Lateral Pharyngoplasty Versus Uvulopalatopharyngoplasty: a Clinical, Polysomnographic and Computed Tomography Measurement Comparison

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Study Objective: To compare the lateral pharyngoplasty procedure with uvulopalatopharyngoplasty (UPPP) in the treatment of obstructive sleep apnea hypopnea syndrome (OSAHS).
Design: Prospective randomized study.
Setting: Academic tertiary center.
Patients: Twenty-seven adults with OSAHS originally selected for treatment with UPPP.
Interventions: Patients were randomly assigned to 2 groups: in one group, we performed the lateral pharyngoplasty (15 cases), and in the other, we did the UPPP (12 cases).
Measurements and Results: We compared treatment outcomes through the evaluation of OSAHS-related symptoms and the analysis of polysomnographic tests and computed tomography measurements of pharyngeal airway. The lateral pharyngoplasty group achieved a statistically greater reduction in body weight, excessive daytime sleepiness, and apnea-hypopnea index. In addition, only in this group did we observe a statistical increase in the amount of deep sleep stages and improvement in morning headaches. Patients from the UPPP group did not present significant changes in the polysomnographic parameters. Pharyngeal airway measurement outcomes were similar in both groups and did not reflect the clinical and polysomnographic differences we observed.
Conclusions: Lateral pharyngoplasty produces better clinical and polysomnographic outcomes in the treatment of OSAHS than does UPPP, without resultant differences in the cross-sectional measurements of the pharyngeal airway between those treatments.
Key Words: obstructive sleep apnea, lateral pharyngoplasty, uvulopalatopharyngoplasty, computed tomography pharyngeal measurements, lateral pharyngeal wall
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INTRODUCTION

THE LATERAL PHARYNGEAL MUSCULAR WALLS (LPW) HAVE A KEY ROLE IN THE PATHOPHYSIOLOGY OF OBSTRUCTIVE SLEEP APNEA-HYPOPNEA SYNDROME (OSAHS).[1,2] These regions are thickened and exceedingly collapsible during respiration in patients with OSAHS, causing narrowing of the pharynx. Such features are present within the whole extension of this organ, increasing airflow resistance and leading to obstructive respiratory events during sleep. Apart from tracheotomy, every current surgical treatment for OSAHS has been designed to create more space in the pharyngeal airway.[3] While this concept seems to work well in most children with OSAHS, it remains remarkably doubtful regarding adult patients.[4-6] In fact, one cannot assess the severity or even make the diagnosis of OSAHS based on upper-airway findings in adult patients. For this reason, we developed a surgical technique designed to splint the pharynx through the rotation of lateral muscle flaps, which we called lateral pharyngoplasty.[7] Our hypothesis was that focusing on changing the LPW properties could be better than focusing on changing the pharyngeal lumen size for treating patients with OSAHS.

Uvulopalatopharyngoplasty (UPPP)[8] is the most common specialized procedure that directly enlarges the upper airway used for treating OSAHS. Therefore, it seems reasonable that, initially, our new procedure should be compared to UPPP. The purpose of this study is to prospectively compare the lateral pharyngoplasty with UPPP, evaluating clinical and polysomnographic outcomes along with computed tomography (CT) measurements of the airway in both groups.

PATIENTS AND METHODS

As a doctoral thesis in our institution, we conducted a randomized controlled trial with 29 OSAHS patients originally selected for UPPP who were subsequently assigned into 2 groups: in the first group, we performed the UPPP, and in the second group, we performed the lateral pharyngoplasty. The study was approved by the Ethics Committee of our institution, and each patient signed a consent form that outlined the objectives of the research and experimental risks.

We included in this study habitual snoring individuals over 18 years of age with an apnea-hypopnea index (AHI: number of apneic plus hypopneic events per hour of sleep) greater than 10 (to avoid misdiagnosis of OSAHS) who failed to tolerate or refused therapy with continuous positive airway pressure. All overweight subjects were operated on only after several months of failure of clinical measurements for weight loss. The inclusion criteria for surgery were the presence of a low-lying soft palate (the majority of the patients were Malampatti type 3 with few type 4) associated with a fiberoptic pharyngoscopy finding of narrowing or collapse in the retropalatal region without narrowing in the hypopharynx (classified as Fujita type 1), both at rest and during the Muller maneuver. In addition, all patients were selected, subjectively, for having bulky lateral oropharyngeal tissues (either the tonsil or the posterior tonsillar pillar). The exclusionary criteria were weight over 130 kg (CT table limit), morbid

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No significant financial interest/other relationship to disclose.

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obesity, the presence of uncontrolled or less than 1 year under control of hypothyroidism, and gross maxillary or mandible deformities.

For stratifying the groups preoperatively, patients were classified as having mild (AHI ≤ 15), moderate (15 < AHI ≤ 30), or severe (AHI > 30) OSAHS.[9] We then randomly assigned subjects from each of these subgroups to undergo the UPPP or the lateral pharyngoplasty procedure. Postoperatively, 1 moderate and 1 severe case, both from the UPPP group, were lost for follow-up, and their partial results were excluded from our analysis. Therefore, our final trial included 15 subjects who underwent lateral pharyngoplasty (12 men and 3 women), and 12 subjects who underwent UPPP (8 men and 4 women).

Surgical Techniques

The UPPP technique we used emphasized the opening of the oropharynx in the lateral port areas[10] with minimal shortening of the soft palate in the midline. In this technique, after a bilateral tonsillectomy, we removed a triangle of mucosa and muscle (palatoglossus) from the lateral free margin of the soft palate and closed this surgical wound by traction and suturing of the palatopharyngeus muscle over it. Additionally, we did a partial uvulectomy. Therefore, the UPPP supports the pharynx through tensioning the inner pharyngeal muscular layer (palatopharyngeus muscle).

The clinical and polysomnographic results of the first 10 cases of lateral pharyngoplasty along with the detailed description of this technique were already reported elsewhere.[7] In this procedure, after the tonsillectomy, we sectioned the superior pharyngeal constrictor muscle within the tonsillar fossa (outer pharyngeal muscular layer) and sutured it to the anterior pillar to provide support to the lateral pharyngeal wall. Then, we performed a Z-plasty between the lateral free margin of the soft palate and the palatopharyngeus muscle, providing lateral support to the soft palate. Additionally, we did a partial uvulectomy. Therefore, the lateral pharyngoplasty supports the pharynx through postoperative retraction of the inner and outer pharyngeal muscular layers.

The total volume of pharyngeal tissues (tonsillar and palatine) removed in each surgery was measured for comparison purposes. The bulk of this measurement corresponded to the tonsillar volume, whereas the palatine excision rarely exceeded 0.6 mL.

Clinical Evaluation

These evaluations were done preoperatively and at least 6 months after the operations. At these periods, we assessed the body mass index (BMI: the weight in kg divided by the square of the height in meters), the neck circumference (measured at the level of the thyrohyoid membrane, in cm), the Epworth Sleepiness Scale scores, and the results from a doctor-administered questionnaire with scales ranging from 1 (irrelevant) to 10 (severely affected/debilitating) to evaluate the following variables: snoring, daytime sleepiness, morning headaches, and the overall impact of the disease on quality of life. A similar questionnaire was used to assess postoperative pain, and we recorded the number of days it took the patients to return to normal nutrition after the operations.

Polysomnography

All subjects underwent overnight polysomnography in a sleep center in a standard fashion with a test time of 7 to 8 hours, both preoperatively and at least 6 months after the operations. We used thermistors for monitoring the oronasal airflow, and we used the latest recommended definitions of apneas and hypopneas from the American Academy of Sleep Medicine[9]: apnea, absence of airflow for at least 10 seconds; hypopnea, reduction (for at least 10 seconds) by more than 50% of the basal ventilatory value or a reduction of 50% or less that is associated with a decrease in oxyhemoglobin saturation above 3% or to an arousal. The polysomnograms were scored according to standard criteria[11] and analyzed by physicians trained in polysomnography reading who were unaware of the type of operation performed in each case. The variables evaluated included: the AHI, the mean and lowest oxyhemoglobin saturation (SaO_2), the percentage of total sleep time spent in stages 3 plus 4 non-rapid eye movement sleep and the percentage of total sleep time spent in rapid eye movement sleep.

Computed Tomography

All patients had CT scans of the upper airway while awake, in the supine position, on a General Electric HiSpeed DX/i CT Scanner (GE Medical Systems, Otogawa, Japan), both preoperatively and at least 6 months after the operations. They were scanned with the head held in neutral position midway between flexion and extension. Axial parallel sections 0.3-cm thick at 0.3-cm intervals were taken from the hard palate to the epiglottis. Sections were positioned, in the lateral scout film of the airway, perpendicularly to the posterior wall of the retropalatal pharynx. No contrast medium was administered. Scans were performed in 2 phases: during quiet tidal breathing (normal phase) and during a Muller maneuver (Muller phase). In this last phase, the subjects were requested to keep continuous inspiration with their mouths closed and their nostrils filled with cotton pledgets soaked with lidocaine gel. This scan process usually took 10 to 12 seconds on each phase. Some patients did not tolerate the whole process during the Muller maneuver (warning us by raising their right hands) and, in these cases, the Muller phase was repeated from the level of the interruption to the end. The digitized images were then traced with a manual cursor, which is incorporated in the scanner software for measurements. Preoperatively, we measured the cross-sectional areas of the airway at 3 levels: hard palate (high retropalatal area) (Figure 1), minimal retropalatal area (Figure 2), and the first section cranial to the tip of the epiglottis (retroglossal area) (Figure 3). In each of these levels, we also measured the sagittal midline diameter and the largest lateral-to-lateral (transverse) diameter of the airway. Each of these measurements was made in both normal and Muller phases. In addition, we determined the tongue width (the distance between the outer convex borders of the hyoglossus muscles, at the normal phase), the mandible width (distance between the most posterior and inferior point of the left and right mandible angles), and the mandible length (distance between the mandible angle and the internal point of the mandible symphysis). Postoperatively, we repeated the luminal airway measurements in both normal and Muller phases.

Nasal Obstruction

Patients with daily nasal obstruction and anatomic features such as deviated septum and turbinate hypertrophy, which didn't improve with medical therapy, were also treated with concomitant nasal surgery. In the lateral pharyngoplasty group, 4 patients underwent septoplasties and 1 underwent a septoplasty with bilateral partial inferior turbinectomy. In the UPPP group, 8 patients underwent septoplasties. All of these subjects had bilateral nasal packing for 1 or 2 days after the procedures. Hospital stay usually lasted 2 days, and discharge criteria included adequate pain control and oral intake of fluids.

Statistical Analysis

Most of the variables we examined didn't have a normal distribution, and, therefore, we used nonparametric tests to compare both treatments. Accordingly, the central tendency measurement adopted was the median, followed by the respective quartile range. The significance of the changes after the operations, in each group, was verified with the nonparametric Wilcoxon test. Comparisons between groups were made with the Mann-Whitney *U* test. In order to evaluate the influence of other variables in the resulting differences of the AHI, we calculated the nonparametric Spearman R correlation coefficient between the variables under consideration. A *P* value of .05 or below was set to indicate significance.

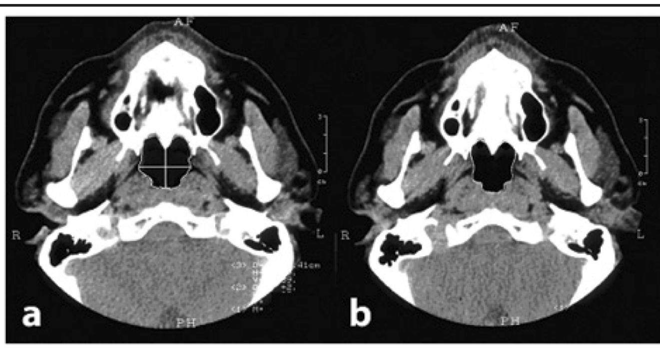

Figure 1—Preoperative computed tomographic scan of the high retropalatal area with the tracings for measuring its cross-sectional area and sagittal and transverse diameters. (a) tidal breathing. (b) Muller maneuver.

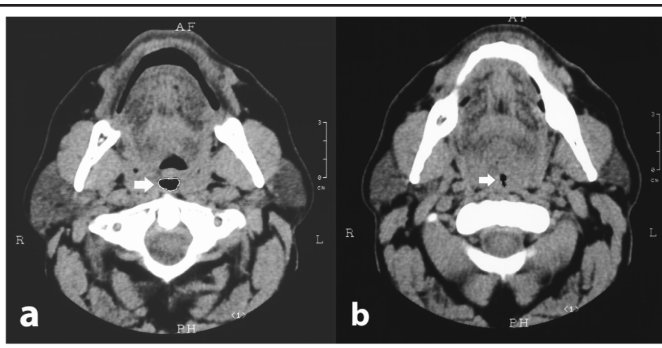

Figure 2—Preoperative computed tomographic scan of the minimal retropalatal area. (a) tidal breathing. (b) Muller maneuver. Arrows point to the retropalatal airway.

RESULTS

The follow-up time, preoperative and postoperative weight, BMI, neck circumference, and the time it took for the patients to return to normal nutrition intake are shown in Table 1 (lateral pharyngoplasty group) and in Table 2 (UPPP group). The follow-up time was similar in both groups (P = .75). Preoperatively, there were no statistical differences between groups regarding weight (P = .20), BMI (P = .37), or neck circumference (P = .71). After the operations, the lateral pharyngoplasty group had a statistically significant reduction in weight, BMI, and neck circumference, whereas no significant changes occurred on these parameters in the UPPP group. Postoperative intergroup comparisons showed a statistically smaller weight (P = .05) and BMI (P = .01) in the lateral pharyngoplasty group, a difference that wasn't observed regarding the neck circumference (P = .83). Because the median BMI did not noticeably change in the lateral pharyngoplasty group, we verified whether the weight loss occurred on a subset of patients in this group and found that the statistical reduction of the BMI happened in the obese patients (BMI $\geq$ 30 kg/m^2, P = .03) and not in the nonobese patients (BMI < 30 kg/m^2, P = .12) from the lateral pharyngoplasty group.

Preoperatively, there were no statistical intergroup differences regarding any of the symptoms we studied. In the lateral pharyngoplasty group, the median Epworth Sleepiness Scale value significantly improved from 14 (12) to 4 (4) (P = .001), as did the self-reported symptoms of snoring (median decreased from 10 to 3, P = .001), daytime sleepiness (median decreased from 5 to 1, P = .001), morning headaches (from 4 to 1, P = .008), and overall impact of the disease on quality of life (from 6 to 1, P = .002). In the UPPP group, we found statistical improvement in the Epworth Sleepiness Scale value (median decreased from 14 to 5, P = .005), in the self-reported symptoms of snoring (median decreased from 9.5 to 3, P = .003), daytime sleepiness (from 5 to 2, P = .003), and overall impact of the disease on quality of life (from 5 to 1.5, P = .003) but not in morning headaches (from 4 to 1, P = .11). Postoperative intergroup comparisons showed that the lateral pharyngoplasty group reported statistically less daytime sleepiness than did the UPPP group (P = .05), without significant differences regarding the other parameters.

The polysomnographic data are shown in Table 3 (lateral pharyngoplasty group) and in Table 4 (UPPP group). Preoperatively, there were no statistical differences between groups regarding any of the polysomnographic variables we studied. After the operations, we observed, in the lateral pharyngo-

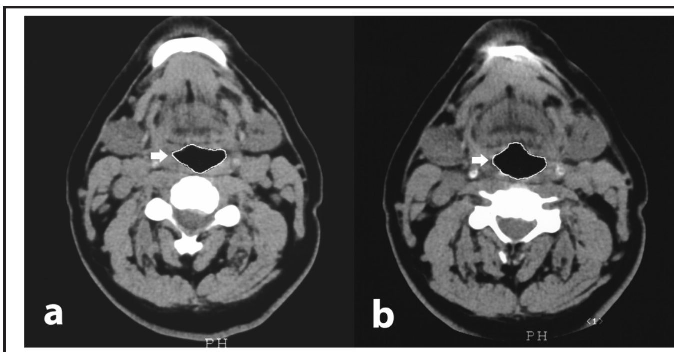

Figure 3—Preoperative computed tomographic scan of the retroglossal area. (a) tidal breathing. (b) Muller maneuver. Arrows point to the retroglossal airway.

plasty group, a statistically significant improvement in the AHI and in the percentage of stages 3 plus 4 non-rapid eye movement sleep, with a tendency toward improvement in the mean and lowest SaO_2 (P = .06 for both) and in the percentage of rapid eye movement sleep (P = .08). For the UPPP group, we did not verify statistical differences in any of the polysomnographic variables we studied. Postoperative intergroup comparisons showed a trend of the AHI to be lower in the lateral pharyngoplasty group (P = .07), without statistical differences regarding the other parameters. The reduction of the AHI in the lateral pharyngoplasty group was greater than in the UPPP group (P = .05).

We verified the influences of the postoperative anthropometric changes in the AHI changes and, studying all the 27 cases, noted that the AHI variation did not correlate with the BMI changes (r = .28; P = .15) or the neck circumference changes (r = .11; P = .59). The analysis of each group showed similar results for the lateral pharyngoplasty group (r = .44; P = .10 regarding the BMI and r = .24; P = .38 regarding the neck circumference) and

Table 1—Lateral pharyngoplasty group: preoperative and postoperative anthropometric data and delay in return to normal nutritional intake.

Patient	Follow-up, months	Weight, kg		BMI, kg/m^2		Neck circumference, cm		Diet delay, days*
No.		Before	After	Before	After	Before	After	
1	8	95	89	31.7	29.7	46.0	44.0	12
2	8	82	82	29.4	29.4	44.0	44.0	8
3	12	69	65	28.0	26.4	42.0	41.0	12
4	6	79	75	28.3	26.9	41.0	41.0	25
5	6	84	74	30.9	27.2	40.0	40.0	10
6	9	78	72	30.5	28.1	42.0	41.0	10
7	7	70	72	27.7	28.5	39.0	39.0	17
8	10	87	87	28.1	28.1	43.5	44.5	20
9	8	93	89	30.4	29.1	45.0	45.0	20
10	8	96	81	33.2	28.0	53.0	46.5	70
11	7	78	78	27.0	27.0	42.0	42.0	15
12	12	80	68	35.6	30.2	37.5	37.0	37
13	6	80	76	26.1	24.8	44.0	43.5	7
14	6	80	79	27.7	27.3	44.0	42.5	43
15	6	69	68	25.0	24.7	43.5	43.5	15
Mean	7.9	81.3	77.0	29.3	27.7	43.1	42.3	21.4
Median	8	80	76	28.3	28.0	43.5	42.5	15
Quartile range	3.0	9	10	3.2	2.2	3.0	3.0	15
P value	—	.005†		.005†		.05†		—

*Time required for patients to return to full preoperative diet after the operations.
†Postoperative significant difference ($P \leq .05$).
BMI refers to body mass index.

Table 2—Uvulopalatopharyngoplasty group: preoperative and postoperative anthropometric data and delay in return to normal nutritional intake.

Patient	Follow-up, months	Weight, kg		BMI, kg/m^2		Neck circumference, cm		Diet delay, days*
No.		Before	After	Before	After	Before	After	
1	7	60	55	26.4	24.4	35.5	35.5	9
2	8	108	107	34.1	33.8	46.5	46.0	8
3	6	72	72	31.2	31.2	37.0	38.0	10
4	10	110	106	32.5	31.3	47.0	46.5	9
5	11	100	94	31.6	29.7	42.5	44.0	12
6	9	90	109	27.8	33.6	43.0	43.5	30
7	7	80	80	27.7	27.7	42.0	42.0	9
8	11	83	82	27.1	26.8	43.0	42.5	11
9	9	89	89	30.8	30.8	38.5	37.0	10
10	6	72	72	31.2	31.2	40.5	40.5	30
11	6	83	82	30.9	30.5	46.0	45.0	17
12	8	95	96	29.6	30.0	44.0	45.5	14
Mean	8.2	86.8	87.0	30.1	30.1	42.1	42.2	14.1
Median	8	86.0	85.5	30.8	30.6	42.8	43.0	10.5
Quartile range	3.0	21.5	25.0	3.6	2.6	5.5	6.0	6.5
P value	—	0.29		0.21		0.86		—

*Time required for patients to return to full preoperative diet after the operations.
BMI refers to body mass index.

for the UPPP group (r = -.29; P = .36 regarding the BMI and r = -.22; P = .50 regarding the neck circumference). A close analysis of the lateral pharyngoplasty group further demonstrated that the AHI changes in this group did not depend on the weight changes; in the 8 patients who lost 5% or more of their BMI after the operations (median BMI decreased from 30.7 to 27.6 kg/m^2), the median AHI improved from 53.8 to 17.4 (P = .025), whereas in the other 7 patients (median BMI increased from 27.7 to 28.1 kg/m^2), the median AHI improved from 27.5 to 9.6 (P = .028).

In Table 5, we can see the results of the CT measurements. Preoperatively, the transverse diameter of the minimal retropalatal area, in the normal phase, was significantly smaller in the lateral pharyngoplasty group (P = .02), without statistical differences in this area between groups (P = .26), whereas the retroglossal area, during the Muller phase, was significantly smaller in the UPPP group (P = .04). In all other preoperative areas and diameters measured, there were no statistical differences between groups, nor was there a difference in the tongue width, mandible length, or mandible width. As expected from the selection criteria for the operations, in both groups, the minimal retropalatal areas were statistically smaller than the retroglossal areas, both in normal and in Muller phases. Studying all patients, no CT mea-

Table 3—Lateral pharyngoplasty group: preoperative and postoperative polysomnographic data

Patient No.	AHI, events/h		Lowest SaO_2, %		Sleep stage 3 + 4, %		REM sleep, %	
	Before	After	Before	After	Before	After	Before	After
1	41.9	9.3	68.0	78.0	0.0	23.2	10.7	3.8
2	29.9	15.6	88.0	77.0	14.8	26.6	15.7	19.4
3	43.6	38.7	58.0	41.5	6.8	9.5	6.6	25.8
4*	17.1	26.2	81.0	79.0	17.6	7.3	16.4	12.5
5	63.9	8.5	63.0	82.0	0.0	18.8	11.9	19.9
6	78.7	8.7	81.0	91.0	3.7	15.3	18.4	14.1
7	33.8	9.6	86.0	79.0	16.0	28.9	15.4	24.2
8*	40.4	8.3	76.0	83.0	0.4	9.6	19.1	26.6
9	14.1	0.4	82.0	90.0	14.9	3.4	12.8	25.2
10*	94.5	26.8	50.0	77.0	0.0	17.2	9.8	24.7
11*	27.5	11.0	77.0	87.0	25.3	26.5	10.4	12.4
12	75.9	24.2	59.0	85.0	4.3	11.1	10.0	11.4
13*	21.2	10.6	81.0	84.0	20.5	31.3	16.9	29.3
14	15.9	8.6	81.0	94.0	22.0	15.6	22.0	18.0
15	25.8	26.2	81.0	87.0	1.4	0.0	21.7	18.5
Mean	41.6	15.5	74.1	81.0	9.8	16.3	14.5	19.1
Median	33.8	10.6	81.0	83.0	6.8	15.6	15.4	19.4
Quartile range	34.0	17.7	18.0	9.0	17.2	17.0	8.0	12.7
P value	0.002†		0.06		0.03†		0.08	

*Concomitant nasal operation.
†Postoperative significant difference ($p \leq 0.05$).
AHI refers to apnea-hypopnea index; REM, rapid eye movement.

Table 4—Uvulopalatopharyngoplasty group: preoperative and postoperative polysomnographic data

Patient No.	AHI, events/h		Lowest SaO_2, %		Sleep stage 3 + 4, %		REM sleep, %	
	Before	After	Before	After	Before	After	Before	After
1*	23.0	21.1	62.0	78.0	19.6	17.5	17.9	22.7
2*	31.2	13.9	76.0	87.0	26.8	11.7	13.0	22.3
3*	14.2	7.7	91.0	87.0	17.5	27.4	8.5	19.9
4*	16.3	24.1	88.0	82.6	16.6	17.3	25.4	14.7
5*	34.1	29.2	64.0	53.0	22.0	7.2	5.7	6.4
6*	59.0	9.1	57.0	64.0	1.6	19.6	25.5	20.0
7*	47.5	14.6	51.0	77.0	0.8	21.6	14.7	14.1
8*	38.3	73.9	51.0	49.0	0.0	3.2	12.6	12.4
9	18.1	45.6	85.0	87.0	0.5	8.0	1.2	17.6
10	42.5	13.3	82.8	80.0	7.6	12.5	14.4	20.4
11	63.7	56.8	19.0	78.0	4.8	9.2	6.4	2.6
12	27.4	50.3	97.0	80.0	21.5	20.4	10.2	3.3
Mean	34.6	30.0	68.6	75.2	11.6	14.6	13.0	14.7
Median	32.6	22.6	70.0	79.0	12.1	14.9	12.8	16.2
Quartile range	24.4	34.4	32.5	14.3	19.4	11.4	8.8	10.8
p value	0.53		0.53		0.24		0.53	

*Concomitant nasal operation.
AHI refers to apnea-hypopnea index; REM, rapid eye movement.

surement statistically correlated with the AHI preoperatively, although a trend was present relating the mandible length with the AHI (r =- .34; P = .08).

Postoperatively, there were no statistical differences between groups in any of the CT measurements we conducted (Table 5). Considering all cases, the only significant correlation we verified with the AHI was a paradoxical correlation between the minimal retropalatal transverse diameter—during the normal phase—and the AHI (r =.43; P = .03). This identical correlation was found in a separate analysis of those patients who did not achieve significant weight differences after the operations (16 cases with postoperative BMI within ± 5% of preoperative BMI; r = .51; P = .04). Intragroup analysis showed, for the UPPP group, a significant postoperative reduction in the transverse diameter of the high retropalatal area, during the normal phase (P = .04), without statistical differences in any other measurement. Paradoxically, after the operations, we found in this group a direct correlation between the minimal retropalatal area— during the normal phase—and the AHI (r = .66; P = .02).

In the lateral pharyngoplasty group, there was a significant increase in the transverse diameter of the minimal retropalatal site during the Muller phase (P = .01), without statistical differences on its area. In addition, we noted in this group a significant postoperative reduction in the retroglossal dimensions, either the area (P = .03) and sagittal (P = .02) and transverse diameters (P = .05) during the Muller phase, without statistical differences in any other measurement. The only correlation we found in this group, after the procedures, was between the minimal retropalatal sagittal diameter—only during the Muller phase—and the AHI (r = -.55; P = .03).

The median tissue volume removed in the lateral pharyngoplasty group was 5.0 (4.2) mL and in the UPPP group was 5.3 (4.8) mL (P = .85), and the bulk of it corresponded to the tonsillar volume. There was no statistical correlation between these volumes and the changes in the AHI, in either the lateral pharyngoplasty group (r = .22; P = .44) or in the UPPP group (r = .44; P = .15).

The patients reported, in the 10-point scale for postoperative pain, a median value of 5.0 (5.0) in the lateral pharyngoplasty group and 6.0 (3.5) in the UPPP group (P = .37). Ten days after the procedures, analgesics were usually no longer required. There was no statistical difference in the median time it took for the subjects to return to normal nutrition intake (Tables 1 and 2) (P = .16).

Extubation occurred uneventfully in all cases, and we did not observe immediate or delayed complications such as bleeding, abscesses, nasopharyngeal stenosis, or alterations in tongue mobility or speech. Four patients in each group reported occasional and mild episodes of oronasal reflux of liquids during swallowing, which disappeared within 2 months (3 cases) and 6 months (1 case) in the lateral pharyngoplasty group and within 4 months (3 cases) and 6 months (1 case) in the UPPP group. We observed no case of permanent palatal incompetence in this study.

DISCUSSION

Lateral pharyngoplasty is a procedure that intends to splint the LPW, preventing collapse of both retropalatal and retroglossal regions.[7] The rationale for this operation is that, at the end of expiration, in OSAHS subjects, both of these regions are significantly narrower in their lateral dimensions.[1] Since even mild OSAHS appears to involve several levels of the upper airway[12]

Table 5—Median computed tomography measurements in both groups

Parameter*	Lateral pharyngoplasty Group Before	After	Uvulopalatopharyngoplasty Group Before	After
High Retropalatal Area (normal)	5.37	5.34	4.54	4.52
Sagittal diameter	2.1	2.2	2.1	2.1
Transverse diameter	2.5	2.4	2.5	2.2†
High Retropalatal Area (Muller)	4.69	4.57	4.54	4.40
Sagittal diameter	2.0	2.3	1.8	2.0
Transverse diameter	2.3	2.3	2.4	2.2
Minimal Retropalatal Area (normal)	0.53	0.65	0.66	0.66
Sagittal diameter	0.7	0.5	0.7	0.5
Transverse diameter	1.1	1.3	1.5	1.6
Minimal Retropalatal Area (Muller)	0.24	0.42	0.37	0.40
Sagittal diameter	0.6	0.4	0.5	0.5
Transverse diameter	0.5	1.0†	0.9	1.1
Retroglossal Area (normal)	2.82	2.27	2.74	2.54
Sagittal diameter	1.6	1.5	1.5	1.3
Transverse diameter	2.9	2.3	2.6	2.7
Retroglossal Area (Muller)	3.11	2.16†	2.04	1.62
Sagittal diameter	1.9	1.4†	1.6	1.3
Transverse diameter	2.7	2.2†	2.0	2.1
Tongue width	5.0	—	5.1	—
Mandible width	9.3	—	9.2	—
Mandible length	7.9	—	7.4	—

*Areas expressed in cm^2 and distances expressed in cm.
†Intragroup postoperative significant difference ($P \leq .05$).

and the majority of patients have 2 or more detectable regions of pharyngeal collapse,[13] we developed this operation to obtain a straightforward approach to a large portion of the LPW and modify their properties.

UPPP failures are usually attributed to the postoperative presence of sites of airway collapse other than the retropalatal region,[14] to partial obstructions within the pharynx, [15] and even to the persistence of retropalatal obstructions.[16] Moreover, this technique, in general, does not reverse the underlying structural or neuromuscular tendency of pharyngeal narrowing in OSAHS, even in patients in whom the disease remits after the operation.[17] Perhaps that is the reason why the effectiveness of UPPP is usually variable.[3]

The rationale for UPPP, as for most of the operations already proposed for treating OSAHS, is enlargement of pharyngeal airway.[8] However, there are no differences between responders and nonresponders to this operation regarding pharyngeal cross-sectional measurements, both before[4,5] and after UPPP procedures.[5] In addition, there are no correlation between preoperative upper-airway measurements and polysomnographic parameters.[6] Clinical, polysomnographic, and physiologic (pharyngeal pressures) factors also cannot predict a favorable response to UPPP.[17] For these reasons, we believe that a surgical treatment for OSAHS should not be focused on changing pharyngeal space but, rather, should be focused on dealing with the pharyngeal muscular wall properties. Regarding the soft palate, it is important, in any palatopharyngeal operation, to avoid injury to the levator veli palatini muscle in order to prevent velopharyngeal incompetence.

There was a statistically significant reduction of the BMI only in the lateral pharyngoplasty group. As other authors have observed,[18] some obese subjects with OSAHS can lose weight only after the effective treatment of their sleep disorder. There was no statistical difference between groups regarding postoperative dysphagia, and the median diet delay for patients in the lateral pharyngoplasty group was 15 days. Because the postoperative evaluations were made at least 6 months after the operations, we believe that the diet delay did not account for the difference in weight loss between groups. Indeed, during this study, we were concerned about the bias we were obtaining with these weight differences. However, today we realize that this bias is actually the most reassuring effect of the lateral pharyngoplasty. We know very little about OSAHS, but what we do know is its relationship with obesity. So, it seems reasonable, if not mandatory, to include the weight loss as a major parameter for evaluating the success of any OSAHS treatment, at least for obese patients. We stand up very strongly for this concept today. It is important to emphasize that, in the lateral pharyngoplasty group, a statistically significant AHI improvement was observed in those who lost 5% or more of their BMI (median preoperative BMI of 30.7 kg/m^2) as well as in those who did not (median preoperative BMI of 27.7 kg/m^2). Fortunately, some explanations linking OSAHS and obesity have begun to appear in the literature, showing the independent association between OSAHS and insulin resistance.[19,20] Also, it has been shown that continuous positive airway pressure rapidly improves insulin sensitivity in OSAHS patients,[21] which is likely to influence a posttreatment weight loss. We plan to study the effect of lateral pharyngoplasty on insulin resistance and hope to explain the weight-loss effect we observed in obese patients.

We observed clinical improvements after the 2 treatments. However, only the lateral pharyngoplasty group had a statistically significant improvement in morning headaches, a symptom that is referred by half of the patients with OSAHS.[22] We evaluated daytime sleepiness using 2 parameters: the Epworth scale, which evaluates the likelihood of a person falling asleep,[23] and a self-evaluation of sleepiness on a 10-point scale, which is more likely to measure a state involving feeling of tiredness or fatigue. In this last questionnaire, the lateral pharyngoplasty group reported statistically less daytime somnolence after the operations. Due to different lifestyles and real opportunities to fall asleep, it is important to evaluate both aspects of this symptom in OSAHS patients. Therefore, clinical measurements statistically favored the lateral pharyngoplasty procedure in this study.

The polysomnographic postoperative data also favored the lateral pharyngoplasty treatment. The statistically greater reduction in the AHI we observed in this group could not be explained by differences in the volume of tissues (tonsillar plus palatine tissues) removed with each technique, which were similar. We believe that this measurement is the most reliable index of postoperative pharyngeal enlargement. In addition, there is no indication that the concomitant nasal operations (5 of 15 cases in the lateral pharyngoplasty group and 8 of 12 cases in the UPPP group) have influenced these results, since the correction of chronic nasal obstruction, per se, does not reduce the AHI[24] and nasal airflow resistance seems to be of minor importance in the pathogenesis of OSAHS.[25] Because, even though we performed the multilevel procedure more often in the UPPP group, this group obtained a worse outcome, we do not have reason to believe that the combined operation confounded our results. Can that different surgical outcome be explained by the airway space? In order to clarify that, we studied the upper-airway CT measurements.

We believe that the CT examination is an excellent tool, since it provides direct 2-dimensional information of the pharyngeal airway. Although we did not monitor the inspiratory force during the Muller maneuver, this maneuver seems to have good reproducibility in evaluations by different examiners.[26] Moreover, the results do not seem to change between the sitting and supine positions[27]; therefore, we believe that the CT exams, with and without a Muller maneuver, mimic the findings of office-based fiberoptic examinations. Since our inclusion criteria for surgical treatment were based on clinical otolaryngology examinations and these are somehow subjective and hard to quantify, we were worried about obtaining bias from preoperative pharyngeal, tongue, or mandible differences, even though we randomly assigned patients to the groups. Therefore, the main role of our CT examinations was to help us identify that possible bias and, secondarily, to quantify postoperative airway changes.

There were no postoperative statistically significant differences between groups in any of the CT airway measurements, despite the clinical and polysomnographic differences we observed. The reduction in the transverse diameter of the high retropalatal area in the UPPP group, during the normal phase, doesn't explain the polysomnographic outcomes because this region is far away from the surgical site and does not seem to be involved in the obstructive events. We think that this shape change can occur due to edema redistribution within this area influenced by a vibrating airflow.[28] On the other hand, there was a significant increase in the transverse diameter of the minimal retropalatal area, during the Muller phase, in the lateral pharyngoplasty group. This shape difference may be a direct effect of the Z-plasties, splinting the lateral port areas but not statistically enlarging this region.

Paradoxically, we noted a significant postoperative reduction in the retroglossal area, during the Muller phase, in the lateral pharyngoplasty group. Although we cannot withdraw variations in the inspiratory forces used here, we noted that some patients pulled their larynx caudally during the maneuver, thereby changing the reference for localizing the retroglossal area and presumably accounting for these differences. In addition, after a palatopharyngeal operation, the impact of inspiratory pressures on the pharynx and tongue presumably changes and may pull the tongue backward.

The preoperative retroglossal area, only during the Muller phase, was significantly smaller in the UPPP group compared to the lateral pharyngoplasty group. We do not believe that this was responsible for the different outcomes of the treatments. The reason is that the mean retroglossal collapse in the UPPP group was less than 30% (from 2.74 to 2.04 cm^2) and this area was statistically greater than the minimal retropalatal area, meaning that these patients had, while awake, retropalatal and not retroglossal collapse. In addition, there was no statistical difference between groups regarding this parameter postoperatively.

There are some possible criticisms to our study. We do not know if our 2-dimensional CT measurements are adequately powered to identify postoperative differences in upper-airway size. The volumetric magnetic resonance imaging technique[29] is probably more suitable for this analysis. However, the volume of tissue removed during the operation provides much more straightforward information regarding this matter than can any imaging examination. In addition, we did not monitor the inspiratory pressure during the Muller maneuver, which would have increased the value of the information on collapsibility of the upper airway but would not have altered our inclusion criteria or our analysis of the pharynx during tidal breathing. Further, controlling the patients for phase of ventilation during dynamic upper-airway imaging[1] is important in a future study to prove that lateral pharyngoplasty effectively splints the lateral pharyngeal walls.

Finally, it is always worth commenting on whether or not OSAHS is an anatomic disorder.[30,31] We think that our study favors the hypothesis that OSAHS, in adults, is a pharyngeal dysfunction and not an anatomic disorder. So far, after controlling 1 population for age and BMI, anatomy can neither differentiate healthy persons from patients with OSAHS nor assess the severity of the disease. For that purpose, we need a functional test, the polysomnography. An anatomic disorder implies an anatomic diagnosis. For instance, tonsillar hypertrophy is an anatomic disorder. To the best of our knowledge, OSAHS is not an anatomic disorder.

CONCLUSION

Lateral pharyngoplasty produces better clinical and polysomnographic outcomes in the treatment of OSAHS than does UPPP, without resultant differences in the cross-sectional measurements of the pharyngeal airway between these treatments. These results may support the concept that changing the LPW properties is better than focusing on changing the pharyngeal airway size for treating patients with OSAHS.

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