Review of surgical treatment in the obstructive sleep apnea syndrome

Revisão do tratamento cirúrgico na síndrome da apneia obstrutiva do sono

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ABSTRACT
Obstructive sleep apnea syndrome is a prevalent disease that results in cardiovascular, metabolic, and cognitive complications. The major treatment modality has been the positive airway pressure device, but adherence to this form of treatment has been limited. For this reason, other forms of treatment may help to control this disease, such as the upper airway and cranial-facial surgical procedures. Therefore, the objective of this paper was to investigate surgical procedures that could be used for obstructive sleep apnea syndrome treatment in adults, as well as their indications and success rates. There are many proposed surgical procedures for the treatment of obstructive sleep apnea syndrome; these include upper airway and cranial-facial surgeries. Although few studies have confirmed the exact benefit of these procedures in the obstructive sleep apnea syndrome treatment, the presence of anatomical alterations in these sites and the severity of obstructive sleep apnea syndrome have been the main factors taken into consideration in the selection of patients to undergo this type of treatment.

Keywords: sleep apnea syndromes/surgery; uvula/surgery; palate, soft/surgery; pharynx/surgery; continuous positive airway pressure; bariatric surgery; pharyngeal muscles/surgery; nasal septum/surgery; treatment outcome; review.

RESUMO
A síndrome da apnéia obstrutiva do sono é uma doença prevalente, que leva a sérias complicações cardiovasculares, metabólicas e cognitivas. A principal modalidade de tratamento tem sido o aparelho de pressão aérea positiva, mas sua adesão tem sido limitada. Por este motivo, outras formas de tratamento podem auxiliar no controle desta doença, dentre elas, os procedimentos cirúrgicos na via aérea superior e os craniofaciais. Desta forma, o objetivo deste trabalho foi mostrar quais são os possíveis procedimentos cirúrgicos para o tratamento da síndrome da apnéia obstrutiva do sono em adultos, bem como a sua indicação e taxas de sucesso. Vários são os procedimentos cirúrgicos propostos para o tratamento da síndrome da apnéia obstrutiva do sono e estes incluem cirurgias na via aérea superior e craniofaciais. Embora faltem estudos, com rigor científico, para que seja possível afirmar o benefício exato desses procedimentos, no tratamento da síndrome da apnéia obstrutiva do sono, a presença de alterações anatômicas nesses locais e a gravidade da síndrome da apnéia obstrutiva do sono têm sido os principais fatores levados em consideração na seleção dos pacientes a serem submetidos a este tipo de tratamento.

Palavras-chave: síndromes da apnéia do sono/cirurgia; úvula/cirurgia; palato mole/cirurgia; faringe/cirurgia; pressão positiva contínua nas vias aéreas; cirurgia bariátrica; músculos faríngeos/cirurgia; septo nasal/cirurgia; resultado de tratamento; revisão.

INTRODUCTION
The obstructive sleep apnea syndrome (OSAS) is characterized by the presence of multiple narrowings or collapses of the upper airway (UA) during sleep, providing different degrees of oxyhemoglobin desaturation and sleep fragmentation due to frequent awakenings.

The OSAS is a highly prevalent disease, affecting 32.9% of the adult population from São Paulo. It causes a series of complications, with cardiovascular, and cognitive complications being the most studied.

The OSAS is a disease with multifactorial pathophysiology, probably derived from functional and anatomical alterations associated with neuromuscular alterations of the pharynx, which is the main site of the disease. The principal anatomical alterations related to the disease are those that include the UA and facial skeleton.

Several treatments have been proposed; however, positive airway pressure devices are considered the treatment of choice for these cases, in particular, for moderate to severe OSAS. The principal limitation of this type of therapy is adhesion.

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Because the UAW collapse site is the pharynx and due to difficulties in relation to therapy adhesion, with positive airway pressure devices, some surgical procedures that involve UAW and facial skeletal are proposed for disease control.

This study aims to identify surgical procedures for OSAS treatment, as well as their indications and success rates.

PREOPERATIVE EVALUATION

The indication for most surgical procedures is based on the presence of anatomical alterations and severity of OSAS. Thus, adequate evaluation of these patients, including clinical evaluation, UA and cranial-facial physical evaluation and polysomnography, is fundamental to obtain the best therapeutic response.

An adequate preanesthetic evaluation is also necessary. We know that the majority of patients with OSAS present UA and cranial-facial anatomical alterations and obesity, factors that can impair intubation. Moreover, the immediate postoperative period must be well attended, as anesthetic may recirculate, mainly in obese patients, often after treatment with opioid analgesic medication, resulting in the respiratory depression. Another factor to be taking into consideration, which can aggravate the diagnosis, is postoperative edema, that can also cause some respiratory discomfort. The use of continuous positive airway pressure (CPAP) in the pre and postoperative periods may facilitate clinical compensation of the patient in order to minimize these complications.

Moreover, it is of fundamental importance that the patient is aware of other possible forms of treatment, and that the doctor supports the decision to proceed with surgical treatment.

TYPES OF SURGICAL PROCEDURES

There are some new procedures that are currently under investigation; therefore, they will not be mentioned in this paper. The following ones are those that can be performed for OSAS treatment:

- Nasal surgeries: septoplasty, turbinectomy, and linear cauterization or radiofrequency of inferior nasal conchae;
- Pharyngeal surgeries: tonsillectomy, uvulopalatopharyngoplasty and its variations, CO₂ laser-assisted uvulopalatoplasty (LAUP), radiofrequency of the soft palate, palate implantations, medium glossectomy, radiofrequency of the tongue base;
- Cranial-facial surgeries: genioglossus muscle advancement and maxilla-mandibular advancement;
- Tracheostomy; and
- Bariatric surgery.

Nasal surgery

Nasal blockage is commonly related to snoring and OSAS, resulting in fragmentation and poor quality sleep, diurnal sleepiness, fatigue, and cognitive impairment. However, with regard to the role of the nose in the pathophysiology of OSAS, the literature is scarce and controversial. Although nasal alterations are frequently found in patients with OSAS, studies show that surgical correction of these alterations is capable of improving the quality of sleep and reducing the diurnal symptoms of patients with apnea, with minimal reductions in the extent of sleep apnea and hypopnea index obtained by polysomnography. Literature recommends correction of nasal obstructive factors in OSAS patients, independently of the diagnosis severity.

The objective of this procedure is to increase the permeability of the nasal fossae and diminish the airway resistance by means of correcting septal deviation (septoplasty) and nasal valve insufficiency, reduction of the inferior nasal concha (turbinectomy, turbinooplasty, linear or radiofrequency cauterization of the inferior nasal concha), and removal of eventual polyps and nasal tumors.

The procedure can be performed with curative intent in young and nonobese patients with mild diagnoses and without other obstructive sites, or coadjuvants, which benefits patients who need CPAP or the intraoral device for treatment of OSAS. Recent studies have demonstrated that nasal surgery promotes the reduction of CPAP pressure, making its use more comfortable, such that it could increase patient adherence.

The ideal procedure in this group of patients must provoke the least possible discomfort, without using nasal packing and inducing few adverse side effects, such as bleeding, crusting and edema of the nasal cavity, so that the limitation of CPAP use in the postoperative period is possible.

Uvulopalatopharyngoplasty and its technical variations

Uvulopalatopharyngoplasty (UPPP) consists on exeresis of part of the soft palate and uvula, with or without tonsillectomy, and was popularized in 1981, by Fujita. Since then, it has been performed in various forms using several surgical techniques. It was initially indicated for all patients with OSAS; however, the results were limited. In a meta-analysis review, Sher et al. questioned the technique’s effectiveness, they achieved 40.7% of success with the procedure. Patients were selected according to disease severity; and superior results were found in patients with milder diagnoses.

Aside from the severity of OSAS, the UPPP success was related to the presence of anatomical alterations in the oropharynx, such as palatine tonsil hypertrophy, tonsillar pillars, redundant palate, and long uvula. Friedman et al. observed better UPPP results in patients with grades III and IV hypertrophic palatine tonsils (greater than 50% obstruction of the oropharyngeal space), associated with class I or II modified Mallampati index (proper relationship between the tongue base and
oropharyngeal tissue) and with a body mass index (BMI) lesser than 40 kg/m², which the author classified as stage 1, with 80.6% of success. The correlation gradually decreased with variation of these parameters (stages 2, 3 and 4)⁰.¹⁹

There is a trend to carry out more conservative procedures, dealing mainly with the lateral pharyngeal wall, sparing the midline, in order to prevent the patient from having difficulties in utilizing the positive air pressure devices, if necessary, and to minimize potential complications⁶,¹⁸.

Thus, the best UPPP results are in nonobese patients with moderate or mild OSAS, with hypertrophy of grades II and IV palatine tonsils, with a class I and II modified Mallampati index and without any anatomical alterations in other sites³.

**CO₂ LAUP**

LAUP consists on the exeresis of part of the soft palate and the uvula with a carbon dioxide laser. Its indication is based on the same characteristics displayed for UPPP; however, it does not include the completion of tonsillectomy; therefore; being indicated only for patients with normotropic palatine tonsils.

The LAUP was introduced by Kamami, in 1990, to treat snoring. The procedure can be completed in an outpatient setting under local anesthesia and may require more than one application¹⁹.

The effectiveness of the procedure for snoring treatment varies from 48 to 86%⁵,¹⁰,2²; for the treatment of OSAS, effectiveness varies from 24 to 48%⁵,¹⁰,2².

The American Academy of Sleep Medicine has developed a practical guide for the use of LAUP, which recommends using this technique only for the treatment of snoring²¹.

Thus, patients who can benefit from the procedure are those presenting symptoms of snoring without OSAS, with anatomical oropharyngeal alteration without palatine tonsil hypertrophy, who are not obese and who do not present alterations in other anatomical sites³.

It is important to remember that this technique deals especially with the oropharyngeal midline, and that the current tendency is to spare the midline and act mainly on the lateral wall³,¹⁸.

**Radiofrequency**

Tissue reduction by radiofrequency technique, also called somnoplasty, was introduced by Powell et al., in 1997²⁴, and was approved by the Food and Drug Administration (FDA) to treat the UA obstruction in 1998. It was initially used in the soft palate and uvula in patients with primary snoring/mild OSAS and, later, in the tongue base for moderate/accentuated OSAS. It consists in volumetric reduction of tissues through the application of low-intensity thermal energy in the submucosa and consequential protein denaturation and thermocoagulation²⁴.

With the use of an electrode, the radiofrequency energy generates ionic agitation in the surrounding tissue, producing heat, with controlled temperature, and consequential tissue injury⁹. This reaction provokes tissue retraction and fibrosis, resulting in reduced volume at the point of application. It can be applied in the soft palate, inferior nasal conchae, and tongue base.

The application of radiofrequency has the advantage of being an outpatient procedure, performed under local anesthesia, as a minimally invasive procedure with little pain²⁰. The disadvantages are that it is a slower method, which may require multiple applications, and there is a high cost of the electrodes. There is not a consensus with regards to the number of applications, with three to four sessions completed for each patient²³.

Complications are rarely found when it is carried out on the soft palate and conchae. When it is carried out on the tongue base, the main complications are abscess and paresthesia of the hypoglossal and lingual nerves²¹.

The best results obtained in radiofrequency of the soft palate are in patients with primary snoring/mild OSAS and normotropic tonsils, with a success rate from 30 to 86%²⁵,²⁶. When it is used on the nasal conchae, success is obtained when exuberant nasal mucosa is present. This is an effective method to reduce symptoms and preserve the nasal mucosa function⁵,²⁵.

The application of radiofrequency at the tongue base has proven to be effective in reducing tongue volume by 17% on average, as demonstrated by cephalometry and magnetic resonance, with a success rate from 20 to 33%²³.

In one recent meta-analysis, 25 articles suggested radiofrequency as a treatment option for snoring and OSAS. In this study, it was shown to be an effective clinical treatment, capable of treating multiple anatomical sites, with improvement of diurnal sleepiness and symptoms of quality of life, but without significantly modifying the polysomnographic parameters²¹.

**Palate implants**

Another proposed method to reduce airway collapse at the oropharyngeal level is the placement of palate implants that were approved by the United States FDA for the reduction of snoring and the treatment of mild to moderate OSAS.

Palate implant is a minimally invasive procedure that involves the submucosal insertion of three rigid polyester implantations in the central part of the soft palate, whereas the more proximal portion of the implant is inserted close to the hard and soft palate junctions²⁷.

The aim is to improve snoring by stiffening the soft palate; however, the effect on OSAS is limited and the long-term benefits are unknown²⁸.
In a prospective nonrandomized study of 25 patients with mild to moderate OSAS, the surgical success and cure rates were between 40 and 28%, respectively. Friedman et al., in a randomized study with 62 obese patients with mild to moderate OSAS, observed a statistically significant improvement in the apnea-hypopnea index (AHI) for the sleep hour after palatal implantation (in comparison with the placebo procedure), with a surgical success rate of 45% \(^2\). Complications are rare, although there are reports of implant extrusion \(^2\).

Glossectomy
Glossectomies used for OSAS treatment are partial and medium, aiming at diminishing volume in relation to the oropharynx. Several techniques are described in the literature. Its main indication is for patients who present the tongue base as the principal obstructive anatomical site.

Glossectomies can be associated with other procedures, such as epiglotctomy and UPPP. The results are unsatisfactory, with success rates varying from 25 to 83%, and complications are not unusual\(^1\).

Genioglossus muscle advancement
The genioglossus muscle advancement is performed through a bone window in the hard palate (mandible), which is anteriorly fixed. The muscle in question, which is inserted, is tractioned, providing anteriorization of the tongue, thereby increasing the retropalatal space.

Genioglossus muscle advancement can be associated with other pharyngeal procedures such as hyoid suspension and UPPP, known as phase I and proposed by the Stanford group\(^3\).

The surgical results vary from 25 to 78%\(^1\), with the technique being combined in most reports with hyoid suspension and/or UPPP.

Thus, the genioglossus muscle advancement has the best results in patients with mild/moderate OSAS that present the tongue base as the main obstructive site.

Maxillomandibular advancement
The maxillomandibular advancement (MMA) is performed through the Le Fort I maxillary osteotomy, with microplate clamping, associated with sagittal osteotomy of the mandible and bicortical screw fixation. Together with the bony structures, all the attached pharyngeal soft tissue is anteriorized in an attempt to increase the posterior airway space and decrease pharyngeal collapsibility during sleep.

This technique was initially used for the treatment of modified dental occlusions and craniofacial dimorphisms, and it was later proposed for the OSAS treatment by the Stanford group, as the Stanford Phase II\(^5\).

The success rate in the literature varies from 75 to 100%\(^5\). In these reports, the use of MMA was indicated in patients with severe OSAS, who did not tolerate CPAP use, or as a rescue for other surgeries that did not obtain the expected results.

MMA can also be indicated as the initial treatment form for OSAS in patients with evident orthognathic alterations, independently of the severity of OSAS\(^7\).

Thus, MMA can be indicated in patients with serious OSAS that do not tolerate the use of CPAP, independent of the craniofacial alterations presence. It can also be indicated as an initial treatment in patients with craniofacial anatomical alterations, independent of the severity of OSAS.

MMA is the most efficient craniofacial surgery for the treatment of OSAS in adults\(^8\). One recent meta-analysis, which included 22 studies, determined a high effectiveness with an average AHI reduction of 64/h to 11/h (p<0.001) and surgical success and a cure index (AHI<5/h) of 86 and 43%, respectively\(^9\). The predictive factors of surgical success include young patients, low AHI and BMI, and greater degree of maxillary advancement\(^10\). Moreover, MMA maintains effectiveness in a long-term follow-up in relation to improved quality of life, excessive diurnal sleepiness, depression, memory loss, and hypertension\(^11\).

Tracheostomy
Tracheostomy is currently reserved for occasional cases and is indicated in patients with accented OSAS, associated with severe hypoxemia and cardiovascular comorbidities, such as cardiac arrhythmias and cor pulmonale. It is also indicated for patients with degree III obesity (BMI>40 kg/m\(^2\)), in whom the use of positive pressure devices is ineffective, intolerable or refused, or in patients with craniofacial skeletal deformities\(^12\).

Tracheostomy can be used temporarily (associated with other surgical modalities and as a form to guarantee permeability to the UAW) or definitively (as a permanent treatment form for OSAS). Tracheostomies are rarely definitively indicated, due to the low acceptance and high morbidity of this technique. However, the approach may be necessary in patients with accented OSAS among whom the CPAP is not tolerated, when other treatment options are ineffective or for patients with increased surgical risk.

Bariatric surgery
Approximately 65% of adults in the United States are overweight (BMI>25 kg/m\(^2\)) and more than 30% are obese (BMI>30 kg/m\(^2\))\(^12\). One recent epidemiological study performed in São Paulo identified 38.4% of those surveyed as overweight and 21.5% as obese\(^2\).
Surgically induced weight loss was initially reported in 1967\(^\text{45}\). Bariatric surgery is currently a weight loss modality for the morbidly obese (BMI>40 kg/m\(^2\)). This is a secure surgery, which results in accentuated and sustained weight loss and is associated with reduced mortality in comparison with conventional weight loss\(^\text{44}\). The candidates for bariatric surgery must meet criteria that include BMI>40 kg/m\(^2\) or BMI>35 kg/m\(^2\) with associated comorbidities (e.g., OSAS)\(^\text{45,46}\).

Obesity is one of the main causes of OSAS, with an estimated prevalence of 40% in obese people (BMI>30 kg/m\(^2\))\(^\text{37}\). A 10% increase in the BMI results in a 32% increase in AHI and a light to moderate reduction in weight may improve sleep apnea and diurnal sleepiness\(^\text{47,48}\).

Two recent meta-analyses evaluated the effectiveness of bariatric surgery to treat OSAS. Greenberg et al.\(^\text{49}\) previously observed that after surgical intervention, BMI decreased from 55 to 38 kg/m\(^2\) and AHI improved from 55 to 16/ apneas per hour. Holty et al.\(^\text{50}\) observed highly prevalent OSAS (79%) among the bariatric surgery candidates (76% had moderate to severe OSAS), but the condition appears to have been extremely underdiagnosed (only 30% in the preoperative period). However, more than 50% of the patients with operated OSAS presented residual disease, despite the weight loss. The greatest predictors of AHI reduction (or OSAS cure) are young age and/or low BMI\(^\text{50}\).

**CONCLUSION**

OSAS is a multifactorial pathophysiological disease that evolves with time. The treatment choice, in particular, for the moderate to severe diagnosis, is the use of positive air pressure devices. Low compliance has been the main limitation of this type of therapy.

Surgical treatment is another treatment option. The indication for surgical treatment is typically based on the presence of anatomical alterations and severity of OSAS. Moreover, surgical treatment can be carried out with both curative intent and as an adjuvant, in an attempt to alleviate the disease or facilitate adherence to positive airway pressure devices.

Despite the lack of studies with scientific rigor, which verify the exact benefit of the procedures in the treatment of OSAS, adequate evaluation and selection of patients is fundamental to optimize the therapeutic results, regardless of the used treatment type.

**REFERENCES**


