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ORIGINAL ARTICLE

Medicine Science International Medical Journal

Medicine Science 2025;14(1):213-7

# Effect of surgically assisted rapid maxillary expansion on obstructive sleep apnea

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Received 21 January 2025; Accepted 15 February 2025
Available online 01 March 2025 with doi: 10.5455/medscience.2025.01.033



**Abstract**

This study investigated the effect of surgically assisted rapid maxillary expansion (SARME) on obstructive sleep apnea syndrome (OSAS) with or without pterygomaxillary separation. The study included 32 patients (13 males, 19 females) who underwent SARMEfor maxillary narrowing and had no other systemic or maxillofacial surgery history. OSAS risk assessment of the patients was performed with the STOP-Bang questionnaire in the pre-surgery (T0) and post-surgery (T1) periods. A significant decrease was detected in the STOP-Bang scores of all participants in the post-surgery (T1) period (p=0.048). While a small decrease was observed in the STOP-Bang scores in the patients who underwent pterygomaxillary separation, the scores did not change in the group without separation. However, the difference between the two groups was not statistically significant (p=0.477). SARME is an effective surgical method that reduces OSAS symptoms. Assessments with the STOP-Bang questionnaire show the benefits of this method, especially in terms of expanding the nasal airway and reducing respiratory resistance. Further studies are required to further examine the effect of the method.

**Keywords:** Obstructive sleep apnea, STOP-Bang, sleep apnea, maxillary expansion

## Introduction

Obstructive sleep apnea syndrome (OSAS) which first described by Guilleminault in 1976 [1] is a condition that characterized by complete or partial upper airway obstruction during sleep [2]. With the increasing life expectancy and obesity the prevalence of OSAS increased worldwide. The reports show approximately 1 in 4 men and 1 in 10 women are affected [3].

Risk factors for OSAS include age, sex, and obesity. Other risk factors include family history, ethnicity, and bad lifestyle choices (such as drinking and smoking). Body mass index (BMI) and OSAS risk are correlated, most likely as a result of upper airway narrowing brought on by an excess of adipose tissue. Although OSAS can effect anyone at any age, its frequency seems to rise with advancing age [4].

Increased risks of several comorbidities, such as metabolic and cardiovascular diseases, behavioral issues, and impairment in neurocognition, are linked to OSAS [4]. Also it was reported that OSAS plays a role in the diseases like nonalcoholic fatty liver disease, insulin resistance, glucose metabolism, kidney disease, cancer, immune system, hypertension, gastroesophageal reflux [4].

The correlations between bimaxillary retrusion, severe bending of the base of the skull, and mandibular growth deficiencies, among other bone structure factors, and OSAS have previously been reported [2]. The most common contributing factor to development of OSAS is morphological anomalies like reduced mandibular body length, posterior displacement of maxilla, narrowing of pharyngeal space, inferiorly positioned hyoid bone [5]. Also transverse maxillary deficiency may lead to posterior tongue displacement and increased nasal resistance to airflow, which can facilitate pharyngeal collapse [4].

The treatment options vary, nonsurgical methods, usage of continuous positive airway pressure (CPAP) mask, weight loss, [3] exercise, positional treatment, pharmacologic therapy, mandibular advancement device [4]. Surgical treatment

**CITATION**
Balaban E, Kose TE, Karabag M, et al. Effect of surgically assisted rapid maxillary expansion on obstructive sleep apnea. Med Science. 2025;14(1):213-7.

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DOI: 10.5455/medscience.2025.01.033

options are uvulopalatopharyngoplasty, maxillomandibular advancement, nasal surgery, tracheostomy, bariatric surgery, hypoglossal nerve stimulation surgeries [3].

Surgically assisted rapid maxillary expansion (SARME) which first described 1938, is a safe and effective surgical technique that allows free mobilization of bone segments in the patients with fused suture in jaws. SARME is used for the treatment of maxillary transverse deficiency by increasing the perimeter of dental arch [2]. Although it has been used to treat crossbite traditionally, but in recent years, it has also become more important in the treatment of OSAS [5]. Possible complications of the technique are gingival recession, infections, hemorrhage, tooth devitalization [2].

Diagnosis of OSAS made by polysomnography, where patients' different parameters like apnea hypopnea index, arousals and microarousals, oxyhemoglobin saturation, distribution of stages of sleep, intensity and frequency of snoring monitored [3]. The method considered as gold standart for the diagnosis but the method in need for costly hospital equipments. Home respiratory polygraphy is a effective alternative where the test applied in patients' home with portable equipment. It shows reliable physicometric properties especially in suspected cases with moderate or severe OSAS cases.

Seeking to make OSAS diagnosis more accessible emphasizes the necessity of developing new algorithms for the early identification, treatment, and control of this illness, primarily in the primary care context [6]. STOP- Bang questionnaire which first developed in 2008 [7] is a simple way to assess the risk of OSAS of the patients. The title of the test is an acronym, and the letters stands for the word are stop (S), tired (T), observed apneas (O), pressure (P), body mass index (B), age (A), neck (N), gender (G) respectively [6].

STOP-Bang questionnaire has demonstrated its reliability and validity in a range of healthcare environments.

The aim of this study is to compare the pre-operative and post-operative STOP-Bang scores and thus the OSAS risks of patients who underwent SARPE with and without pterygomaxillary seperation. All patients were otherwise healthy. Exclusion criterias were presence of any syndrome, incomplete datas/ records postoperatively, prior orthodontic treatment or surgery of the maxillofacial area.

## Material and Methods

### Study Design

This study was approved by the Ethics Committee of Recep Tayyip Erdoğan University, Faculty of Medicine with the approval number 2024/221 Informed Consent form obtained from all the patients.

Study group composed of 32 patients (13 male, 19 female) who operated at the Recep Tayyip Erdoğan University Faculty of Dentistry between 2018 and 2024 for the maxillary transverse deficieny. Only patients with clinical and radiographic findings of transverse maxillary deficiency were included in the study. After orthodontic examinations patients were divided into two main groups: those with and without pterygomaxillary seperation.

The inclusion criteria for the study were as follows;

- Over 18 years of age,
- Patients underwent SARME of the maxilla,
- Patients signed the informed consent form.

The exclusion criteria for the study were as follows;

- Patients with a systemic contraindication for SARME,
- Patients with any developmental syndrome,
- Patients without the cognitive capacity to answer the STOP-Bang questionnaire,
- Patients receiving hypnotic treatment or with chronic alcoholism.

### Surgical Technique

All patients included in the study were operated on by the same team with the same technique for maxillary expansion. The surgical technique used was a modification of the technique described by Bell and Epker in 1976 [8]. Accordingly, an incision was made from the first molar region to the midline on both sides of the maxillary vestibule. After this incision, a subperiosteal flap was lifted on the lateral wall of the maxilla, thus exposing the apertura piriformis extending to the anterior base of the nose and the pterygomaxillary fissure. A periosteal elevator was used to lift the nasal mucoperiosteum to protect the nasal mucosa. Then, Lefort 1 osteotomy was performed, followed by osteotomy along the midpalatal suture between the upper central incisors. In 26 of the 32 patients included in the study, an osteotomy was additionally performed at the pterygomaxillary junction, while in 6 patients, the pterygomaxillary suture was not released. Then, a rapid mechanical expansion was performed. A Hyrax-type acrylic bonded expansion appliance was used for maxillary expansion and rotated until the initial bone resistance was achieved. Then, 10 more rotations were made, for a total expansion of 10 mm. The expansion was applied gradually to reduce the risk of undesirable fracture line formation.

### Questionnaire

The STOP-Bang questionnaire is used as an easily completed Obstructive Sleep Apnea Syndrome (OSAS) screening tool. The abbreviation of this questionnaire stands for the following terms: "S" for snoring, "T" for fatigue, "O" for observed apneas, "P" for blood pressure, "B" for BMI (body mass index >35 kg/m$^2$), "A" for age (over 50 years), "N" for neck circumference (>43 cm for men or >41 cm for women) and "G" for gender (male). These 8 items are organized as dichotomous questions answered YES/ NO, with each "YES" answer being recorded as 1 point. A score of 0 to 2 indicates low OSAS risk, a score of 3 to 4 indicates moderate OSAS risk and a score of 5 or higher indicates high OSAS risk. The STOP-Bang questionnaire was applied face to

DOI: 10.5455/medscience.2025.01.033

face to the patients who underwent surgery in the preoperative (operation day) (T0) and postoperative (1st year control session) (T1) periods and the scores obtained by the patients were recorded. It was examined whether the change in the obtained data between T0-T1 times was statistically significant.

### Statistical Analysis

Statistical Package for Social Sciences (SPSS) Windows version 28 (SPSS Inc. Chicago, IL, USA) software program used in the evaluation of the data in the study,. Descriptive statistical methods (number, percentage, minimum, median, maximum, mean, standard deviation) were used while evaluating the data. The normal distribution of the data used in the study was tested with the Shapiro Wilk test. Parametric tests were used for measurements with normal distribution, and non-parametric tests were used for measurements without normal distribution. Dependent sample t-test was used for comparing two dependent measurements of quantitative data with normal distribution, and Wilcoxon signed rank test was used for situations without normal distribution. The change of two dependent categorical variables with time was tested with the McNemar test and for more than two situations with the McNemar-Bowker test. The Type I Error probability was determined as $\alpha$=0.05 for all analyzes.

## Results

The data regarding age, gender, body mass index and apnea scores (at T0-T1) of the 32 participants included in the study are given in Table 1. Accordingly, while all participants were between 18-32 years of age, the average age was 20.18. Since the average body mass index of the participants was 23.10 at T0 and 23.94 at T1, all participants answered "No" to the 5th question of the STOP-Bang questionnaire. In addition, the average apnea score obtained from the STOP-Bang questionnaire was 1.28 at T0, while this value was 0.96 at T1.

**Table 1.** Age, gender, body mass index and apnea scores

| | Mean | Std. dev. | Median | Range |
|---|---|---|---|---|
| **Age T0** | 18.281 | 3.837 | 17.000 | 15.000 |
| **Age T1** | 20.188 | 4.768 | 19.500 | 18.000 |
| **BMI T0** | 23.103 | 3.401 | 22.810 | 14.000 |
| **BMI T1** | 23.944 | 4.120 | 22.855 | 15.580 |
| **STOP-Bang score T0** | 1.281 | .958 | 1.000 | 4.000 |
| **STOP-Bang score T1** | 0.969 | 0.897 | 1.000 | 3.000 |

Table 2 shows the distribution of responses to survey questions at T0 and T1. Accordingly, 34.4% (n=11) of the participants reported snoring in the preoperative period, while this rate was 25% (n=8) in the postoperative period. In addition, the rate of patients who stated that they frequently felt tired, exhausted or sleepy during the day at T0 was 31.2% (n=10), while this rate was 15.6% (n=5) in the T1 period. The rate of patients who were observed to stop breathing or have a blocked throat/gasp during sleep was 18.8% (n=6) at T0, while this rate was 15.6% (n=5) at T1. In addition, all of the participants answered "No" to the 4th question of the survey, "Do you have high blood pressure or are you being treated for it?" Since none of the participants were over 50 years old, all participants answered "No" to the 6th question of the survey. Similarly, all participants answered "No" to the 7th question of the survey, which asked about the width of the patients' neck circumference. The gender distribution of the participants was 40.6% (n=13) male and 59.4% (19) female.

**Table 2.** Distribution of responses to survey questions

| | | N | % |
|---|---|---|---|
| **Gender** | **Male** | 13 | 40.6% |
| | **Female** | 19 | 59.4% |
| **Snoring T0** | **No** | 21 | 65.6% |
| | **Yes** | 11 | 34.4% |
| **Snoring T1** | **No** | 24 | 75.0% |
| | **Yes** | 8 | 25.0% |
| **Tired T0** | **No** | 22 | 68.8% |
| | **Yes** | 10 | 31.2% |
| **Tired T1** | **No** | 27 | 84.4% |
| | **Yes** | 5 | 15.6% |
| **Observed T0** | **No** | 26 | 81.3% |
| | **Yes** | 6 | 18.8% |
| **Observed T1** | **No** | 27 | 84.4% |
| | **Yes** | 5 | 15.6% |
| **Neck T0** | **No** | 0 | 0.0% |
| | **Yes** | 32 | 100.0% |
| **Neck T1** | **No** | 0 | 0.0% |
| | **Yes** | 32 | 100.0% |

Table 3 shows the comparison results of the participants' scores according to the STOP-Bang questionnaire in the T0 and T1 periods. Accordingly, the difference between the participants' scores at T0 and T1 was found to be statistically significant (p=0.048). In other words, a significant decrease in patient scores was observed after SARME.

**Table 3.** STOP-Bang scores at T0 and T1

| | Mean | Std. dev. | Median | Range | *p. |
|---|---|---|---|---|---|
| **STOP-Bang score T0** | 1.281 | 0.958 | 1.000 | 4.000 | **0.048** |
| **STOP-Bang score T1** | 0.969 | 0.897 | 1.000 | 3.000 | |

* Significance levels according to Wilcoxon test

When the changes in the questionnaire scores of patients who underwent and did not undergo pterygomaxillary suture osteotomy during SARME were examined in the T0-T1 time interval, it was observed that there was a small decrease in the scores of patients who underwent pterygomaxillary osteotomy. No change was observed in the questionnaire scores of groups who did not undergo pterygomaxillary suture osteotomy during SARME. When the amounts of change in the two patient groups were compared, the difference between the groups was not statistically significant (p=0.477) (Table 4).

DOI: 10.5455/medscience.2025.01.033

**Table 4.** Scores of patients who underwent and did not undergo pterygomaxillary suture osteotomy

| | | Mean | Std. dev. | Median | Range | *p |
|---|---|---|---|---|---|---|
| **Pterygomaxillary separation** | **No** | 0.000 | 1.414 | 0.00 | 4.00 | **0.477** |
| | **Yes** | -.0385 | 0.941 | 0.00 | 4.00 | |

* Significance levels according to Mann-Whitney-U test

## Discussion

Different techniques for SARME suggested, there's no agreement on the optimal surgical approach. Some clinicians recommend disconnecting nearly all of the articulating maxillary structures in order to provide adequate space for transverse extension. Some clinicians favor SARPE without pterygomaxillary separation to attain the lowest potential levels of postoperative problems and morbidity [9]. Different researchers reported different results for the opening type of the maxilla with or without pterygomaxillary seperation. Sygouros et al. found no significant differences in two groups mentioned above, they report more buccal tipping of posterior teeth and buccal bending of alveolar process in patients without pterygomaxillary seperation [10]. Kılıc et al. reported more expansion at premolar region in patients with pterygomaxillary seperation and more expansion at molar region in patients without pterygomaxillary seperation. Also without statistically not significant, they report more maxillary apical base expansion in seperation group [11]. Despite these results Möhlhenrich et al. reported a V-shaped transverse expansion in non-seperated groups and paralel expansion in anterior and posterior segments of maxilla at seperated groups [9]. Therefore, 26 of the 32 participants included in our study had an osteotomy applied to the pterygomaxillary suture during SARME (to provide more transverse skeletal development).

Heldmaier et al. reported 10 patients who underwent SARPE with pterygomaxillary disjunction for the transverse maxillary hypoplasia. They analyzed pre and post op CBCT scans and three-dimensional stereophotogrammetry. According to their results most of SARPE's effects on nasal soft tissue are clinically and statistically negligible. Airway volume at nasopharyngeal area had a significant increase [5]. According to the results of our study, when the changes in the questionnaire scores between T0-T1 were examined, there was a small decrease in the scores of patients who underwent pterygomaxillary osteotomy and no change was observed in patients who did not undergo pterygomaxillary suture osteotomy during SARME. However, the difference between the groups was not statistically significant. This result can be re-evaluated with further studies with larger samples. The results of our study are partially similar to the results of the study by Heldmaier et al.

The STOP-Bang questionnaire has been widely used in preoperative clinics, sleep clinics, the general public, and other particular populations to identify people at high risk of OSAS because of its high sensitivity and ease of use [12]. If a test will be used for screening rather than disease confirmation a test with high sensitivity, that is, a low false negative rate should be preferred. In Turkish version of the STOP-Bang questionnaire the sensitivity of the test in AHI>5, AHI>15 and AHI>30 groups were 91.9%, 92.3, and 93.8 respectively. Specificity values showed lower values in same groups as 5.6%, 6.9% and 7.7% respectively [13]. Based on the information provided above, it is also suggested to utilize this test as a screening tool for patients with OSAS, despite the test's extremely low specificity [13]. Because of the easy application of the test and no need for test reports obtained by advanced diagnostic methods, we believe that STOP-Bang questionnaire may used in the clinical practice of dentistry especially in the surgical cases. Thus we selected this OSAS risk assessment method in this study.

Studies in the literature examining the relationship between maxillary constriction and OSAS have revealed that patients with OSAS have narrower and deeper maxillary domes [14,15]. In his studies, Timms revealed that airway resistance in the nasopharyngeal region increases in patients with maxillary constriction and that this situation can be corrected by maxillary expansion [16-18]. Reduction of OSAS symptoms after SARME operations reported in the literature [2,12]. When the results of our study are examined, the average apnea score obtained from the STOP-Bang questionnaire of the participants decreased statistically significantly in the period after SARME (p=0.048). While the average score before SARME was 1.28, this value was 0.96 after SARME. Our study supports the data in the literature in terms of these results. OSAS improvement after SARME may result from two factors. Firstly with the expansion of oral cavity area, tongue may advance into the oral cavity and this cause expanded posterior airway space. Secondly with the expansion of nasal cavity airflow resistance reduced [2].

Vinha et al. investigated the effect of SARME on OSAS and daytime sleepiness. 16 individuals with OSAS (confirmed with full night polysomnography) and maxillary transverse deficiency included in the study. They reported 54,6% reduction in the respiratory disturbance index and 56.2% in the apnea-hypopnea index. They concluded that SARME improves microarousal, desaturation, respiratory disruptions, and daytime sleepiness while also encouraging an improvement in OSAS symptoms [2]. Nie et al. reported 20 years old case with daytime sleepiness, snoring complaints. PSG showed AHI 54.2 and classified as severe OSAS. Maxillary transverse deficiency and Class II malocclusion noted. Bone anchored RME and bilateral interoral mandibular distraction osteogenesis performed. After the operations and orthodontic treatment they reported that patient's OSAS was greatly reduced [12]. Bonetti et al. reported a case with severe OSAS. SARME and mandibular symphyseal distraction osteogenesis performed and after 6 months they report a dramatically decrease in te somnohraphic parameters [19]. According to the results of our study, the rate of patients reporting the presence of apnea-

DOI: 10.5455/medscience.2025.01.033

hypopnea was 18.8% (n=6) before SARME, while this rate was 15.6% (n=5) after SARME. Similarly, according to the results of our study, the rate of patients reporting daytime sleepiness before SARME was 31.2% (n=10), while this rate was 15.6% (n=5) after SARME. In addition, 34.4% (n=11) of the participants reported snoring in the preoperative period, while this rate was 25% (n=8) in the postoperative period. Although all participants in our study did not give any answers that would increase the score to the 4th, 5th, 6th and 7th Questions of the STOP-Bang survey, considering the decrease in OSAS scores, our study supports the literature data that SARME reduces the respiratory symptoms of OSAS.

This study demonstrates that SARME significantly reduces OSAS symptoms (according to the STOP-Bang questionnaire) by widening the upper airway and decreasing air resistance in the nasopharynx. Further studies with larger samples are needed to examine the effects of SARME technique and modifications on OSAS symptoms.

## Conclusion

Transverse expansion in the upper jaw after SARME may lead to airway expansion. Accordingly, a decrease in OSAS findings is observed. Our results suggest that SARME may be a treatment option for patients with OSAS. Further studies with larger samples are needed for more concrete results.

**Conflict of Interests**
*The authors declare that there is no conflict of interest in the study.*

**Financial Disclosure**
*The authors declare that they have received no financial support for the study.*

**Ethical Approval**
*This study was performed in line with the principles of the Declaration of Helsinki and approved by the Recep Tayyip Erdoğan University Non-invasive Clinical Research Ethics Committee (15.08.2024/ 2024/221). All participants signed a statement of informed consent after receiving clarifications regarding the intervention and all phases of the data collection process.*

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