Surgical Management of Obstructive Sleep Disordered Breathing: ENT Perspective

Assistant Professor Paraya Assanasen, M.D.
Wish Banhiran, M.D.
Associate Professor Choakchai Metheetrairut, M.D.
Department of Otolaryngology, Faculty of Medicine Siriraj Hospital

Obstructive sleep disordered breathing (OSDB) is a collective term that encompasses a spectrum of disorders ranging from primary snoring and upper airway resistance syndrome (UARS) to varying severity levels of obstructive sleep apnea syndrome (OSAS). The actual prevalence of snoring in Thailand is unknown, but it is estimated to be 20% in middle-aged male and 5% in middle-aged female.[1] The percentage is even higher in elderly people. OSAS affects about 4% of middle-aged male and 2% of middle-aged female.[2] OSAS is characterized by periodic collapse of the upper airway during sleep, which leads to either complete (apneas) or partial airway obstruction (hypopneas), or both, resulting in arousal and oxygen desaturation. Risk factors for this condition include obesity, anatomical abnormalities, aging, male sex, and family history. Recognition of OSAS is important since it causes daytime somnolence, neurocognitive defects, chronic fatigue, and depression. In addition, it can increase the risk of having traffic accident, hypertension, cardiovascular disease, stroke, pulmonary hypertension, and cardiac arrhythmia. It is also very annoying to bed partners of the patients.

Surgical Management

The treatment options for OSDB include weight loss, proper sleep hygiene, positional therapy, oral devices, continuous positive airway pressure (CPAP), and surgery. In moderate to severe OSAS, CPAP is usually considered the most effective treatment. However, in patients who have significant structural pathology and/or who are intolerant to nasal CPAP, surgery offers a viable alternative. The aims of surgical treatment of OSDB are to enlarge the size of the upper airway and to correct anatomical abnormalities at multiple levels of the upper aerodigestive tract which may start from nasal cavity to nasopharynx, oropharynx, and hypopharynx. The selection of

surgical procedure(s) should be based on the patient's airway structure, type and location(s) of the pathology, medical status, severity of sleep apnea, and his or her desire and preference. Potential risks and complications must be fully explained to all surgical candidates. To improve the surgical outcomes, the correction of the upper airway may need more than one level especially in patients with moderate to severe OSAS.

1. Nasal and/or nasopharyngeal surgery

Surgical correction of nasal obstruction has been shown to have beneficial effects on nocturnal nasal breathing in patients with OSDB. It does not only help relieving nasal obstruction, but also facilitates the use of nasal CPAP.[3] Various procedures are available to correct nasal obstruction secondary to deviated nasal septum (e.g. septoplasty), turbinate hypertrophy [submucous diathermy, radiofrequency volumetric tissue reduction (RFVTR), outfracture of the turbinate, submucous turbinoplasty, turbinectomy, intraturbinal use of Nd:YAG laser], or nasal valve abnormalities. Yariktas and colleagues[4] reported a significant improvement in snoring complaints in patients undergoing septoplasty for causes other than snoring. However, one recent study showed that although nasal surgery significantly decreased nasal resistance, it did not seem to decrease snoring intensity, snoring time, or OSDB in an objective assessment by postoperative polysomnogram.[5]

RFVTR of hypertrophic inferior turbinate is effective in patients with retractable nasal obstruction who do not respond to conventional treatments. It also has beneficial effect in patients who have nasal congestion during nasal CPAP usage. The advantages of RFVTR over electrocautery and laser surgery reside in its precision in thermal ablating tissues, less postoperative pain, and the ease of use during operation. The temperature of target tissue remains within a range of 60-90°C. The coagulated tissue is gradually resorbed within 6-8 weeks. In a study by Li et al., no adverse effect from this procedure, such as bleeding, crusting, dryness, infection, adhesion, or a worsening of obstruction, were encountered.[6] Mild edema was noted in all patients but only for a short duration (24-48 hours) and did not interfere with nightly use of nasal CPAP. Postoperative discomfort was mild. Eight weeks after treatment, subjective nasal breathing improved in 21 of 22 patients, with a 58.5% reduction in severity and a 56.5% decrease in the frequency of nasal obstruction. So far, the duration of radiofrequency effect on nasal obstruction reported by several authors has been at least 1-2 years.[7] Patients who benefit most from correction of nasal obstruction as a sole intervention are probably those with the mildest forms of OSDB without other significant predisposing anatomical abnormalities.

Adenotonsillar hypertrophy is the major cause of OSAS in children. Tonsillectomy and adenoidectomy are effective in improving the physical sequelae and quality of life of affected children.[8]

2. Oropharyngeal surgery

The surgical options available for the obstruction at oropharyngeal level are as followed.

2.1 Uvulopalatopharyngoplasty (UPPP) is designed to eliminate the excess loose palatal and pharyngeal mucosal and submucosal tissues. It is recommended for treatment of nonobese or mildly obese snorers with mild to moderate OSAS in whom correctable anatomical abnormalities are identified in the oropharyngeal and palate areas and who are intolerant of CPAP. Removal of tonsils and other redundant pharyngeal folds is followed by lateralization, suture fixation, tightening, and stabilization of the pharyngeal airway below the palatal level. Reported complications include airway obstruction, hemorrhage, velopharyngeal incompetence, and nasopharyngeal stenosis. Metaanalysis of the data indicates a success rate of only 40%.[9] Several modifications of this surgical techniques have been established such as submucosal UPPP introduced by Friedman and colleagues to provide faster wound healing, less postoperative pain, and suture line dehiscence.[10]

2.2 Laser-assisted uvulopalatoplasty (LAUP) is an outpatient surgical procedure in which the uvula and soft palate are reduced and reshaped with the CO_2 laser to increase the oropharyngeal airway size and to reduce the vibratory soft tissue. It excises only the uvula and associated soft-palate tissues and does not remove or alter tonsils or lateral pharyngeal-wall tissues. The LAUP procedure is most often performed to alleviate snoring. It provides good and lasting results in snoring improvement if performed correctly in properly selected patients. The intensity of snoring can be reduced up to 75%. The snoring reduction is assessed 4 to 6 weeks after surgery to determine if additional treatments are needed. The procedure could be repeated if the patients still snore. Ferguson and colleagues performed a randomized trial of LAUP in the treatment of mild OSAS [respiratory disturbance index (RDI) =10-27 per hour].[11] The RDI post-LAUP was reduced by 21% overall compared with no change with the control group at outcome, and 48% of patients reported significant improvement of snoring after the LAUP.

2.3 Uvulopalatal flap (UPF) A one-stage UPF is a modification of UPPP, which can be performed in the outpatient setting under local anesthesia or under general anesthesia. The mucosa over the lingual surface of the uvula and soft palate is removed with cold knife dissection. The uvular tip is then amputated, and the uvula is reflected up toward the soft palate and sutured. It offers

potential advantages over the traditional UPPP in maintenance of palatal dynamics, lessened chance of scar contracture, reversibility, and lessened pain. Neruntarat assessed the safety and efficacy of UPF for the treatment of simple snoring under local anesthesia.[12] Significant improvement was observed in snoring scale and mean snoring index with the overall success rate of 88%. Li and colleagues reported the favorable surgical outcomes of a modified UPPP-extended UPF, which consisted of bilateral tonsillectomy, dissection and removal of submucosal adipose tissue of the soft palate and supratonsillar area; imbrication; and reposition of the denuded uvulopalatal flap, in the treatment of OSAS.[13] Six months after operation, there was a significant decrease in mean RDI and a significant improvement in mean minimal oxygen saturation and snoring index.

2.4 Injection snoreplasty is designed for treatment of palatal snoring. A sclerosing agent is injected submucosally into the midline soft palate to induce scarring or control fibrosis, which diminishes palatal flutter snoring. Two sclerosing agents introduced by Mair and Brietzke include 10 mg/ml of sodium tetradecrylsulfate (STS) which has a low cost and long standing safety record, and 50% ethanol (99% dehydrated alcohol) diluted with 2% lidocaine without epinephrine (not yet approved by FDA for this purpose).[14] After injection, snoring gradually improves with greatest effect for about 6 weeks. If the snoring is not satisfactorily reduced, reinjection may be considered at different sites. Satisfaction in terms of decreased snoring severity for the treatment of simple snoring was reported by 76.7% of the patients who underwent injection snoreplasty compared with 87.5% of those who received RFVTR of the soft palate.[15] It is simple to perform, minimally painful, highly effective, and inexpensive. However, its long-term side effects have not yet been proven. Complications reported include mucosal breakdown and soft palate fistula in some patients which have resolved in every case without sequelae. There have been no reports of postinjection swallowing difficulty, speech problem, or anaphylaxis.[16]

2.5 Tonsillectomy is indicated in patients with OSDB who have enlarged tonsil. Tonsillectomy and adenoidectomy significantly improved behavioral and emotional difficulties and quality of life found in children with documented OSAS.[17] Lingual tonsillar hypertrophy can be relieved using laser vaporization. Suzuki and colleagues performed lingual tonsillectomy using a new ultrasonic coagulating dissector (SonoSurg®) in patient with snoring and OSAS.[18] This instrument converts ultrasonic vibrations into energy, which minimizes bleeding by coagulation during cutting tissue. The investigator found that the operative time was shortened, and it was effective and safe as patients had less postoperative hemorrhage and pain, and faster recovery with shorter stays.

2.6 Procedure for tongue base hypertrophy and collapse Narrow retrolingual space is a problematic component of OSAS. Treatment of this area requires invasive surgery with high morbidity. A new minimally invasive technique that achieves stabilization of the tongue base (Repose®) has been described. It uses a soft tissue to bone anchor inserted intra-orally into the mandible with an attached prolene suture that is passed through the tongue. Rigidity is added to the airway after incorporation of the suture in the tongue musculature. The tongue base suspension combined with UPPP has been shown to reduce RDI better than UPPP alone. This minimally invasive technique is highly successful at 81.81% when combined with UPPP in the severe OSAS patients with multilevel airway collapse.[19] In addition, middle part of tongue base can be resected using laser (laser midline glossectomy). The insertion of genioglossus muscle can be advanced anteriorly through mandibular osteotomy to increase retrolingual space.

2.7 Radiofrequency volumetric tissue reduction (RFVTR) The novel radiofrequency procedures are technically simple, minimally invasive, and are associated with reduced postoperative pain and discomfort compared with traditional surgical procedures. It can be performed as an outpatient basis under local anesthesia with a low complication rate and good therapeutic results.[20]

Soft palatal radiofrequency reduces the volume of palatal soft tissue and produces scar tissue to alleviate velopharyngeal vibration and collapse in snoring and mild OSDB. In a randomized, placebo-controlled trial, RFVTR of the soft palate was significantly better than placebo in improving snoring.[21] Said and Strome conducted telephone interviews to assess the long-term efficacy (average follow-up of 14 months) and morbidity of RFVTR of the soft palate for snoring.[22] The majority of patients responded favorably to treatment without significant complications or long-term sequelae. The clinical outcome in snoring control appears to be comparable to more invasive palatal procedures presently available. Recurrence rate of snoring reported by Li et al. at 12-18 months was 41% in their patients.[23] Fortunately, due to its minimal change in palatal anatomy and little discomfort, 95% of patients who had prior treatment reported their willingness to consider retreatment with the same modality. Complications reported are minor including palatal edema, mucosal ulceration with spontaneous resolve in all patients.[24] Rombaux and colleagues recently compared the side effects and the postoperative complications of UPPP, LAUP, RFVTR, 3 procedures commonly used for the treatment of primary snoring.[25] The data reveal that RFTVR is a safer and less painful procedure and has less complication rate than UPPP and LAUP. Postoperative discomfort after LAUP and after UPPP appears to be very similar. However, the success rate of RFTVR of the soft palate is lower compared to the more invasive technique of UPPP.[26]

Radiofrequency tongue base reduction is generally considered as an adjunctive treatment to other upper airway procedures in OSA patients with macroglossia, or relative macroglossia. It improves upper airway patency by reducing the size of the tongue. This modality is a multiple-staged procedure separated by approximately 4 weeks, performed in an outpatient setting using local anesthesia with minimal discomfort and morbidity. Due to its slow and variable effect, treatment sessions are repeated every 4-6 weeks until snoring and other OSA symptoms resolve. Potential complications include superficial tongue ulceration, pain on swallowing, and tongue abscess. There were no changes in speech or swallowing.[27] Fischer and colleagues evaluated the safety and efficacy of multilevel radiofrequency application to soft palate, tonsils, and base of tongue in 15 patients with moderate to severe OSAS.[28] There were significant decreases in score on Epworth sleepiness scale, their daytime sleepiness, snoring score, and RDI with low complication rate. This study has shown that radiofrequency offers the potential of altering the upper airway size in patients with moderate to severe OSAS.

Radiofrequency-assisted uvulopalatoplasty (RAUP) is similar to LAUP, but it is done with a non-temperatured controlled radiofrequency instrument, instead of a laser. A special radiofrequency electrode is used to make two vertical cuts on either side of the uvula. These are joined by a horizontal cut and the uvula is removed. Most patients are able to return to work on the next day. Wedman and Miljeteig performed RAUP in 40 male social snorers and followed up until 3 months postoperatively.[29] Snoring sounds and daytime tiredness reduced significantly. The relative small investments needed and its simplicity makes RAUP a good alternative to known treatment strategies.

The Coblation method replaces the extreme heat of laser and standard electrosurgery with a gentle heating of the tissues causing physical reduction and shrinkage of the affected site. This is achieved by molecular disintegration via a plasma-mediated cold ablative process compared to the gradual and slow vascular degeneration produced by traditional radiofrequency procedures. Thus, Coblation results in rapid and precise volumetric tissue removal with little or no collateral tissue damage. In addition, it can simultaneously achieve coagulation of smaller blood vessels within few seconds rather than several minutes with a delayed response like traditional radiofrequency. Its efficacy in volumetric tissue removal has been clearly demonstrated in tonsillectomy[30] and inferior turbinate reduction procedure.[31]

2.8 Pillar procedure is another technique that has been approved by FDA for the treatment of snoring and mild to moderate OSAS. It involves inserting three tiny woven polyester into soft palate under local anesthesia and stiffens the soft palate leading to reduced both vibration

and collapse of the soft palate to obstruct the airway. Rather than surgical removal of tissue, the procedure is designed to reinforce the soft palate. The inserts induce a natural tissue response that secures them within the palate and provide structural support to the soft palate. It is a new surgical tool offering a simple, safe, effective and minimally invasive procedure with good patient acceptance. The advantage of this procedure is very little tissue damage and a single treatment session with potential less relapse rate due to its permanent palatal framework. Nordgard et al report short-term results of pillar implants in 25 patients with AHI between 10-30 and BMI less than 30[32] The AHI was reduced from a mean of 16.2 to 12.1 ($p < 0.05$), Epworth Sleepiness Score decreased from 9.7 to 5.5 ($p < 0.001$), and the visual analog scale of snoring intensity reported by bed partner reduced from 8.4 to 4.3 ($p < 0.001$). It has also been shown to reduce snoring and daytime sleepiness at the 3-month follow-up[33] and over a period of one year[34] without complications. Partial extrusion rate have been reported from 4 to 17.8%.[35] Speech, swallowing, and taste were unchanged. More extensive studies are needed to assure good long-term outcome.

3. Hypopharyngeal surgery

Since the genioglossus muscle is attached to the lingual surface of the mandible at the genial tubercle and also to the hyoid complex just above the larynx. Movement forward of either or both of these anatomic structures will stabilize the tongue base along with the associated pharyngeal dilators. Therefore, hyoid myotomy with suspension and a mandibular osteotomy with genioglossus muscle advancement provide a high rate of surgical success. Neruntarat[36] performed hyoid myotomy with suspension in the treatment of hypopharyngeal obstruction of 32 patients with OSAS under local anesthesia and assess its safety and efficacy. There were significant decreases in RDI, Epworth sleepiness scale, snoring scale and a significant increase in the lowest oxygen saturation with a low probability of complications. Similar results were also found in another recent study.[37]

4. Other surgery

In retractable case, distraction osteogenesis can improve airway obstruction by expanding the maxillofacial skeleton. In individuals who require more aggressive advancement of the hypopharyngeal airway, maxillary-mandibular advancement is an effective mechanism to maximize their airway space. The surgical success rate of maxillomandibular advancement was 84% in one recent study.[38] Complications include bleeding, infections, upper airway obstruction, hematoma, and facial anesthesia.

If all treatment modalities fail, tracheostomy can be considered as a final therapeutic option, especially in morbidly obese patients with severe OSAS, significant oxygen desaturation, and/or associated cardiac disease.

Patients with OSAS are more likely to be obese, have hypertension and other cardiovascular disease, and have difficult airways both at intubation and after surgery. The care of these patients requires vigilance to minimize postoperative edema and prevent airway compromise and other complications. If patients undergo surgery under general anesthesia, they should be closely monitored postoperatively in an intensive care unit setting by experienced staff. Since postoperative airway problems usually occur in patients underwent combined multiple simultaneous surgeries, stage procedures are encouraged to avoid this potential complication. Intravenous corticosteroid can be given to reduce swelling or edema of the airway. It should be noted that apnea is aggravated by narcotics, and life-threatening loss of airway can be precipitated. Thus, antiemetics, sleeping medications, relaxants, and sedative tranquilizers should be avoided. The criteria for discharging the patients include having a secured airway, adequate fluid intake, and good pain controls.

Conclusion

There is clear association between OSAS and morbidity and mortality. Although nonsurgical treatment is effective, most are limited by patient compliance. Surgical therapy is an alternative in patients who are intolerant of conservative treatments. Outcome data have demonstrated that surgical therapy can be successful in the treatment of OSDB. A careful evaluation of location and cause of airway abnormality and proper selection of patients can result in improved clinical outcome and patients' quality of life and general health with minimal complications.

References

1. Lugaresi E, Cirignotta F, Coccagna G, Baruzzi A. Snoring and the obstructive apnea syndrome. Electroencephalogr Clin Neurophysiol 1982;35:421-30.
2. Young T, Palta M, Demsey J, Skatrud J, Weber S, Badr S. The occurrence of sleep-disordered breathing among middle-aged adults. N Engl J Med 1993;328:1230-5.
3. Friedman M, Tanyeri H, Lim JW, Landsberg R, Vaidyanathan K, Caldarelli D. Effect of improved nasal breathing on obstructive sleep apnea. Otolaryngol Head Neck Surg 2000;122:71-4.

4. Yariktas M, Doner F, Dogru H, Tuz M. The beneficial effect of septoplasty on snoring. Kulak Burun Bogaz Ihtis Derg 2003;10:58-60.
5. Virkkula P, Bachour A, Hytonen M, Salmi T, Malmberg H, Hurmerinta K et al. Snoring is not relieved by nasal surgery despite improvement in nasal resistance. Chest 2006;129:81-7.
6. Li KK, Powell NB, Riley RW, Troell RJ, Guilleminault C. Radiofrequency volumetric tissue reduction for treatment of turbinate hypertrophy: a pilot study. Otolaryngol Head Neck Surg 1998;119:569-73.
7. Porter MW, Hales NW, Nease CJ, Krempl GA. Long-term results of inferior turbinate hypertrophy with radiofrequency treatment: a new standard of care? Laryngoscope 2006;116:554-7.
8. Ray RM, Bower CM. Pediatric obstructive sleep apnea: the year in review. Curr Opin Otolaryngol Head Neck Surg 2005;13:360-5.
9. Sher AE, Schechtman KB, Piccirillo JF. The efficacy of surgical modifications of the upper airway in adults with obstructive sleep apnea syndrome. Sleep 1996;19:156-77.
10. Friedman M, Landsberg R, Tanyeri H. Submucosal uvulopalatopharyngoplasty. Op Tech Otolaryngol Head Neck Surg 2000;11:26-9.
11. Ferguson KA, Heighway K, Ruby RR. A randomized trial of laser-assisted uvulopalatoplasty in the treatment of mild obstructive sleep apnea. Am J Respir Crit Care Med 2003;167:15-9.
12. Neruntarat C. Uvulopalatal flap for snoring on an outpatient basis. Otolaryngol Head Neck Surg 2003;129:353-9.
13. Li HY, Li KK, Chen NH, Wang PC. Modified uvulopalatopharyngoplasty: the extended uvulopalatal flap. Am J Otolaryngol 2003;24:311-6.
14. Brietzke SE, Mair EA. Injection snoreplasty: investigation of alternative sclerotherapy agents. Otolaryngol Head Neck Surg 2004;130:47-57.
15. Iseri M, Balcioglu O. Radiofrequency versus injection snoreplasty in simple snoring. Otolaryngol Head Neck Surg 2005;133:224-8.
16. Brietzke SE, Mair EA. Injection snoreplasty: how to treat snoring without all the pain and expense. Otolaryngol Head Neck Surg 2001;124:503-10.
17. Tran KD, Nguyen CD, Weedon J, Goldstein NA. Child behavior and quality of life in pediatric obstructive sleep apnea. Arch Otolaryngol Head Neck Surg 2005;131:52-7.
18. Suzuki K, Kawakatsu K, Hattori C, Hattori H., Nishimura Y, Yonekura A et al. Application of lingual tonsillectomy to sleep apnea syndrome involving lingual tonsils. Acta Otolaryngol Suppl 2003;550:65-71.
19. Omur M, Ozturan D, Elez F, Unver C, Derman S. Tongue base suspension combined with UPPP in severe OSA patients. Otolaryngol Head Neck Surg 2005;133:218-23.
20. Troell RJ. Radiofrequency techniques in the treatment of sleep-disordered breathing. Otolaryngol Clin North Am 2003;36:473-93.
21. Stuck BA, Sauter A, Hormann K, Verse T, Maurer JT. Radiofrequency surgery of the soft palate in the treatment of snoring. A placebo-controlled trial. Sleep 2005;28:847-50.

22. Said B, Strome M. Long-term results of radiofrequency volumetric tissue reduction of the palate for snoring. Ann Otol Rhinol Laryngol 2003;112:276-9.
23. Li KK, Powell NB, Riley RW, Troell R J, Guilleminault C. Radiofrequency volumetric reduction of the palate: an extended follow-up study. Otolaryngol Head Neck Surg 2000;122:410-4.
24. Kezirian EJ, Powell NB, Riley RW, Hester JE. Incidence of complications in radiofrequency treatment of the upper airway. Laryngoscope 2005;115:1298-304.
25. Rombaux P, Hamoir M, Bertrand B, Aubert G, Liistro G, Rodenstein D. Postoperative pain and side effects after uvulopalatopharyngoplasty, laser-assisted uvulopalatoplasty, and radiofrequency tissue volume reduction in primary snoring. Laryngoscope 2003;113:2169-73.
26. Hofmann T, Schwantzer G, Reckenzaun E, Koch H, Wolf G. Radiofrequency tissue volume reduction of the soft palate and UPPP in the treatment of snoring. Eur Arch Otorhinolaryngol 2006;263:164-70.
27. Riley RW, Powell NB, Li KK, Weaver EM, Guilleminault C. An adjunctive method of radiofrequency volumetric tissue reduction of the tongue for OSAS. Otolaryngol Head Neck Surg 2003;129:37-42.
28. Fischer Y, Khan M, Mann WJ. Multilevel temperature-controlled radiofrequency therapy of soft palate, base of tongue, and tonsils in adults with obstructive sleep apnea. Laryngoscope 2003;113:1786-91.
29. Wedman J, Miljeteig H. Treatment of simple snoring using radio waves for ablation of uvula and soft palate: a day-case surgery procedure. Laryngoscope 2002;112:1256-9.
30. Belloso A, Chidambaram A, Morar P, Timms MS. Coblation tonsillectomy versus dissection tonsillectomy: postoperative hemorrhage. Laryngoscope 2003;113:2010-3.
31. Bhattacharyya N, Kepnes LJ. Clinical effectiveness of coblation inferior turbinate reduction. Otolaryngol Head Neck Surg 2003;129:365-71.
32. Nordgard S, Stene BK, Skjostad KW. Soft palate implants for the treatment of mild to moderate obstructive sleep apnea. Otolaryngol Head Neck Surg 2006;134:565-70.
33. Maurer JT, Verse T, Stuck BA, Hormann K, Hein G. Palatal implants for primary snoring: short-term results of a new minimally invasive surgical technique. Otolaryngol Head Neck Surg 2005;132:125-31.
34. Maurer JT, Hein G, Verse T, Hormann K, Stuck BA. Long-term results of palatal implants for primary snoring. Otolaryngol Head Neck Surg 2005;133:573-8.
35. Romanow JH, Catalano PJ. Initial U.S. pilot study: palatal implants for the treatment of snoring. Otolaryngol Head Neck Surg 2006;134:551-7.
36. Neruntarat C. Hyoid myotomy with suspension under local anesthesia for obstructive sleep apnea syndrome. Eur Arch Otorhinolaryngol 2003;260:286-90.
37. den Herder C, van Tinteren H, de Vries N. Hyoidthyroidpexia: a surgical treatment for sleep apnea syndrome. Laryngoscope 2005;115:740-5.
38. Smatt Y, Ferri J. Retrospective study of 18 patients treated by maxillomandibular advancement with adjunctive procedures for obstructive sleep apnea syndrome. J Craniofac Surg 2005;16:770-7.