treatment modalities for OSA, with continuous positive airway pressure (CPAP) being the gold standard of treatment.[6] The surgical procedures performed for the treatment of OSA aim to unblock the upper airway and/or decrease its collapsibility. This seeks to control OSA or improve the permeability of the upper airway to facilitate adaptation to CPAP.

There is no consensus in the literature on the ideal follow-up of patients with OSA undergoing surgical treatment. Patients should be monitored and reassessed by a sleep study after a healing period, but there is no consensus on the ideal time after surgery.[7]

The aim of the present study was to evaluate the evolution of OSA, comparing data from the preoperative period, the immediate postoperative period, and the late postoperative period, in patients undergoing pharyngeal surgery associated with nasal surgery, as well as comparing the findings of arterial tonometry – Watch-PAT 200 (Itamar Medical Ltd., Israel) – and polysomnography (PSG) type 1 in the late postoperative period of patients undergoing pharyngeal surgery associated with nasal surgery.

Material and Methods

We included adults (age $\geq$ 18 years old) with moderate or severe OSA (AHI $\geq$ 15 events/hour) diagnosed by overnight PSG performed at a sleep laboratory in accordance with the International Classification of Sleep Disorders – Third Edition (ICSD-3) recommendations,[8] who had hypertrophic palatine tonsils (Brodsky grades III and IV[9]) and indications for pharyngeal surgery associated with nasal surgery (septoplasty and/or turbinectomy). The exclusion criteria were: history of previous pharyngeal surgery, habitual use of sedative or stimulant medications, beta-blocker therapy, peripheral arterial disease, alcohol and/or drug abuse, history of positive airway pressure therapy in the last 30 days, and any decompensated chronic diseases which would constitute a clinical contraindication for surgical intervention under general anesthesia.

Of the 23 consecutively selected patients from the sleep respiratory disorders outpatient clinic of the Department of Otorhinolaryngology and Head and Neck Surgery at our institution, with moderate to severe OSA and with indication for pharyngeal surgery associated with nasal surgery, 17 completed the study. All patients agreed to participate and provided written informed consent. The study protocol was approved by the institutional Research Ethics Committee with opinion no. 192.034.

Subjects included in the study underwent physical examination, anthropometric evaluation, surgical intervention as described below, and monitoring of sleep parameters. Preoperatively, all answered questionnaires and underwent physical examination and type 1 PSG.[10] On the 1st night after surgery, they were evaluated in hospital with the Watch-PAT 200 portable sleep study device (Itamar Medical Ltd., Israel),[11] that assesses sleep through peripheral arterial tonometry. After a minimum period of 3 months, they were recalled to answer the questionnaires again, undergo a new anthropometric assessment, and were submitted to new assessments with PSG type 1 and Watch-PAT on different nights.

The Berlin,[12] SF-36[13] and Epworth sleepiness scale (ESS)[14] questionnaires were applied before surgical treatment and in the late postoperative period (at least 3 months after surgery). The subjective improvement of symptoms in the late postoperative period was also evaluated, asking patients to graduate from 0 to 100% the improvement obtained with the treatment.

Pharyngeal surgery consisted of tonsillectomy, hemostasis with bipolar electrocautery and 2-0 catgut sutures, closure of muscle and mucosal tissues with interrupted 3-0 Vicryl sutures, detachment of the palatal webbing, and resection of excess uvular mucosa when necessary. The surgical technique has been described in detail by Vidigal et al.[15] Nasal surgery (turbinectomy with or without septoplasty) was performed simultaneously with pharyngeal surgery. No nasal packing was used. Surgical procedures were performed in the same hospital under the supervision of a single physician, always in the morning.

All patients underwent balanced general anesthesia, performed by a single team of anesthesiologists. No patient received preanesthetic medication and benzodiazepines were not used intraoperatively and postoperatively.

The software used for statistical analysis was IBM SPSS Statistics for Windows version 24.0 (IBM Corp., Armonk, NY, USA). Continuous variables were represented by mean and standard deviation (SD). Data distribution was analyzed using the Kolmogorov-Smirnov test. Continuous data were analyzed using the Generalized Estimating Equations (GEE) method for repeated measures, using the Z score to normalize the data. Homogeneity correction was performed using the Greenhouse-Geisser test. Categorical data were represented by absolute and percentage frequency (%), using the chi-squared test. The assessment of the reliability of the AHI

Table 1 Sample profile.

	n	Minimum	Maximum	Mean	Standard deviation
Age (years old)	17	22	59	38.12	12.53
BMI (kg/m^2)	17	25.60	45.10	33.10	5.80
NC (cm)	17	39.0	48.50	42.67	2.90
AHI (events/h)	17	22.90	105.20	63.15	27.30
RDI (events/h)	17	26.70	105.20	64.25	26.60

Abbreviations: BMI, body mass index; NC, neck circumference; AHI: apnea–hypopnea index; RDI, respiratory disturbance index.
Data expressed as mean, standard deviation, minimum, and maximum.

between the methods was confirmed by Cronbach α and represented by the Bland-Altman graph and Spearman correlation (rho).

Results

In the group of 17 patients included in the study, age ranged from 22 to 59 years, with a mean of 38.1 ± 12.5 years, and 82.3% (14 patients) were male. Body mass index (BMI) ranged from 25.6 to 45.1 kg/m2, and the mean was 33.1 ± 5.8 kg/m^2. The mean neck circumference was 42.6 ± 2.9 cm. The mean AHI was 63.1 ± 27.3 events/hour, ranging from 22.9 to 105.2 events/hour (►**Table 1**). Fifteen patients (88.2%) were diagnosed with severe OSA (AHI > 30 events/hour). Friedman staging[16] classified 5 patients (29.4%) at stage 1, 9 patients (52.9%) at stage 2, and 3 patients (17.6%) at stage 4, due to BMI > 40 kg/m2.

The average time between surgery and postoperative reevaluation was 175 days, with a minimum of 92 and a maximum of 699 days. Patients underwent an assessment with Watch-PAT and PSG type 1 on different days. The average time between the 2 exams was 31 days, with an SD of 81.6.

There was a statistically significant difference in relation to BMI and neck circumference measurement, but BMI and neck circumference values remained high (32.4 ± 5.0 kg/m2 and 42.2 ± 2.9 cm). Regarding the questionnaires, there was a category change in eight patients in the Berlin questionnaire, which went from positive to OSA, before treatment, to negative. The ESS showed significant improvement after treatment. The SF-36 questionnaire showed significant improvement in the domains of role-physical, general health perception and social functioning (►**Table 2**). Regarding the subjective improvement of symptoms, when asking patients to graduate from 0 to 100% the improvement obtained with the treatment, the result obtained was 77.5 ± 22.5%.

►**Table 3** represents the comparison of data between preoperative PSG, Watch-PAT in the immediate postoperative period, Watch-PAT in the late postoperative period and PSG in the late postoperative period. There was no significant difference in sleep efficiency. Regarding AHI, respiratory disturbance index (RDI), nadir of peripheral oxyhemoglobin saturation (SpO2) and the percentage of time with SpO2 < 90% (tSpO2 < 90%), there was a progressive improvement, with a decrease in AHI, RDI and tSpO2 < 90%, and an increase in nadir of SpO2. In the comparison between the 2 methods used in the late postoperative period – Watch-PAT and PSG – there was no significant difference in AHI, RDI and tSpO2 < 90%. The nadir of SpO2 was different between the 2 methods.

Table 2 Comparison of anthropometric data and questionnaires between preoperative period and late postoperative period ($n = 17$).

	Preop	LPostop	*p-value*
BMI (kg/m^2)	33.1 ± 5.8	32.4 ± 5.0	0.01*
Neck circumference (cm)	42.6 ± 2.9	42.2 ± 2.9	0.03*
Berlin Questionnaire¥			
OSA positive (*n*)	16 (94.2%)	8 (47.1%)	**0.001***
OSA negative (*n*)	1 (5.8%)	9 (52.9%)	
Sleepiness (ESS)	13.9 ± 4.9	6.7 ± 3.5	< **0.001***
SF-36			
Physical functioning	80.4 ± 24.2	89.6 ± 14.4	0.059
Role-physical	75.0 ± 42.8	93.7 ± 24.1	**0.02***
Bodily pain	80.1 ± 28.8	79.3 ± 29.0	0.80
General health perception	67.2 ± 25.8	85.6 ± 14.2	< **0.001***
Vitality	58.8 ± 16.5	63.8 ± 8.1	0.15
Social functioning	79.8 ± 27.1	92.3 ± 16.35	**0.01***
Role-emotional	100.0 ± 43.7	89.7 ± 27.4	0.12
Mental health	75.1 ± 19.8	79.4 ± 17.6	0.059

Abbreviations: BMI, body mass index; OSA, obstructive sleep apnea; Preop, preoperative; LPostop, late postoperative period; ESS, Epworth sleep scale.
GEE, $p \leq 0{,}05$*; ¥ Chi-squared test.

►**Figure 1** illustrates AHI, RDI, nadir of SpO2, and tSpO2 < 90% in the 17 analyzed patients and ►**Figure 2** shows the results found in the 4 analyzed moments.

In the correlation between the AHI of PSG and Watch-PAT in the late postoperative period, there was a significant positive correlation ($r = 0.88$; $p < 0.001$) (►**Figure 3**). The Bland-Altman graph and Cronbach $\alpha = 0.81$ demonstrate good reliability between the methods (►**Figure 4**).

Table 3 Comparison of data between Preop PSG, IPostop WP, LPostop WP and LPostop PSG.

	Preop PSG	IPostop WP	LPostop WP	LPostop PSG	p
Sleep Efficiency (%)	83.11 ± 8.50	79.61 ± 9.50	84.60 ± 10.70	83.20 ± 8.90	0.67
AHI (events/h)	63.15 ± 26.40	51.00 ± 24.25	33.80 ± 21.15†Δ	31.61 ± 27.10¥ π	<0.001*
RDI (events/h)	64.25 ± 25.75	54.30 ± 22.20	38.70 ± 18.35†Δ	34.30 ± 26.20¥ π	<0.001*
Nadir SpO2 (%)	70.55 ± 12.80	77.65 ± 10.20	80.95 ± 9.30†	77.56 ± 10.95¥ μ	<0.001*
tSpO2 < 90% (%)	28.90 ± 27.40	29.65 ± 33.30	9.65 ± 19.50†	13.80 ± 25.00	<0,001*

Legend: PSG, polysomnography; WP, Watch-PAT; Preop, preoperative period; IPostop, immediate postoperative period; LPostop, late postoperative period; AHI, apnea/hypopnea index; RDI, respiratory disturbance index; SpO2, peripheral oxyhemoglobin saturation; tSpO2 <90%, percentage of sleep time with peripheral oxyhemoglobin saturation below 90%. † statistical difference between Preop PSG and LPostop WP; ¥ statistical difference between Preop PSG and LPostop PSG; Δ statistical difference between IPostop WP and LPostop WP; π statistical difference between IPostop WP and LPostop PSG; μ statistical difference between LPostop WP and LPostop PSG.
GEE, $p \leq 0.05^*$ Data expressed as mean and standard deviation.

Discussion

In the present study, a progressive improvement in respiratory parameters was observed when comparing the preoperative period, the immediate postoperative period, and late postoperative period exams, although we did not find a statistical difference in the comparison between the immediate postoperative period and the preoperative PSG, perhaps due to the small sample. In a study published in 2020, which evaluated the immediate impact of surgery on a group of 22 patients, there was a statistically significant improvement in AHI on the first night after surgery.[17] These findings show that, despite the patients having severe OSA, they did not experience a worsening of the parameters in the immediate postoperative period, even with the edema caused by the surgery. In ►**Figure 1**, we can see that the parameters evaluated in the immediate postoperative period worsened in some patients, but show an important improvement in the exams performed in the late postoperative period. Others show better results in the immediate postoperative period

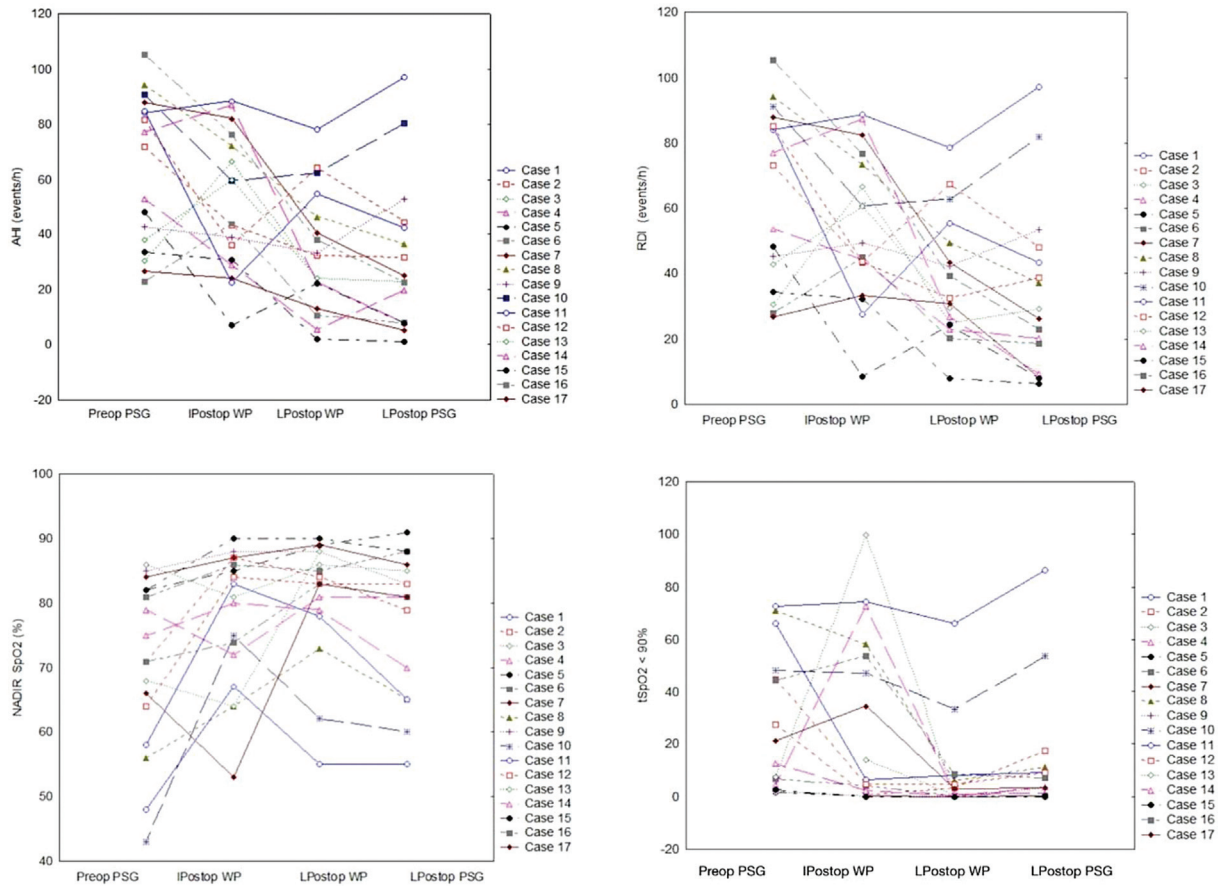

Fig. 1 AHI, RDI, nadir SpO2 and tSpO2 < 90% in the 17 study subjects. AHI: apnea/hypopnea index (events/hour), RDI: respiratory disturbance index (events/hour), SpO2: peripheral oxyhemoglobin saturation (%), tSpO2 < 90%: percentage of sleep time with SpO_2 below 90% (%), PSG: polysomnography, WP: Watch-PAT, Preop: preoperative period, IPostop: immediate postoperative period, LPostop: late postoperative period.

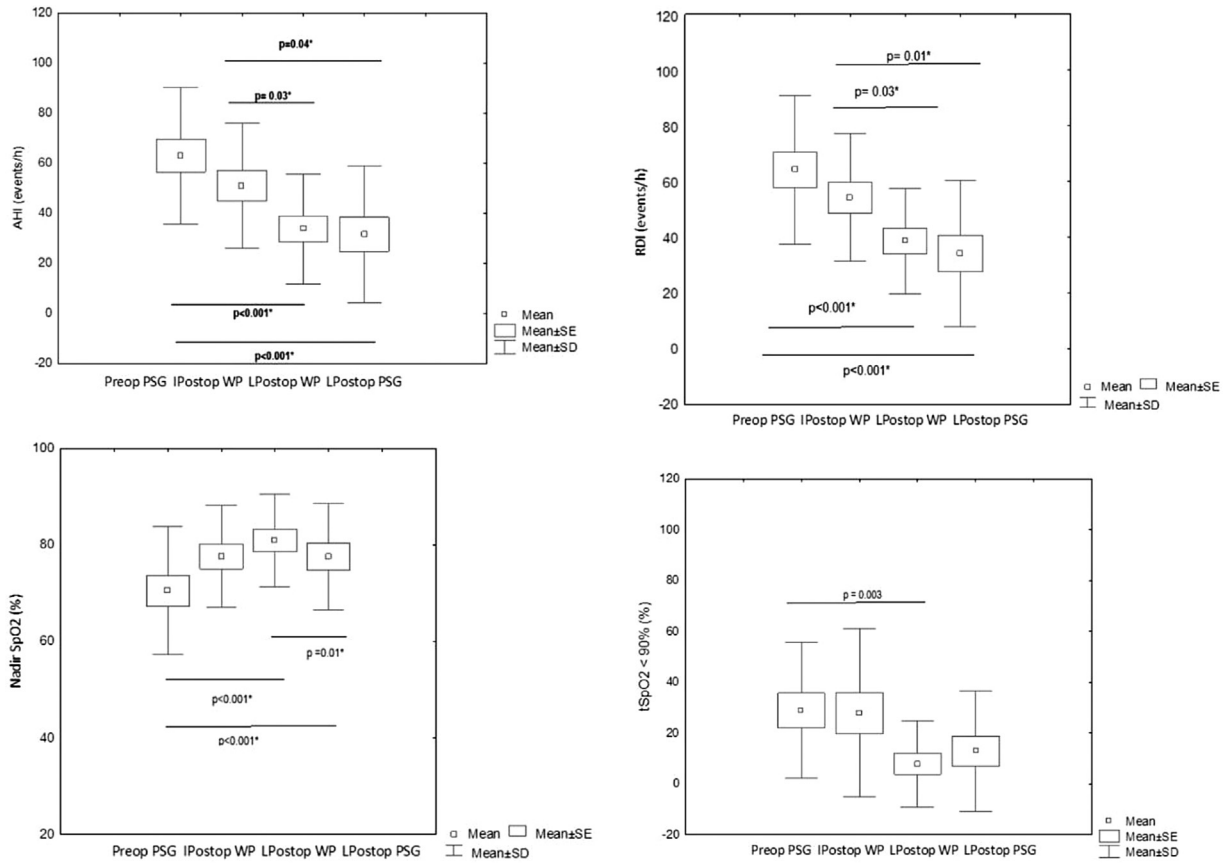

Fig. 2 AHI, RDI, nadir SpO2 and tSpO2 < 90% in the 4 analyzed moments. AHI: apnea-hypopnea index (events/hour), RDI: respiratory disturbance index (events/hour), SpO2: peripheral oxyhemoglobin saturation (%), tSpO2 < 90%: percentage of sleep time with SpO_2 below 90% (%), PSG: polysomnography, WP: Watch-PAT, Preop: preoperative period, IPostop: immediate postoperative period, LPostop: late postoperative period.

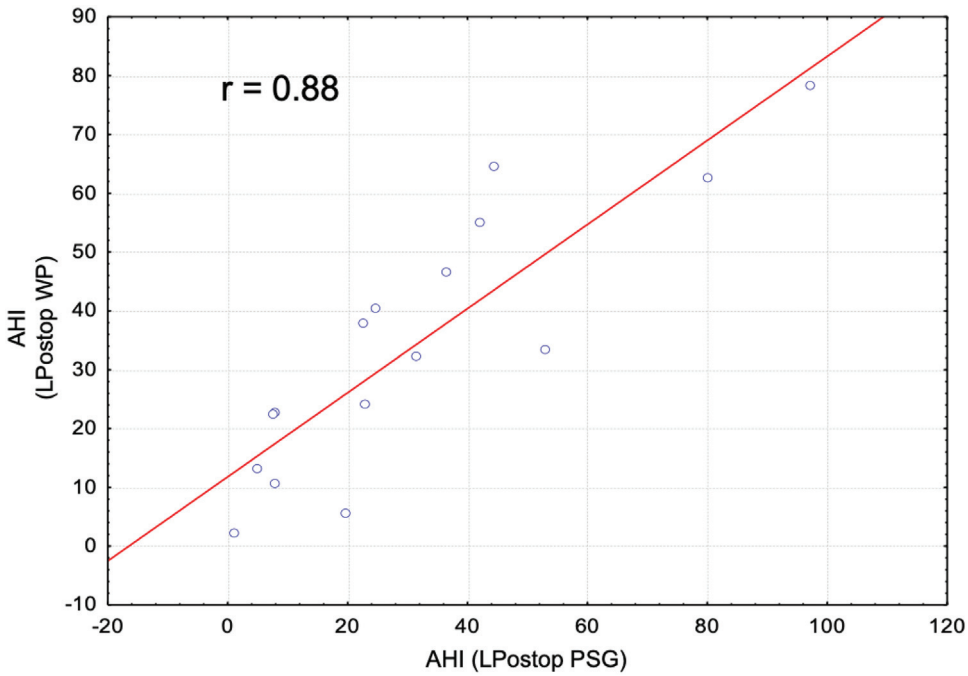

Fig. 3 Spearman correlation of AHI in the late postoperative period (r = 0.88; $p < 0.001^*$). AHI: apnea-hypopnea index (events/hour), PSG: polysomnography, WP: Watch-PAT, LPostop: late postoperative period.

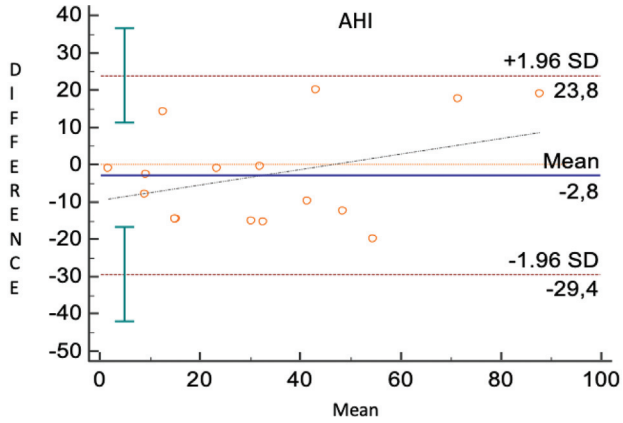

Fig. 4 Bland-Altman chart of the AHI in the late postoperative period. AHI: apnea-hypopnea index (events/hour).

compared with late postoperative results. These findings suggest that a sleep study performed in the immediate postoperative period does not always demonstrate the success or failure of surgical treatment and that a sleep study should be performed in a later postoperative period.

A favorable impact of pharyngeal surgery was observed both in the improvement of polysomnographic parameters and in excessive daytime sleepiness and quality of life. It is important to note that the improvement in quality of life may also have been influenced by the effects of nasal procedures associated with pharyngeal surgery, since these procedures have little influence on AHI but may improve the subjective quality of sleep and quality of life.[18,19]

There was no significant difference in sleep efficiency. In the immediate postoperative period, a worsening of sleep efficiency is expected, as it is the 1st night after surgery and also because of the presence of pain. We found no statistically significant difference, probably due to the small size of our sample. In the late postoperative period, the patients presented sleep efficiency similar to the result found in the preoperative examination, with values close to normal. Obstructive sleep apnea patients, especially those with severe OSA, have normal sleep efficiency due to chronic REM sleep and N3 sleep deprivation.

The statistically significant reduction in BMI and neck circumference measure in the late postoperative evaluation could have influenced the clinical and polysomnographic improvement of patients. However, the BMI and neck circumference measure averages remained quite high, suggesting that the impact of this reduction should not have been significant.

We observed, however, that despite this improvement found in polysomnographic parameters and questionnaires, many patients still have residual OSA, which leads to the need to repeat the exam in the postoperative period, even in the presence of clinical improvement, so that the treatment is carried out. One study demonstrated improvement in subjective symptoms of OSA after surgical treatment with modified uvulopalatopharyngoplasty, both in the group considered successful by PSG and in the group that was not successful by PSG.[20] As in the present study, other authors have also observed a significant reduction in the rates of respiratory events after pharyngeal surgery for OSA (78–81). Choi et al.[21] studied 41 adults who underwent uvulopalatopharyngoplasty associated with nasal surgery and found a reduction in AHI from 45.9 ± 23.4 events/hour to 20.9 ± 22.1 events/hour. In a pilot study involving 13 individuals with OSA undergoing tonsillectomy and nasal surgery, Stow et al.[22] found a reduction in the RDI from 31.7 events/hour to 5.5 events/hour. Tan et al.[23] studied the effect of tonsillectomy in 34 adults with OSA with grade III and IV palatine tonsils and observed a reduction in the RDI from 42.2 ± 25.6 events/hour to 13.1 ± 21.7 events/hour after surgery. The persistence of high AHI and RDI values in the group of patients in the present study after surgical treatment can be explained by their characteristics, which had a high mean BMI, as well as the fact that the vast majority of patients have severe OSA, with the average of the AHI also quite high.

When comparing the findings of PSG and arterial tonometry performed in the late postoperative period, no significant differences were found in the AHI and the RDI. The data that showed a statistically significant difference was nadir of SpO2, which can be explained by the effect between different nights of the exams. This was a limitation of the present study, since the ideal would be that the monitoring with the Watch-PAT had been carried out on the same night as the PSG; however, even on different nights, it was possible to observe that the evaluation through peripheral arterial tonometry has shown to be effective in the postoperative follow-up of these patients. Another limitation of the present study was the great variation in the timing of PSG in the late postoperative period. Despite this difference, with an average of 175 days, we set a minimum period of 3 months after surgery for this reassessment, in order to avoid the influence of edema and the healing period. In the correlation between the AHI of Watch-PAT and PSG in the late postoperative period, a significant positive correlation was found, with $r = 0.88$, a value similar to those obtained in several studies that compared Watch-PAT with PSG type 1.[11,24–28]

Conclusions

The improvement in respiratory parameters was progressive over time, when comparing the preoperative period, the immediate postoperative and late postoperative periods.

There was a favorable impact of pharyngeal surgery on the improvement of polysomnographic and clinical respiratory parameters (excessive daytime sleepiness and quality of life); however, many patients maintained residual OSA, suggesting the need for a new sleep study in the postoperative period, even in the presence of improvement in clinical symptoms.

The monitoring of peripheral arterial tonometry through Watch-PAT showed similar findings to those of PSG type 1 in the late postoperative period in patients with moderate and severe OSA undergoing pharyngeal and nasal surgery, in relation to AHI and RDI, which can be considered as an option in postoperative follow-up of patients.

Conflict of Interests
The authors have no conflict of interests to declare.

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