Vol. 00 No. 00 ■■ 2020

Submental intubation for maxillomandibular advancement improves short-term nasal breathing outcomes

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Objective. The purpose of this study was to determine if submental intubation during maxillomandibular advancement (MMA) reduces the development of nasal obstruction in patients with obstructive sleep apnea (OSA).

Study Design. This study was a prospective, single cohort of consecutive adult patients undergoing MMA surgery for OSA at a single institution. The primary outcome measure was the development of nasal obstruction using the Nasal Obstruction Symptom Evaluation scale. Secondary outcomes included the rate of reintubation, submandibular duct function, development of neck infection, the need for subsequent surgical correction of nasal obstruction, and changes in the Apnea-Hypopnea Index.

Results. Twenty consecutive patients (85% male, mean age 47 years) were included in the study. Nasal Obstruction Symptom Evaluation scores improved in 88% of patients, with a mean improvement from 46.6 ± 28.9 to 15.9 ± 20.9 at 3 months ($P < .01$). No participant required reintubation, and all patients had adequate bilateral submandibular gland function at follow-up. The mean Apnea-Hypopnea Index improved from 58.1 ± 32.0 to 8.3 ± 4.7 ($P < .01$).

Conclusion. Submental intubation for patients undergoing MMA for OSA appears to be a well-tolerated, expeditious alternative to nasal intubation with excellent nasal breathing results. Larger, prospective investigations to confirm these findings should be considered. (Oral Surg Oral Med Oral Pathol Oral Radiol 2020;000:1−5)

Obstructive sleep apnea (OSA) is a disorder characterized by recurrent collapse of the upper airway during sleep. The resulting hypoxia and arousals place patients at risk for a variety of health consequences, including cardiovascular disease, insulin resistance, and neurocognitive dysfunction.[1,2] First-line therapy for OSA is positive airway pressure (PAP). In patients with moderate to severe OSA, PAP has been found to reduce cardiovascular risk, improve cognition, and increase quality of life.[3-5] However, 46% to 83% of patients are noncompliant with PAP therapy.[6] It is therefore imperative to identify other treatment modalities to PAP.

Maxillomandibular advancement (MMA) surgery for obstructive sleep apnea (OSA) was first described in 1981 as an alternative treatment for OSA.[7] Since its description, numerous studies, including a recent meta-analysis, have found consistent, drastic improvement in the Apnea-Hypopnea Index (AHI) and quality-of-life symptoms.[8] However, several complications are possible, including but not limited to lasting paresthesia, malunion, malocclusion, and nasal obstruction.

A recent review of 379 patients undergoing MMA for OSA found that 19% of patients returned to the practice for surgical correction of nasal obstruction after MMA.[9] The mechanism for nasal obstruction after LeFort I advancement and impaction has not been clearly elucidated; however, clinical observation suggests 3 potential pathways: failure of midline septal repositioning, buckling of septum with maxillary impaction, and/or decreased nasal space with maxillary impaction. Failure of midline septal repositioning may result from inherent displacement of the nasal septum from the conventional nasal endotracheal tube. Tracheotomy provides an alternative to nasal intubation during MMA, but it may be associated with several complications including loss of airway and injury to vital cervicothoracic structures.[10,11]

Submental intubation (SMI) has been used for more than 30 years, most typically in the management of maxillofacial trauma.[12] The use of SMI during orthognathic surgery has also been reported with the apparent elimination of nasal septal deviation.[13] Prospective examination of nasal obstruction symptoms has not been previously reported in patients undergoing MMA for the treatment of OSA.

The authors pose the following research question: In patients with OSA undergoing MMA, does the use of SMI reduce the development of nasal obstruction? Specific aims are as follows:

Statement of Clinical Relevance

Submental intubation for patients undergoing maxillomandibular advancement for obstructive sleep apnea appears to be a well-tolerated, expeditious alternative to nasal intubation, resulting in excellent nasal breathing outcomes.

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Received for publication Sep 15, 2019; returned for revision Oct 30, 2019; accepted for publication Dec 27, 2019.

2212-4403/$-see front matter
https://doi.org/10.1016/j.oooo.2019.12.008

I. To test whether SMI reduces the Nasal Obstruction and Septoplasty Effectiveness (NOSE) Scale score
II. To test whether SMI is associated with the development of complications, including reintubation, submandibular gland dysfunction, infection or the need for secondary correction of nasal obstruction

MATERIALS AND METHODS

The authors implemented a prospective, nonblinded cohort study design. All patients were recruited at the Sleep Surgery Center at Emory University Midtown Hospital. Consecutive patients who were deemed candidates for MMA for the treatment of OSA were recruited for this study. Inclusion criteria were diagnosis of moderate to severe OSA, age $\geq$18 years, and ability to give informed consent. Exclusion criteria were the presence of nasal polyps or those requiring a concomitant nasal procedure for septal deviation or turbinate reduction. Approval from the Emory Institutional Board was obtained for this prospective study (IRB00088693). Additionally, we read and followed the guidelines of the Helsinki Declaration.

Preoperative workup

A comprehensive history and physical examination was completed on all patients. All patients received supine nasolaryngoscopy. Patients were selected for MMA based on the presence of moderate or severe OSA (AHI $\geq$ 15). All patients had their nasal competence measured using the NOSE scale as well as their sleep latency using the Epworth Sleepiness Scale (ESS). Records included clinical photos, cone beam computed tomography, panoramic and lateral cephalometric radiographs, and dental impressions. All patients have virtual surgery planning, including the construction of intermediate and final occlusal splints. Planning for all male patients generally involved a 10-mm advancement at the maxillary incisal edge, counterclockwise MMA rotation with a 2-mm downward movement of the posterior maxilla and establishing 2 mm of maxillary tooth display at rest. Planning for female patients generally involved an 8-mm advancement at the maxillary incisal edge, counterclockwise MMA rotation with a 2-mm downward movement of the posterior maxilla, and establishing 4 mm of maxillary tooth display at rest.

Operative steps

Submental intubation. Before intubation, a standard 7.0 mm or smaller reinforced endotracheal tube is selected. A fine mosquito clamp is used to circumferentially detach the plastic hub from the tube shaft. The hub is then manually reattached to the endotracheal tube. After transoral intubation with this prepared reinforced endotracheal tube, the tube is secured to the left side of the mouth using regular anesthesia tape. The neck is slightly hyperextended. The skin is cleansed with alcohol and mouth is irrigated with 0.12% chlorhexidine. Local anesthesia is injected into both the external neck and floor of mouth. A throat pack is placed. A medium bite block is placed on the right side. A 2-cm incision is made immediately off midline at the palpable lingual cortex of the left mandible. A tonsil hemostat is used to bluntly dissect a tract from the neck to the floor of mouth. With the assistance of a sweetheart retractor, the tips of the hemostat are identified, lateral to Wharton's papillae, via mucosal tenting. An incision is made over the tines and a Ciaglia Blue Rhino dilator (Cook Medical LLC, Bloomington, IN, USA) is grasped and pulled through the neck incision. At this time, the tape securing the endotracheal tube is released and the centimeter marking is noted at the second molar. The tonsil hemostat reenters the wound through the neck and grasps the endotracheal tube after the hub has been removed. Once the tube is pulled through the neck and the hub is reattached, the pilot balloon is passed through the same wound to exit through the neck. The circuit is reconnected and end-tidal carbon dioxide verified. Once confirmed, the tube is secured to the neck skin using 2.0 nylon suture.

LeFort I and bilateral sagittal split osteotomy. Erich arch bars are attached to the maxillary and mandibular teeth. The LeFort I osteotomy, down fracture, and mobilization are then completed following using traditional techniques. The maxilla is then placed into MMF using the intermediate splint. The nasal crest of the maxilla is reduced using a pineapple bur to create a trough for the nasal septum. The maxilla is then fixated using 2 piriform rim and 2 zygomatic plates or screws. The MMF is then released and the bilateral sagittal split osteotomies completed. The mandible is placed in MMF using the final splint followed by rigid fixation with bicortical position screws and plates/screws. The MMF is then released and the final occlusion checked.

Septal repositioning. The inferior 2−3 mm of the cartilaginous nasal septum is removed. Using a drill hole in the anterior nasal spine, a 2.0 Vicryl (Ethicon, Johnson & Johnson, New Brunswick, NJ, USA) suture is passed through the caudal septum and anchored to the drill hole using a figure 8 pattern.

Submental intubation reversal. After wound closure, the endotracheal tube is passed into the oral cavity and secured with tape. The submental incision is closed with interrupted 5.0 fast gut suture.

Postoperative care

After extubation, heavy class II elastics are placed while in the operating room. Patients are sent to surgical care unit or intensive care unit based on the patient's comorbidities. Patients are generally discharged on postoperative day 2 or 3. Postoperative visits are scheduled at weeks 1, 3, and 5. Arch bars are removed at the 5-week follow-up visit followed by a postoperative panoramic lateral cephalometric x-ray examinations. A sleep study is repeated 3 months after the surgery.

A comprehensive physical examination is completed at the 4-month visit. Nasal competence is again evaluated using the NOSE scale, and sleepiness is assessed by repeating the ESS. Submandibular gland function is also assessed. This functional testing involves compression of each submandibular gland in a posterior to anterior direction. The emergence of clear saliva is considered to represent a patent, well-functioning gland.

Study variables and analysis plan

Patient demographic characteristics, anthropometric measures, virtual surgical planning data, pre- and postoperative lateral cephalogram tracings, sleep study data, postoperative submandibular gland function, presence of postoperative neck infection or orocutaneous fistula, and the need to reintubate were recorded by a trained research assistant. These data were stored on the password-protected institutional network behind a secure firewall.

Nasal Obstruction Symptom Evaluation Scale. The NOSE instrument is a validated survey used in assessing nasal obstruction. The 5-question survey asks respondents to rate, over the past month, how much of a problem various conditions have been for the patient. A 0-to-4 Likert scale is used, with 0 indicating "not a problem" and 4 indicating "severe problem." For a total score, responses are summed and multiplied by 5. In this study, the baseline NOSE score was obtained during the visit before surgery. NOSE scores were interpreted as follows: None to mild nasal obstruction (0−25), moderate nasal obstruction (30−50), severe nasal obstruction (55−75), extreme nasal obstruction (80−100).[14]

Stata Software Version 11 (StataCorp LLP, College Station, TX, USA) was used to perform descriptive and inferential statistics. Paired *t* tests compared pre- and postoperative values of the primary efficacy endpoint (NOSE score) and other continuous study variables. Statistical significance was defined as $P < .05$.

RESULTS

A total of 21 patients were screened, although 1 patient was excluded because of the presence of nasal polyps, resulting in 20 patients completing the study. The mean age of patients was 47 years, and 85% of patients were male. The mean preoperative body mass index was 34.4 kg/m^2. The mean AHI and oxygen nadir were 58.1% and 76.8%, respectively. The mean preoperative NOSE and ESS scores were 46.6 and 12.9, respectively (Table I).

Table I. Participants characteristics (N = 20)

Variable	*Mean ± SD*
Demographic characteristics	
Age (y)	47.4 ± 10.9
Sex: male	85%
Body mass index (kg/m^2)	34.4 ± 4.0
*Polysomnogram**	
Apnea-Hypopnea Index (events/h)	58.1 ± 32.0
Oxygen nadir (%)	76.8 ± 9.4
Symptoms and quality of life†	
Epworth Sleepiness Scale (0−24, 24 worst)	12.9 ± 4.5
NOSE (0−100, 100 worst)	46.6 ± 28.9

SD, standard deviation; NOSE, Nasal Obstruction Symptom Evaluation.
*n = 18.
†n = 17.

The mean virtual surgery planning planned moves were 8.0, 8.4, 11.1, and 12.5 mm for anterior nasal spine (ANS), A point, B point, and pogonion, respectively (Table II).

The mean increase in sella−nasion−A point was 8.5° ($P < .01$), whereas the mean increase in; sella−nasion−B point was 5.8° ($P < .01$). The mean increase in ANB was 3.4° ($P = .02$). The mean decrease in the mandibular plane angle was 2.7° ($P < .01$). The mean change in N-ANS was a decrease of 1.4 mm ($P = .16$) (Table III).

The mean reduction in NOSE score was 30.7 ($P < .01$). The mean reduction in the ESS was 9.7 ($P < .01$). The mean reduction in AHI was 49.8

Table II. Virtual surgical planning distances

Location	*Change (mean ± SD)*
ANS (mm)	8.0 ± 1.2
A (mm)	8.4 ± 1.1
B (mm)	11.2 ± 1.0
Pogonion (mm)	12.5 ± 1.2

SD, standard deviation; *ANS,* anterior nasal spine; *A,* A point; *B,* B point.

Table III. Cephalometric changes

Lateral cephalogram (n = 16)	*Preoperative (mean ± SD)*	*Postoperative (mean ± SD)*	*P*
SNA (°)	84.4 ± 9.3	92.9 ± 7.9	$P < .01$
SNB (°)	81.1 ± 7.5	86.9 ± 6.2	$P < .01$
MP-SN (°)	30.3 ± 8.6	26.9 ± 6.5	$P = .02$
ANB (°)	3.4 ± 4.5	6.0 ± 4.4	$P < .01$
N-ANS (mm)	48.9 ± 6.1	47.5 ± 5.4	$P = .16$

SD, standard deviation; *ANS,* anterior nasal spine; *A,* A point; *B,* B point; *SNA,* sella-nasion−A point; *SNB,* sella-nasion−B point; *MP-SN,* angle between mandibular plane and sella-nasion line; *N-ANS,* distance between nasion and anterior nasal spine.

Table IV. Sleep-related parameters

Outcome	*Preoperative (mean ± SD)*	*Postoperative (mean ± SD)*	*P*
NOSE Score (n = 17)	46.6 ± 28.9	15.9 ± 20.9	<.01
Epworth Sleepiness Scale (n = 17)	12.9 ± 4.5	3.2 ± 2.8	<.01
Apnea-Hypopnea Index (n = 18)	58.1 ± 32.0	8.3 ± 4.7	<.01
Oxygen nadir (%) (n = 18)	76.8 ± 9.4	83.8 ± 6.9	<.01

SD, standard deviation; NOSE, Nasal Obstruction Symptom Evaluation.

($P < .01$), whereas the mean increase in oxygen nadir was 7% ($P < .01$) (Table IV).

No participant required reintubation or developed an infection. All patients had normal submandibular gland function. Two patients developed clinically worse nasal obstruction (as determined by NOSE scores). One participant required a second surgical procedure (septoplasty), and another required medical treatment for turbinate hypertrophy. The mean surgical time for the SMI was 7.3 ± 1.0 minutes (range 5.0−9.5 minutes).

DISCUSSION

The purpose of this study was to determine if SMI during MMA for OSA resulted in reduced nasal obstruction and improved NOSE scores. The results of this study suggest that SMI combined with minimal nasal cartilaginous trimming and suturing to the ANS does result in a significant reduction in NOSE score that is consistent with reduced nasal obstruction. Furthermore it is a well-tolerated and relatively quick procedure that does not appear to result in the need for reintubation or the development of complications.

This study is the first to use the validated NOSE questionnaire to evaluate nasal obstruction after MMA for OSA. Although the need for secondary septoplasty after MMA has been reported to be 19%, the percentage of patients with worsened subjective nasal breathing is not known.[9] These patients may have clinically bothersome nasal obstruction that may go unrecognized. Furthermore, there is a relatively high discordance between subjective and objective nasal findings.[15-17] Consequently, patient-reported outcome measures such as NOSE represent the gold standard in identifying and quantifying nasal obstruction. Eight-eight percent of patients in this study reported improved nasal breathing. Two patients in this study reported worsening nasal obstruction. The first participant experienced postoperative bilateral, dynamic internal nasal valve collapse. This participant underwent bilateral nasal valve stabilization with correction of nasal obstruction. The second patient experienced persistent inferior turbinate hypertrophy which was refractory to steroid nasal sprays and required in-office turbinate reduction with radiofrequency ablation. Inferior turbinate hypertrophy is common among patients with OSA as a result of turbulent nasal flow that may not be relieved by the use of continuous positive airway pressure.[18,19]

The results of this study also confirm that MMA results in substantial improvements in the AHI and minimum oxygen saturation as well as the ESS. Our results are relatively similar to the most recent meta-analysis of MMA for OSA involving 518 patients. Zaghi et al.[8] reported an 80% reduction in AHI, improvement of oxygen nadir from 70% to 87% and an improvement of ESS from 13.5 to 3.2. By comparison, our group had a 66% reduction in AHI, improvement of oxygen nadir from 77% to 84%, and an improvement of ESS from 12.9 to 3.2.

One must also note that recent nasal intubation techniques using smaller endotracheal tubes (e.g., 6.0 microlaryngoscopy tubes) provide an alternative approach to submental intubation. With careful manipulation, the endotracheal tube can be displaced to access the nasal septum. This approach avoids the untoward side effects and complications of SMI. The most notable side effect is a 2-cm submental scar. Potential risks include hemorrhage, damage to Wharton's ducts, or genioglossus tendon avulsion (if performed midline).

There are several limitations of this study, including a relatively small sample size. Our follow-up time was also limited to 3 months, and despite the use of validated measures (NOSE and ESS), the possibility exists that with time patients could experience surgical relapse or develop nasal obstruction. Furthermore, all patients underwent counterclockwise rotation during MMA, and the potential influence on nasal obstruction is unclear.

In conclusion, SMI for patients undergoing MMA for OSA appears to be a well-tolerated, expeditious alternative to nasal intubation. The authors suggest that the improved visualization and ability to precisely reposition the nasal septum after LeFort I osteotomy translates to improved nasal breathing. Larger, prospective investigations to confirm these findings should be considered.

Everett G. Seay, RPSGT, assisted with study coordination and data organization.

DISCLOSURE

There are no conflicts of interest to declare.

FUNDING

No funding was received for this project.

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