Effects of Obstructive Sleep Apnea Surgery on Middle Ear Function

Hsin-Ching Lin, MD; Michael Friedman, MD; Hsueh-Wen Chang, PhD; Chi-Hsin Shao, MD; Tanya M. Pulver, MD; Yung-Che Chen, MD

Objective: To study the effect of Z-palatopharyngoplasty plus radiofrequency of the base of the tongue on middle ear function.

Design: A retrospective review of a prospective data set at a tertiary care center.

Setting: University-affiliated medical center.

Patients: The study population included 47 patients (42 men and 5 women; mean age, 40.8 years) who underwent Z-palatopharyngoplasty plus radiofrequency of the base of the tongue for obstructive sleep apnea/hypopnea syndrome. All patients had healthy eardrums and no previous history of chronic ear disease.

Main Outcome Measures: Pure-tone audiometric and tympanometric assessments were performed preoperatively and at 3 days, 7 days, 1 month, and 3 months postoperatively. Levels of baseline and postoperative middle ear pressure were compared.

Results: Twelve patients (26%) reported otologic concerns, such as ear pressure and/or otalgia, within 1 week postoperatively. No permanent otologic discomfort occurred. A trend toward reduced middle ear pressure was noted in this study. The decrease in middle ear pressure became apparent on day 3. However, mean pressure changes were no longer significantly different than preoperative values by 1 week after surgery.

Conclusions: We found that Z-palatopharyngoplasty plus radiofrequency of the base of the tongue for obstructive sleep apnea/hypopnea syndrome induces changes in middle ear function. However, the changes were temporary and not significant after 3 months of follow-up.


Author Affiliations:
Department of Otolaryngology (Drs Lin and Shao), Division of Pulmonary and Critical Care Medicine, Department of Internal Medicine (Dr Chen), and Sleep Center (Drs Lin and Chen), Chang Gung Memorial Hospital, Kaohsiung Medical Center, Chang Gung University College of Medicine, and Department of Biological Sciences, National Sun Yat-Sen University (Dr Chang), Kaohsiung, Taiwan; and Department of Otolaryngology and Bronchoesophagology, Rush University Medical Center (Dr Friedman), and Department of Otolaryngology, Advanced Center for Speciality Care, Advocate Illinois Masonic Medical Center (Drs Friedman and Pulver), Chicago.

C LINICALLY, A SUBSET OF PA- tients with obstructive sleep apnea/hypopnea syndrome (OSAHS) who cannot tolerate continuous positive airway pressure therapy will be candidates for upper airway surgery. The benefits of OSAHS surgery have been demonstrated.1,2 The reported success rate for uvulopalatopharyngoplasty (UPPP), the most common surgical procedure for OSAHS, is approximately 40.7% when performed as an isolated procedure in nonselected OSAHS patients, according to a systematic review.3 Many modifications of palatal operations have been described in the management of OSAHS, and considerable interest has developed with regard to recent surgical advances in the past decade.4-7 Z-palatopharyngoplasty (ZPPP) was designed to more effectively widen the anteroposterior and lateral oropharyngeal space of OSAHS patients.8 The reported results showed that ZPPP is more successful with regard to acceptable morbidity for OSAHS patients than for those with UPPP. The follow-up studies9,10 confirmed the clinical benefits of this technique for OSAHS patients.

Palatal musculature is known to be responsible for the active opening of the eustachian tube and to play a role in middle ear function. Classic UPPP and its modification, the ZPPP technique, involve structural alteration of the soft palate followed by the formation of scar tissue. Postoperative morbidities and complications, such as temporary postoperative velopharyngeal insufficiency, pain, the sensation of a lump in the throat, dry throat, and frequent throat clearing, have been reported,8-10 but, to our knowledge, relatively little attention has been given to potential otologic implications of the primary surgical procedure used to treat OSAHS. The objective of this study was to investigate further the effects of ZPPP on middle ear pressure (MEP).

METHODS

We performed a retrospective study of a prospective group of patients. Approval for this study...
or greater oxygen desaturation. The apnea/hypopnea index was compared with baseline, lasting at least 10 seconds, and with 4% reduction in thoracoabdominal movement or airflow when confined as an abnormal respiratory event with at least a 30% effort to breath during apnea. Obstructive hypopnea was defined as a cessation of airflow for at least 10 seconds with apnea and hypopnea episodes during sleep. Obstructive apnea was defined as the total number of apnea and hypopnea episodes per hour of electroencephalographic sleep. Central respiratory events were excluded for severity classification. Obstructive sleep apnea/hypopnea syndrome is defined as an apnea/hypopnea index of more than 5. All polysonograms were scored and read by a board-certified physician (Y.-C.C.).

All surgical procedures were performed by the first author (H.-C.L.) with the patient under general anesthesia via orotracheal intubation. Exposure was obtained using a standard mouth retractor with the head of the patient extended. The surgery was performed in the same manner as previously described.4 Subjective symptoms of middle ear function and pure-tone audiometry and tympanometry were noted preoperatively. The patients were questioned routinely regarding possible complications at follow-up appointments. Pure-tone audiometry and tympanometry were repeated at 3 days, 7 days, 1 month, and 3 months postoperatively. Tympanometry was performed using the same device (Middle Ear Analyzer, reference No. 2000-97xx, serial No. AL072079; VIASYS Neurocare Inc, Madison, Wisconsin) and the same examiner, as was pure-tone audiometry (GSI 61 Clinical Audiometer, model No. 1761, serial No. 0937; Grason-Stadler, Milford, New Hampshire). Initial and subsequent tympanometric peak pressures were collected. Because no truly satisfactory clinical test indicative of middle ear function in patients with intact tympanic membranes has been available until the present day, and the static MEP that produces the maximal acoustic immittance is approximately equal to the gas pressure in the middle ear, most physicians perform tympanometric assessments as surrogates.14 In our study, we measured the serial tympanometric peak pressures before and after surgery to respond to the changes in MEP.

The statistical analysis was used by repeated-measures analysis of variance. Complications occurring immediately and 3 months postoperatively also were recorded.

### RESULTS

Forty-seven patients (42 men and 5 women; mean age, 40.8 years) had a minimum follow-up of 3 months and complete data available for analysis. The mean (SD) of the preoperative body mass index (calculated as weight in kilograms divided by height in meters squared), Epworth Sleepiness Scale score, apnea/hypopnea index (events per hour), percentage saturation of oxygen, lowest percentage saturation of oxygen, and desaturation index (events per hour) were 26.8 (3.3), 10.5 (4.3), 42.0 (24.7), 94.9 (2.7), 78.5 (9.5), and 35.8 (27.5), respectively.

No perioperative complications or cases of immediate postoperative airway obstruction occurred in this study. Temporary postoperative ear fullness or pressure was reported by 12 patients (26%). This symptom lasted from 1 to 7 days and was most bothersome during the first 3 days after surgery. The severity of ear pressure subsequently decreased and was noted by patients only occasionally thereafter. No cases of persistent concerns or interference with daily activities were encountered in this study. No other otologic concerns were reported after the procedure.

The changes in MEP are detailed in the Table. A trend toward reduced MEP was noted in this study. The decrease in MEP became apparent on day 3. However, mean pressure changes were no longer significantly different than preoperative values by 1 week after surgery.

### Table. Changes in MEP After ZPPP Plus RFBOT Mean (SD)\(^a\)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Right MEP, dPa</th>
<th>Left MEP, dPa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before operation</td>
<td>−5.11 (23.72)</td>
<td>−1.49 (13.18)</td>
</tr>
<tr>
<td>POD 3(^b)</td>
<td>−33.30 (72.08)</td>
<td>−24.68 (54.90)</td>
</tr>
<tr>
<td>POD 7</td>
<td>−13.72 (49.58)</td>
<td>−6.60 (25.98)</td>
</tr>
<tr>
<td>POM 1</td>
<td>−5.00 (21.62)</td>
<td>2.23 (13.01)</td>
</tr>
<tr>
<td>POM 3</td>
<td>−2.45 (21.24)</td>
<td>0.21 (12.55)</td>
</tr>
</tbody>
</table>

Abbreviations: dPa, decipascal; MEP, middle ear pressure; POD, postoperative day; POM, postoperative month; RFBOT, radiofrequency of the base of the tongue; ZPPP, Z-palatopharyngoplasty.

\(^a\) \(P < .001\) by repeated-measures analysis of variance.

\(^b\) Means is significantly different from those of other variables via the Tukey multiple comparison procedure.

A MEDLINE database search regarding middle ear function after palatopharyngeal surgery for OSA yielded few reports. Only 2 previous studies have been conducted regarding this issue. The first, written by Finkelstein et al,15 studied the UPPP effect on eustachian tube function and revealed that patients with middle ear abnormalities and those undergoing middle ear surgery were high-risk candidates for UPPP and needed to have their middle ear function carefully evaluated postoperatively. The second study, conducted by Marais and Armstrong,16 investigated the effects of laser uvulopalatoplasty on middle ear function and found no significant effects on MEPs or middle ear volumes 3 months after laser-assisted uvulopalatoplasty.

In a previous meta-analysis\(^5\) of multilevel OSA surgery coauthored by some of us, the reported overall complication rate was 14.6%. Bleeding, dry throat, and velopharyngeal insufficiency, manifested mainly as...
swallowing and speech problems, account for most reported complications. No long-term nasal regurgitation occurred in a previous ZPPP study, coauthored by some of us; however, 30% of the 52 patients reported ear fullness or pressure after surgery. Thus, we undertook this study to further investigate the presence of subclinical adverse effects on middle ear function after ZPPP plus RFBOT for the treatment of OSAHS. In this report, 12 of the 47 patients (26%) reported ear fullness or pressure postoperatively. In these patients, the symptom lasted between 1 and 7 days. After 3 days, the severity of ear pressure decreased and was noted by most patients only occasionally thereafter.

The eustachian tube is passively closed in the resting state. It opens during active maneuvers, such as swallowing, yawning, or sneezing, thereby permitting the equalization of middle ear and atmospheric pressures. Four muscles are associated with the eustachian tube, namely, the tensor veli palatini (TVP), which arises from the lateral side; the levator veli palatini (LVP) (or dilator tubae), which originates inferiorly; and the tensor tympani and salpingopharyngeus, which also arise from the inferior aspect of the tubal cartilage near the pharyngeal orifice. The tensor tympani does not appear to be involved in active dilatation of the eustachian tube; however, stretch receptors may be present in the tympanic membrane that modulate MEP through the tensor tympani muscle, thereby affecting the TVP and the opening of the eustachian tube. 14-16 The first 2 of these muscles may be affected by the sagittal velar incisions performed in any palatal surgery. Complete anteroposterior transection to the hard palate would almost certainly result in a malfunctioning eustachian tube, as seen in cleft palate. Although the relative importance of the 3 muscles is unknown, complex interplay among them is likely. However, it is believed that in the normal state, the LVP and TVP are the most important contributors to eustachian tube function, but owing to its small size, the salpingopharyngeus contributes the least. 17,18

The results of the present study suggest that ZPPP plus RFBOT for the treatment of OSAHS induces changes in MEPs on postoperative day 3. However, the changes in our study were temporary and not significant after the first postsurgical week. We treated the patients with ZPPP plus the most common tongue base surgical modality, RFBOT. Because RFBOT is a minimally invasive technique and most eustachian tube–controlled muscle is located in the soft palate, we suspect that alteration of middle ear function is the result of palatopharyngeal manipulation. The ZPPP technique retracts the midline of the soft palate anterolaterally, which widens the retropalatal area. The uvula is split in the midline and sutured laterally along with the adjacent soft palate, creating an effective anterolateral pull on the soft palate and widening the retropalatal area.

Anatomically, most of the anterior portion of the soft palate is not muscular but aponeurotic, and most of the TVP and LVP fibers are located in the posterior portion. 19 Without the extensive anterior fixation of the TVP, the LVP mainly occupies the fleshy free posterior portion of the soft palate, which it enters laterally with its fibers partially extending into the upper surface of the palatine aponeurosis as far as the median plane, where they blend with those of the opposite side. Because ZPPP preserves the muscles of the soft palate and manipulates mainly the anterior surface of the soft palate, the risk of possible complications is minimized. Temporary middle ear dysfunction may be caused by postoperative velopharyngeal edema or muscle spasm, and the effects of anesthesia (eg, intubation and anesthetic agents and gases) are also possible confounding factors. In our study, gradual resolution occurred within 1 week postoperatively and may be attributed to antibiotic and anti-inflammatory therapy, but more research needs to be conducted in this area. Accordingly, as the severity of inflammation decreases and swallowing improves, spontaneous resolution of the middle ear dysfunction after ZPPP plus RFBOT may be expected.

The major limitations of this study are its retrospective nature and lack of a control group, short follow-up period (limited to 3 months), and relatively small sample size. Further studies with longer follow-up and larger numbers of patients are necessary.

We found that ZPPP combined with RFBOT for the treatment of OSAHS induces changes in MEP. However, the changes tend to revert to normal within a short period and are not significant after 3 months of follow-up. Despite anterolateral and anterosuperior advancement of the soft palate with the ZPPP procedure, permanent eustachian tube dysfunction was not identified in this study.

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Correspondence: Michael Friedman, MD, 30 N Michigan Ave, Ste 1107, Chicago, IL 60602 (hednnek@aol.com).

Author Contributions: Drs Lin and Friedman had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. Study concept and design: Lin. Acquisition of data: Lin, Shao, and Chen. Analysis and interpretation of data: Lin, Friedman, Chang, and Pulver. Drafting of the manuscript: Lin. Critical revision of the manuscript for important intellectual content: Friedman, Shao, Pulver, and Chen. Statistical analysis: Chang. Administrative, technical, and material support: Lin. Study supervision: Friedman.

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Additional Contributions: Mao-Chang Su, MD, Chien-Hung Chin, MD, Meng-Chih Lin, MD, Pei-Ling Wang, BS, Shu-Chun Kung, BS, Lain-Jung Liou, BS, and Wei-Chie Liu, BS, provided assistance in manuscript preparation.
REFERENCES