A Rational Approach to the Management of Obstructive Sleep Apnea Syndrome

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Abstract Snoring & obstructive sleep apnea syndrome (OSAS) is a globally prevalent problem which is on the rise in recent times. The treatment modalities include medical appliances and surgery. It is mandatory to have a rational approach in the management of OSAS, by meticulously analyzing both anatomical and physiological parameters causing the disorder. To define a rational approach for the management of OSAS, by devising a comprehensive protocol with assessment of anatomical level of obstruction by dynamic MRI and physiological factors by Epworth sleepiness scale (ESS) and Polysomnography. A prospective study in 110 patients was conducted over a period of 2 years, at our institute. All patients in the study group were evaluated with dynamic MRI and ESS and Polysomnography. As per the management protocols defined in the study, surgery was advocated in 46 patients (Group 1) with severe compromise in airway, while another group of 64 patients (Group 2) were provided continuous positive airway pressure support (CPAP). Successful outcomes among these 110 patients were analyzed at the end of the study period. A few patients required multimodal therapy which included surgery and CPAP support. Among 46 patients, surgical treatment proved successful in 41 patients in whom AHI reduced from 46.96 to 12.88 (improved by 62%) and ESS improved by almost ten points. Among 64 patients in CPAP group, AHI reduced from 54.2 to 11.3 (improved by 79%) and ESS improved by 11 points in all

the patients, but six of them had poor compliance. Five patients among the surgical group had persistence of symptoms. Inferences derived from the above results proved the success of formulating a rational approach in the management of OSAS. Critical analysis of the anatomical and physiological factors inducing obstructive episodes and an appropriate treatment plan is vital, to produce successful outcomes in patients with OSAS. Failure of surgical procedures, are often due to improper case selection. A small group of patients may require multimodal therapy with surgery and CPAP.

Keywords Obstructive sleep apnea syndrome · Respiratory distress index · Polysomnography · Sleep MRI · Epworth sleepiness scale

Introduction

Snoring & obstructive sleep apnea syndrome (OSAS) is a common disease of all age groups with a myriad of presentations. It affects 2–4% of middle aged adults and 1–3% of children in the general population. Guilleminault, Eldridge and Dement were the first to describe sleep syndrome in 1973 and they established one of the first sleep clinics in the world [1].

Significant advances have been made since then in the field of sleep medicine and the present day otolaryngologist must be familiar with the diagnosis and various methods of management of sleep apnoea. Apnea means “*Cessation of breath*”. It is characterized by repetitive episodes of upper airway obstruction that occur during sleep, usually associated with a reduction in blood oxygen saturation. Clinically significant OSAS is likely to be present when AHI >14 events/hr sleep, in association with unexplained daytime

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sleepiness or a minimum of two of the other features of the condition like snoring, irritability, restless sleep and choking episodes.

The treatment modalities include medical appliances and surgery. Opinion regarding the ideal management of OSAS still remains divided, between the choice of surgery and medical therapy. There are two schools of thought; one extreme view completely negates any role for surgery, while the other extreme advocates surgery in majority of these cases. A rational approach needs to be devised, by analyzing both anatomical and physiological parameters for the optimal management of OSAS. This study proposes a rational approach by clinically correlating the anatomical and physiological factors influencing OSAS, which can help in developing future scientific management strategies for OSAS.

Materials and Methods

This prospective study of 110 patients, was conducted over 2 year period (March 2008 to Feb 2010), in the Department of Snoring & Sleep Disorders at our institute.

All patients were selected into this study after a meticulous history to establish a clinical diagnosis of OSAS and confirmed by Epworth sleepiness scale scores. After approval from the institutional ethical committee, the study group was counseled in detail and an informed consent was obtained for participation in this study. Patients were evaluated with dynamic (Sleep) MRI for assessment of anatomical levels of obstruction and a comprehensive study of physiological parameters during sleep was assessed by Polysomnography.

Inclusion criteria for the study was adult patients who presented with snoring and excessive day time sleepiness and only those patients who were having airway collapse in Sleep MRI.

In our study, the indications for surgery were based on a specific protocol as listed below:

- RDI >20
- O₂ saturation <90%
- Excessive day time sleepiness
- Significant cardiac arrhythmia
- Refused or rejected medical therapy/CPAP

Indications for CPAP used were:

- AHI >40
- AHI <40 if patient is unfit/reluctant for surgery
- Morbidly obese patients

Exclusion criteria were those patients who were already using CPAP or underwent surgery elsewhere, patients who were using antipsychotic medications/hypothyroidism/metabolic disorders/hypotonia.

Epworth sleepiness scale (ESS) score above ten (out of 24) indicate excessive day time sleepiness indicating OSAS. Subjects were given ESS questionnaires which included questions on presence of snoring, its intensity and the presence of any choking episode during sleep, recurrent awakening from sleep, excessive day time sleepiness, prior medical and surgical history, smoking and alcohol consumption, diabetes, hypertension, hypo/hyperthyroidism, asthma and exercise.

Sleep MRI (*High definition GE open 2.0 Tesla*) was used in our study for evaluating patients suffering from OSA, to identify the cause and level of obstruction and to determine ideal patients who would benefit from surgery. Dynamic narrowing is said to be present if the pharyngeal cavity lumen close in one of the images and if there is more than 50% reduction in the pharyngeal space all through during sleep as compared to maximum area seen in wakeful state. Reduction in airspace up to 50% is considered normal [2].

The Polysomnogram machine used in our study was *CleveMed Sleep Scout System P/N 502-0146-1*, Type III device, 9 channels unit, Cleveland, Ohio, United States. The Electrodes were placed by international 10–20 system. PSG record included overnight monitoring of pulse oximetry, ECG, EEG, anterior tibialis EMG, nasal and oral airflow, chest and abdominal movements, snoring and sleeping position. The Polysomnographic records were manually scored according to the standard criteria (Fig. 1). The main purpose of a sleep study is to confirm physiological factors contributing to decide the management of OSAS and to assess its severity in order to guide the therapeutic choices to offer patients.

Physical Examination includes Height and Weight, BMI (27.8 and 27.3 kg/m² were considered normal for a male and female, respectively), blood pressure, neck circumference—(17" and 15" were considered normal for a male and female, respectively), Hyomandibular distance, nasal patency assessed, oropharyngeal airway assessed, respiratory system, cardiovascular, endocrine and neurological system examination to detect any coexisting diseases.

Correlation of dynamic sleep MRI with Polysomnography was performed to plan the appropriate plan of management (surgery or CPAP) and the treatment outcomes were assessed 6 months later with postoperative/with CPAP Polysomnography and ESS scores.

The success of surgical treatment for OSAS was categorized by the criteria used by Sher et al. [3] in their 1996 review. This is defined as 50% improvement in RDI, with a decrease in the RDI to below 20, or the apnea index to below 10 from the pre operative level.

Results

In our case series of 110 patients, 62 patients had retro-palatal (Level I) collapse out of them 26 were provided

Fig. 1 Polysomnography

Fig. 2 Dynamic MRI showing type I and II airway collapse

CPAP and 36 patients underwent surgery. Seven patients had nasal polypi, 11 had turbinate hypertrophy, 5 had marked septal deviation along with retropalatal (Level I) collapse for which they underwent LAUP and nasal procedures accordingly (FESS/Turbinoplasty/Septoplasty). LAUP alone was done for 13 patients (Table 1). Among the 36 patients with level I collapse who underwent surgery three of them had persistence of symptoms (Table 3).

Both retropalatal and retrolingual collapse (level II) were noted in 40 patients out of them 32 were provided CPAP and

8 patients underwent surgery (Fig. 2). In this group six patients had combined LAUP and genioglossus advancement procedure. One syndromic patient had narrowed nasopharyngeal airway with retrognathia, he underwent maxillomandibular osteotomy and advancement. One morbidly obese patient had tracheostomy. Among the eight patients with level II collapse who underwent surgery, two of them had persistence of symptoms (Table 3).

Eight patients had retrolingual (level III) collapse for which two patients underwent genioglossus advancement

Table 1 Rationale in management of group I and II patients

Level of Airway Collapse (n = 110)	Surgery (n = 46)		CPAP (n = 64)
Level I – 62 (56.3%)	LAUP	13	26 (41.9%)
	LAUP + FESS	7	
	LAUP + Turbinoplasty	11	
	LAUP + Septoplasty	5	
	Total	36 (58.1%)	
Level II – 40 (36.4%)	LAUP + GGA	6	32 (80.0%)
	MMA	1	
	Tracheostomy	1	
	Total	8 (20.0%)	
Level III – 8 (7.3%)	GGA	2 (25.0%)	6 (75.0%)

Table 2 Correlation between pre surgical AHI, ESS, and post surgical AHI and ESS

Surgery	No of patients (n = 46)	Pre op (average)		Post op (average)	
		AHI	ESS	AHI	ESS
LAUP	13	30.0	15.6	14.4	6.9
LAUP + FESS	7	38.1	14.0	12.4	7.0
LAUP + septoplasty	5	32.5	17.0	12.5	5.0
LAUP + turbinoplasty	11	31.7	16.0	12.8	6.0
LAUP + GGA	6	35.3	18.0	18.1	8.0
MMA	1	77.6	20.0	14.3	9.0
Tracheostomy	1	89.2	22.0	03.2	4.0
GGA	2	41.3	19.0	15.4	8.0

while remaining six patients were provided with CPAP. See Table 2

Six patients who were not comfortable with CPAP underwent surgery (Table 3). Five of them had retropalatal (Level I) collapse for which they underwent LAUP and

One had both retropalatal and retrolingual collapse (level II) for which he had combined LAUP and mandibular osteotomy and genioglossus advancement procedure.

The above decrease in Mean Average score in AHI and ESS proves that there is significant relief in the sleep apnea

Table 3 Panorama of outcomes in treatment of OSAS

Level of airway collapse (<i>n</i> = 110)	Surgery (<i>n</i> = 46)	CPAP (<i>n</i> = 64)	
		Success rate	Poor outcome
Level I—62 (56.3%)	LAUP	10	3
	LAUP + FESS	7	0
	LAUP + turbinoplasty	11	0
	LAUP + septoplasty	5	0
	Total	33 (91.7%)	3 (8.3%)
Level II—40 (36.4%)	LAUP + GGA	4	2
	MMA	1	0
	Tracheostomy	1	0
	Total	6 (75.0%)	2 (25.0%)
Level III—8 (7.3%)	GGA	2 (100%)	0
Total		41 (89.1%)	5 (10.9%)

features with both surgical intervention and CPAP support. The rationale exists in the meticulous selection of ideal cases for surgery and CPAP therapy.

Treatment with Surgery

The Mean Average AHI score in group 1 was 46.96 before surgery and reduced to 12.88 after surgical intervention. The Mean Average ESS was reduced from 17 to 7 (Table 4).

Treatment with CPAP

The Mean Average AHI score in group 2 was 54.2 prior to CPAP therapy and reduced to 11.3 with CPAP support. The Mean Average ESS was reduced from 16 to 5 (Table 5).

The data collected was analyzed using SPSS software with the application of student 't' test for numerical values and the Carl Pearson method for correlation. Group 1 had patients selected for various surgical interventions and group 2 contained patients who were provided CPAP support as the primary mode of treatment.

Overall analysis of group 1 and 2 showed a significant positive correlation factor of $r = 0.604$ with $p < 0.01$ was observed between AHI and ESS prior to surgery or CPAP therapy.

Post treatment analysis among each group showed the following results:

In group 1 (surgical group) the post op AHI vs. ESS correlation was $r = 0.588$ significant at the level of 0.01.

In group 2 (CPAP group), AHI vs. ESS correlation with CPAP was $r = 0.1$ significant at the level of 0.01.

In our study of 110 patients, level I obstruction proved to be the commonest (56.3%) and surgery was the primary

treatment modality (58.1%) even though in selective cases CPAP was provided (41.9%). Three patients out of 36 who underwent surgery had failure (8.3%). Five patients out of 26 who were provided with CPAP had poor compliance (19.2%).

For the patients who were having level II obstruction (36.4%), CPAP proved to be the ideal treatment modality in most cases (80.0%), in rest of the patients underwent various surgical procedures (20.0%). Two patients out of eight who underwent surgery had failure (25.0%). One patient out of 32 who were provided with CPAP had poor compliance (3.1%).

For the patients who were having level III obstruction (7.3%), CPAP was found to be a better choice (75.0%). Two patients underwent surgery (25.0%).

Overall, out of 46 patients who underwent surgery five had failure (10.9%) and six patients out of 64 who were provided with CPAP had poor compliance (9.4%).

Discussion

Obstructive sleep apnea syndrome requires a rational management with correction of both physiological factors influencing collapse of airway and mechanical obstruction compromising the airflow. Traditionally treatment for snoring has focused on subjective assessment by Epworth sleepiness scale and treatment resolving only the mechanical obstruction in order to abstain people from snoring.

Current concept focuses on meticulous assessment of both anatomical and physiological parameters attributed to causation of OSAS. Objective assessment is done through apnea hypopnoea index score and symptomatic assessment is done through ESS. This study has focused on devising a

Table 4 Correlation between AHI, ESS before surgery and after surgery

No of patients	Pre OP (average)		Post OP (average)	
	AHI	ESS	AHI	ESS
46	46.96	17	12.88	7

Correlations

		AHI - PRE OP	ESS - PRE OP	AHI - POST OP	ESS - POST OP
AHI - PRE OP	Pearson Correlation	1	.662**	.387*	.357*
	Sig. (2-tailed)		.000	.015	.026
	n	46	46	46	46
ESS - PRE OP	Pearson Correlation	.662**	1	.462**	.599**
	Sig. (2-tailed)	.000		.003	.000
	n	46	46	46	46
AHI - POST OP	Pearson Correlation	.387*	.462**	1	.588**
	Sig. (2-tailed)	.015	.003		.000
	n	46	46	46	46
ESS - POST OP	Pearson Correlation	.357*	.599**	.588**	1
	Sig. (2-tailed)	.026	.000	.000	
	n	46	46	46	46

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

**CORRELATION BETWEEN AHI AND ESS PRE OP
IN SURGICAL GROUP** **CORRELATION BETWEEN AHI AND ESS POST OP
IN SURGICAL GROUP**

Table 5 Correlation between AHI, ESS before using CPAP and after using CPAP

No of patients	Before CPAP (average)		With CPAP (average)	
	AHI	ESS	AHI	ESS
64	54.2	16	11.3	5

Correlations

		AHI - WITHOUT CPAP	ESS - WITHOUT CPAP	AHI - WITH CPAP	ESS - WITH CPAP
AHI - WITHOUT CPAP	Pearson Correlation	1	.387**	.586**	.172
	Sig. (2-tailed)		.002	.000	.178
	n	64	64	64	64
ESS - WITHOUT CPAP	Pearson Correlation	.387**	1	.127	.206
	Sig. (2-tailed)	.002		.320	.106
	n	64	64	64	64
AHI - WITH CPAP	Pearson Correlation	.586**	.127	1	.100
	Sig. (2-tailed)	.000	.320		.436
	n	64	64	64	64
ESS - WITH CPAP	Pearson Correlation	.172	.206	.100	1
	Sig. (2-tailed)	.178	.106	.436	
	n	64	64	64	64

** . Correlation is significant at the 0.01 level (2-tailed).

CORRELATION BETWEEN AHI AND ESS PRE OP IN SURGICAL GROUP

CORRELATION BETWEEN AHI AND ESS POST OP IN SURGICAL GROUP

rationale based on the above two parameters for ideal management of OSAS. This study has documented definitive improvement in ESS and AHI scores by intervention with surgery and or CPAP.

The Fujita classification of airway obstruction divides the velohypopharynx into descriptive levels:

- Type I is retropalatal, posterior to the soft palate or velopharyngeal
- Type II is both retropalatal and retrolingual, or velohypopharyngeal
- Type III is retrolingual, posterior to the tongue base or hypopharyngeal

Literature analysis as per level of obstruction:

Level I Collapse

Kamami in his study of 63 patients reported with 50% of patients being cured of their obstructive sleep apnea and a significant reduction occurring in an additional 25% of patients with LAUP [4]. In a study by Walker R P et al. [5] in a case series of 43 patients, RDI decreased from 24.6 to 16.2. Mickelson et al. [6] reported on 36 patients that significant decrease in RDI from 28.1 to 7.9.

In our study of 110 patients, 62 patients were having level I airway collapse. LAUP was done alone in 13 patients and 23 patients underwent combined LAUP with nasal and other procedures. In patients with LAUP alone, in three patients AHI was reduced by only 25% but in others there was significant improvement over 50% in AHI. Post operatively AHI was significantly improved in all patients who underwent various nasal procedures along with LAUP. In this study success rate by LAUP alone is 76.9%. Average AHI reduced from 30.01 to 14.41 and ESS score improved from 15.6 to 6.9.

In a study by Kim et al. [7] the PSG effects after nasal surgery for snoring and OSAS showed a significant improvement in AHI, AI, and O₂ saturation index as well as a decrease in duration of snoring, however snoring and OSAS were only completely relieved in 19% of 21 patients.

In our study CPAP was prescribed for 26 patients with level I obstruction, in all of these patients AHI was reduced significantly over 50%.

Level II Collapse

Johnson and Chin [8] revealed a mean reduction in the AHI by 44.1, from a pre op value of 58.7 to post op value of 10.5 in patients undergoing UPPP and GGA. Riley et al. [9] revealed an overall success rate of 61% in a review of 239 patients undergoing GGA, hyoid suspension, and UPPP. In a case series of Powell et al. out of 175 patients 166 had

successful outcome, with a cure rate of 95%. The mean RDI was reduced from 72.3 to 7.2 [10]. For tracheostomy two studies reports the role of temporary tracheostomy in management of OSAS [11, 12]. Tracheostomy reliably eliminated all grades of OSAS severity in 79 patients and 20% were decanulated eventually, but there was a 2.5% tracheostomy related mortality [11].

In our study, 40 patients were found to be having level II airway collapse. In this group LAUP was done along with GGA in six patients. In four patients AHI was reduced by more than 50%. Success rate of this procedure is 66.6%. AHI reduced from 35.3 to 18.1 and improvement in ESS score is of ten points. MMA was done for one patient while one patient underwent tracheostomy because of severe respiratory distress, in both patients AHI was reduced significantly.

Randomized controlled study in level II obstruction shows that CPAP improves subjective and objective sleepiness [13]. Objective improvements are found in symptomatic patients with AHI >15 or > ten 4% desaturations/hr. Meta-analysis of several RCTs showed evidence of differential outcome with OSAS severity, with significant improvements in subjective Epworth sleepiness score in two studies of patients with severe OSAS [14].

In our study CPAP was given for 32 patients; all have shown great subjective and objective improvement as assessed by ESS, PSG, and MRI with CPAP.

Level III Collapse

In our study eight patients were having level III obstruction. All patients have shown good improvement on subjective assessment. For two patients GGA was done, for both of them there was more than 50% improvement in AHI. The success rates of the procedures have been variable, ranging from 23 to 77% [15, 16]. Rest of the patients were benefitted by CPAP. For level III obstruction several studies have documented that optimal CPAP implementation can normalize AHI and oxygenation. Patients who have moderate to severe OSAS should be treated with CPAP [17].

In addition who have mild OSAS in presence of comorbid factors, experience benefit from CPAP [17] persistence of sleep apnea may occur in patients treated with CPAP. This underscores the need for regular follow up and adjustment of mask interface to treat OSAS. In one study, persistence of sleep apnea was defined as AHI greater than ten per hour and occurred in 17% of the study subjects [18].

A meta-analysis of 11 trials assessing the effects of CPAP on subjective and objective sleepiness reported that CPAP reduced the ESS score an average of 2.94 points more than placebo ($p < 0.001$) [19].

Ramirez and Loube [20] revealed in morbidly obese patients a 42% success rate.

Overall, in five patients after surgery CPAP support was given to relieve the obstruction. The probable reason for this collapse inspite of surgical clearance may be attributed to muscle relaxicity and hypotonia, soft tissue edema, anatomically narrow oropharynx or subclinical central apnoea. None of the patient had post surgery nasopharyngeal regurgitation, velopharyngeal incompetence, aspiration syndrome.

Conclusion

Management of a patient with Sleep Disordered Breathing requires a multidisciplinary team approach. A systematic evaluation of each patient with a rationale stepwise surgical approach is necessary to produce the best outcomes.

A detailed history, clinical examination and simple overnight observation will usually help to clinch the diagnosis of obstructive sleep apnea syndrome. Polysomnography is the gold standard investigation to help diagnose the type and severity of sleep apnea. Sleep MRI (dynamic MRI) with Sleep Nasendoscopy has obviated the need for cumbersome cephalometric measures to establish the site of obstruction. Patients need to be counseled regarding all medical and surgical treatments that are available.

Continuous positive airway pressure support therapy is considered as the first line treatment, however surgery should be offered to patients, in selected and indicated cases and also those struggling to tolerate nasal CPAP. As otolaryngologist, we have the responsibility of helping the group of patients who cannot or will not accept CPAP as a permanent form of management.

The majority of patients select surgical treatment because of intolerance of nonsurgical treatments; some may consider surgery to improve their ability to tolerate nonsurgical treatments, such as the reduction of therapeutic CPAP pressure or improvement of nasal symptoms caused by CPAP use. The surgeon must educate the patient regarding complications and expected efficacy. Patients should be counseled about the treatment options and their eventual outcomes.

Key Message

Rational approach is mandatory in the management of OSAS by taking into consideration both the anatomical level of obstruction and the various physiological factors inducing obstruction. State of the art technological advancement like the dynamic sleep MRI and comprehensive PSG provide a vital hand in the decision making for the management of OSAS.

References

- Guilleminault C, Eldridge FL, Dement WC (1973) Insomnia with sleep apnea: a new syndrome. *Science* 181:856–858
- Suto Y, Matsuda E, Inoue Y, Suzuki T, Ohta Y (1996) Sleep apnea syndrome. Comparison of MR imaging of the oropharynx with physiologic indexes. *Radiology* 201:393–398
- Sher JW, Schechtman KB, Piccirillo JF (1996) The efficacy of surgical modifications of the upper airway in adults with obstructive sleep apnea syndrome. *Sleep* 19:156–177
- Kamani Y (1994) Outpatient treatment of sleep apnea syndrome with CO₂ laser: laser assisted uvulopalatopharyngoplasty. *J Otolaryngol* 24:395–398
- Walker RP, Garrity T, Gopalasami C (1999) Early polysomnographic findings and long term subjective results in sleep apnea patients treated with LAUP. *Laryngoscope* 109:1438–1444
- Mickelson SA, Ahuja (1999) Short term objective and long term subjective results of LAUP for obstructive sleep apnea. *Laryngoscope* 109:362–367
- Kim ST, Choi JH, Jeon HG, Cha He, Kim DY, Chung Ys (2004) Polysomnographic effects of nasal surgery for snoring and obstructive sleep apnoea. *Acta Oto Laryngol* 124:297–300
- Johnson NT, Chin J (1994) Uvulopalatopharyngoplasty and inferior sagittal mandibular osteotomy with genioglossus advancement for treatment of obstructive sleep apnea. *Chest* 105: 278
- Riley R, Powell N, Guilleminault C (1993) Obstructive sleep apnea syndrome: a review of 306 consecutively treated surgical patients. *Otolaryngol Head Neck Surg* 108:117
- Li KK, Riley RW, Powell NB et al (1999) Overview of phase II surgery for obstructive sleep apnea syndrome. *Ear Nose Throat J* 78:851–857
- Thatcher GW, Maisel RH (2003) The long term evaluation of tracheostoma in the management of obstructive sleep apnoea. *Laryngoscope* 113:201–204
- Campanini A, De Vito A, Frassinetti S, Vieini C (2003) Temporary tracheostomy in the surgical treatment of obstructive sleep apnoea syndrome: personal experience. *Acta Otorhinolaryngologica Italica* 23:474–478
- Engelman Hm, kingshott R, Wraith PK, Mackay TW, Deary IJ, Douglas NJ (1999) Randomized placebo-controlled crossover trial of continuous positive airway pressure for mild sleep apnea/hypoapnea syndrome. *Am J Respir Crit Care Med* 159:461–467
- Ballester E, Badia Jr, Hernandez L, Carrasco E, De Pablo J, Fornas C et al (1999) Evidence of the effectiveness of CPAP in the treatment of sleep apnea/hypoapnea syndrome. *Am J Respir Crit Care Med* 159:495–501
- Lee NR, Givens CD Jr, Wilson J et al (1999) Staged surgical treatment of obstructive sleep apnea syndrome: a review of 35 patients. *J Oral Maxillofac Surg* 57:382–385
- Bettega G, Pepin J, Veale D et al (2000) Obstructive sleep apnea syndrome: fifty one consecutive patients treated by maxillofacial surgery. *Am J Respir Crit Care Med* 162:641–649
- Loube DI, Gay PC, Strohl KP et al (1999) Indications for positive airway pressure treatment of adult obstructive sleep apnea patients: a consensus statement. *Chest* 115(3):863–866
- Baltzan Ma, Kassissia I, Elkhali O et al (2006) Prevalence of persistent sleep apnea in patients treated with continuous positive airway pressure. *Sleep* 29(4):557–563
- Patel SR, White DP, Malhotra A et al (2003) Continuous positive airway pressure therapy for treating sleepiness in a diverse population with obstructive sleep apnea: results of a metaanalysis. *Arch Intern Med* 163(5):565–571
- Ramirez SG, Loube Di (1996) Inferior sagittal osteotomy with hyoid bone suspension for obese patients with sleep apnea. *Arch Otolaryngol Head and Neck Surg* 122:953