Long-term Swallowing Performance Following Transoral Robotic Surgery for Obstructive Sleep Apnea

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Objective/Hypothesis: This study aimed to evaluate the long-term swallowing performance following transoral robotic surgery (TORS) to the base of tongue (BOT) in the treatment of obstructive sleep apnea (OSA).

Study Design: Retrospective and prospective cohort study.

Methods: Data analysis of 39 patients who underwent BOT reduction via TORS to treat OSA at our center from September 2013 to April 2016. Long-term swallowing functions were assessed using subjective self-evaluated swallowing disturbances questionnaire (SDQ) and objective fiberoptic endoscopic evaluation of swallowing (FEES).

Results: Seven patients underwent TORS BOT reduction alone, whereas 32 had also uvulopalatoplasty ± tonsillectomy, with a surgical success rate of 71.4%. Mean time for swallowing evaluation was 27.4 ± 9.43 months. Twenty-five patients completed the SDQ with an average score of 9.26 ± 10.05. In 32%, the SDQ was positive for dysphagia. In 10 out of 14 patients who underwent FEES, swallowing problems were noticed. The most common pathological findings were food residue in the vallecula followed by early spillage of food into the hypopharynx, penetration of solid food and liquid on the vocal folds surface, and aspiration.

Conclusions: BOT reduction via TORS has a negative effect on long-term swallowing function. A self-assessment questionnaire can help detect patients who suffer from swallowing impairment. Postoperative objective swallowing tests are essential not only in the immediate postoperative period but also during late routine follow-up. Proper patient selection and detailed information about surgery and possible late-swallowing effect are important factors before scheduling BOT reduction via TORS for OSA treatment.

Key Words: Transoral robotic surgery, obstructive sleep apnea, dysphagia.

Level of Evidence: 4

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INTRODUCTION

Obstructive sleep apnea (OSA) syndrome has a significant effect on public health. Comorbidities such as hypertension, stroke, heart failure, coronary heart disease, cognitive dysfunction, diabetes mellitus, and arrhythmias are more common in patients with OSA. An association exists between OSA, motor vehicle accidents, arrhythmias are more common in patients with OSA. An association exists between OSA, motor vehicle accidents, and death.1–3 Left untreated, the 15-year mortality rate for adults is increased by 30%.4 OSA results from multilevel collapse of the upper airway during sleep, with the tongue base being the most common site of obstruction. Continuous positive airway pressure is the standard of care for medical treatment of OSA, but the compliance rate ranges from 30% to 60%, with many individuals unable to tolerate daily use.4–8 Alternative treatments include the use of oral devices and surgical procedures.2

Surgical treatment for OSA aims to relieve obstruction by increasing the airway volume and/or removing a specific pathologic lesion. Despite the numerous available procedures, tonsillectomy, uvulopalatopharyngoplasty, transoral midline glossectomy, genioglossal advancement with hyoid suspension, maxillomandibular osteotomy and advancement, the outcomes are inconsistent and unpredictable. Transoral robotic surgery (TORS) is becoming an acceptable approach to the tongue base in the treatment of selected patients with OSA after failing positive airway pressure therapy.9 TORS is used to access the regions that have been difficult to treat surgically prior to the use of the robot.

TORS was initially introduced as a surgical technique by O’Malley et al.10 in the treatment of base of tongue (BOT) neoplasms. TORS offers superior visualization, ergonomics, and instrument access by overcoming the obstacle associated with accessing the BOT and hypopharynx. This renders TORS ideal for multilevel surgery, obviating the need for open access and its associated morbidity.

The role of TORS was expanded in 2010 by Vicini et al.,11 who reported their experience with TORS addressing obstruction at the BOT level in the treatment of OSA, asserting its safety and efficacy. Since then, other groups have incorporated the use of TORS in the surgical...
<table>
<thead>
<tr>
<th>First Author</th>
<th>No. of Patients</th>
<th>Mean Age (Years)</th>
<th>Follow-up (Months)</th>
<th>Surgical Procedures</th>
<th>Swallowing Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toh¹</td>
<td>20</td>
<td>47.1 ± 11.4</td>
<td>Mean 8.2 ± 3.2</td>
<td>Primary tonsillectomy with uvulopalatal flap and TORS tongue base reduction with partial epiglottidectomy.</td>
<td>Slight difficulty in swallowing (5%) starting 2 months after surgery.</td>
</tr>
<tr>
<td>Lee²²</td>
<td>20</td>
<td>45.7</td>
<td>Up to 19</td>
<td>TORS lingual tonsillectomy + UPPP.</td>
<td>Transient dysphagia (20.8%). Transient globes sensation (8.3%). Resolved 3 months postoperatively.</td>
</tr>
<tr>
<td>Friedman⁹</td>
<td>27</td>
<td>43.8 ± 9.2</td>
<td>Up to 6</td>
<td>TORS midline glossectomy + ZPP.</td>
<td>19.3 ± 8.4 days to normal diet.</td>
</tr>
<tr>
<td>Suh²³</td>
<td>50</td>
<td>43.3 ± 8.4</td>
<td>Up to 6</td>
<td>TORS midline glossectomy with lingual tonsillectomy (100%) + palatal surgery (88%).</td>
<td>Prolonged dysphagia (8%) lasting up to 6 months postoperatively. Oropharyngeal stenosis (2%) required subsequent surgery.</td>
</tr>
<tr>
<td>Lin²⁴</td>
<td>12</td>
<td>46.5 ± 13.3</td>
<td>Up to 12</td>
<td>TORS BOT reduction alone.</td>
<td>Oropharyngeal scar (8%) required subsequent surgery.</td>
</tr>
<tr>
<td>Lin²⁵</td>
<td>39</td>
<td>46.5 ± 13.2</td>
<td>Up to 12</td>
<td>TORS BOT reduction (100%) + partial epiglottectomy + UPPP. BOT alone (28.2%), BOT UPPP (5.1%), BOT + epiglottectomy (17.9%), BOT + UPPP + epiglottectomy (48.7%).</td>
<td>Oropharyngeal scar (7.7%) required subsequent surgery. All patients were able to tolerate a regular diet by 3 to 4 weeks following the surgery.</td>
</tr>
<tr>
<td>Arora²⁶</td>
<td>14</td>
<td>54.3 ± 14.6</td>
<td>Mean 18.9 ± 6.2, range 12–24</td>
<td>TORS BOT reduction (100%) + wedge epiglottoplasty (71.4%).</td>
<td>Swallowing status returned to baseline 3 months after surgery (as mean MDADI score returned to the preoperative level in 3 months following surgery). Temporary dysphagia (14%) resolved within 1.5 months postoperatively.</td>
</tr>
<tr>
<td>Hoff²⁷</td>
<td>285</td>
<td>51.5 ± 11.1</td>
<td>Up to 12</td>
<td>TORS lingual tonsillectomy and tongue base resection (partial glossectomy). Concomitant robotic surgical procedures: palatine tonsillectomy 3.4%, epiglottectomy 9.2%, epiglottoplasty 7.5%, other procedures (supraglottoplasty, epiglottopexy, uvuloplasty, uvulectomy, and endoscopy) 1.7%. Common concomitant nonrobotic procedures: UPPP/revisional UPPP 66.2%, lateral pharyngoplasty 12.3%, palatine tonsillectomy 32.1%, palatal Z-plasty 9.6%.</td>
<td>Temporary dysphagia/odynophagia (5.6%) resolved at 3 months postoperatively. Feeding tube placement in the immediate postoperative period (0.7%).</td>
</tr>
<tr>
<td>Glazer²⁸</td>
<td>166</td>
<td>54.6 ± 12.3</td>
<td>Up to 4</td>
<td>TORS lingual tonsillectomy (100%), partial midline glossectomy (39.2%), epiglottectomy (47.6%), tonsillectomy (42.2), UPPP (28.3%), pharyngoplasty (25.3%), palatoplasty (28.3%), uvulectomy (15.1%).</td>
<td>Aspiration (0.6%) leading to prolonged hospital stay. Dysphagia and gastrostomy tube dependence (0.6%) that was removed after 4 months. Dehydration and/or pain control (9.6%) that resolved after short hospitalization. Persistent globes sensation (4.8%).</td>
</tr>
<tr>
<td>Easa¹⁵</td>
<td>78</td>
<td>48</td>
<td>Mean 20 ± 7.12</td>
<td>TORS tongue base reduction alone (29.48%), TORS in combination with other surgeries as a part of multilevel surgery (70.51%). Epiglottoplasty (100%), tracheostomy (82%), associated surgical procedures (nasal + palatal) (70%), median anterior glossectomy (19%).</td>
<td>Minimal insignificant short-term impact on swallowing function (4.58 ± 7.03 preoperative MDADI score versus 5.19 ± 8.32 postoperative score) (P = .56). Mean time starting oral feeding was 1.05 ± 0.25 days (average, 1–3 days). Significant aspiration (6%) and mild aspiration (18%) in the first postoperative week as was demonstrated in a gastrografluoroscopy examination. Possible related signs of aspiration (2.4%) in a chest radiography done routinely 1 week postoperatively. No complaints of swallowing.</td>
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management of OSA, typically concomitant with other upper airway procedures. Review of the literature reveals that TORS BOT reduction decreases the apnea-hypopnea index (AHI) and symptoms of sleepiness in adult patients with OSA and is considered successful in the majority of cases.12–14 Complications occur in 21.3% of the patients, most of them minor, including taste alteration, tongue numbness, tongue soreness, and edema. Transient dysphagia represents the most common complication (7.2%), followed by bleeding (4.2%). Most complications are resolved within the follow-up period.11

Esa et al. studied the outcomes related to swallowing function in 75 patients who underwent TORS for sleep apnea on both short- and long-term scales. In no case was nasogastric tube feeding required. Five patients (6%) showed significant aspiration on Gastrografin fluoroscopic examination after 1 week; there was no significant correlation between the volume of tissue removed from both tongue base and epiglottis to the incidence of aspiration. No long-term swallowing complaint was registered. All of the patients in that study also had epiglottoplasty performed during surgery, and the long-term swallowing outcome was defined by patients' complaints without an objective assessment.15 Toh et al. described self-resolving difficulties in swallowing (1 of 20 patients [5%]) after TORS for BOT with supraglottic laryngoplasty.1

Review of the literature supports that the above-mentioned swallowing problems probably are not a major player after TORS for OSA (Table I). Transient dysphagia is almost always attributed to the pain caused by the surgery.

The final changes at the BOT created by soft tissue reduction during surgery and the healing process, including the fibrosis created at the operation site, may influence the swallowing mechanism, though this aspect has not been investigated yet. Some patients have limited awareness of their swallowing alteration; thus, lack of symptoms does not exclude an underlying swallowing pathology.

Undiagnosed and untreated, these patients may be at a high risk for dehydration, malnutrition, kidney problems, and even aspiration pneumonia secondary to food or liquid aspirations and microaspirations. The aim of this study was to evaluate the long-term swallowing performance after BOT reduction via TORS for OSA treatment.

**MATERIALS AND METHODS**

Thirty-nine patients who underwent TORS BOT reduction for OSA, from September 2013 to April 2016 at our center, were included in the study. Patients over 18 years of age who presented with OSA symptoms and diagnosis that had failed conventional therapy with positive airway pressure were referred to a sleep endoscopy examination under sedation. Patients diagnosed with an enlarged BOT obstructing the upper airway during sleep were offered the TORS procedure for reduction of their BOT. During the test, other sites that contributed to the obstruction were also noted and were later also addressed during the definitive operation.

Surgeries included partial BOT excision as a stand-alone procedure or part of a multilevel operation including tonsillectomy, uvulectomy, or uvulopalatoplasty. The operations were performed by the same surgeon (Z.G.) using the da Vinci Surgical System (Intuitive Surgical, Inc., Sunnyvale, CA). Detailed description of TORS-assisted BOT reduction was previously described.11 Under general anesthesia, a Feyh-Kastenbauer laryngeal retractor (Gyrus AMI, Southborough, MA) is inserted. The da Vinci Surgical System is docked at the right side of the patient’s bed. An 8-mm camera at a 0° angle is installed and inserted into the mouth. One of the robotic arms is installed with a 5-mm monopolar cautery with a spatula tip, and the second arm with a 5-mm Maryland dissector. Surgery begins with a tongue base tissue reduction. A midline split of the lingual tonsils is made commencing anteriorly from the foramen cecum and...
circumvallate papilla to epiglottis and vallecula in the posterior aspect. The lateral extent of the dissection is 1 cm to either side of the midline. The dissection’s plane is the area between the intrinsic muscles of the tongue and the lymphatic tissue. In case of palatine tonsils hypertrophy, reduction of the tonsillar tissue is performed. For patients with hypertrophic uvula and collapsed soft palate, an uvulectomy is performed using the robotic arms. When indicated, posterior pillars and soft palate are sutured clockwise at the end of the operation after removing the robotic arms from the surgical field, producing a progressive enlarging vector for the lateral wall and palate.

Patients’ demographics, comorbidities, admission time, and the volume of tissue removed during surgery were retrieved from the patients’ medical records. Surgical success was defined as anatomic patency of the upper airway by examination, symptomatic relief, and improvement in the polysomnogram measures (AHI < 20 and a decrease in AHI by 50%). A telephone survey was conducted at a minimum 11 months postoperatively. The patients were asked about their current complaints and whether they experienced swallowing difficulties. Swallowing difficulties were evaluated using the swallowing disturbances questionnaire (SDQ). This questionnaire, containing 15 questions, was proven to be a sensitive and accurate tool for identifying patients with true swallowing disturbances. Ten questions refer to the pharyngeal phase of swallowing, whereas five questions refer to the oral phase. Fourteen questions are scored from 0 to 3, and one is a yes or no question. The yes answer scores 2.5 points; a result of more than 11 points is considered pathologic and requires further investigation. Twenty five patients answered the SDQ questionnaire by telephone, and 14 patients underwent a fiberoptic endoscopic evaluation of swallowing (FEES). During the FEES, a flexible endoscope was inserted through the nose, to observe the area of the naso/oropharynx and larynx for the evaluation of the swallowing process. During the examination, colored food was served in three textures: solid (biscuit), puree (apple sauce), and liquid (milk) to assess the swallowing mechanism performance. The swallowing process was assessed by the physicians (J.T.C., L.B. and M.P.) along with speech and language pathologists specialized in swallowing (F.A.). FEES pathological findings included food aspiration, food penetration (food entry into the larynx area without penetration under the vocal cords), food residues, early spillage (when the swallowing reflex initiates in the level of the tongue base or pyriform sinuses instead at the pharyngeal arches), tongue movement, and swallowing strength.

Evaluation of the FEES test was done using the Swallowing Performance Status Scale (SPSS). This tool describes the swallowing function with a recommendation for the correct feeding technique. The score ranges from 1 to 7. A score of 1 means normal swallowing, whereas a score of 7 represents a severe impairment with multiple aspirations and inability to pass food to the esophagus. A score of 3 or higher was considered a pathological test score (Table II).

During the postoperative period, we noticed that although some patients have a crater-like appearance seen during fiberoptic examination, some demonstrated a relatively more natural look of the BOT without depression (Fig. 1).

Correlation between these two postoperative configurations with swallowing function was examined. This study was approved by the Committee for the Protection of Human Subjects (institutional review board) of Rambam Health Care Campus, Technion School of Medicine, and all subjects provided informed consent before data collection.

**Statistical Analysis**

Descriptive statistics for all subjects were generated for all measures, including means and standard deviations for continuous measures using SAS version 9.3 (SAS Institute, Cary, NC). Next, two sample t tests were performed to compare the different groups, and Pearson correlation coefficient was used to establish if there is a relationship between variables.

**RESULTS**

Our cohort comprised 39 patients who underwent TORS to the BOT. Thirty-four were men (87%). The mean age was 53.8 ± 10.133 years (range, 32–76 years). Seven patients (20.5%) underwent BOT reduction alone, whereas 31 patients (79.5%) underwent uvulopalatoplasty ± tonsillectomy as well. One patient underwent tonsillectomy and uvulopalatoplasty via TORS without BOT reduction (Table III). The mean operation duration time was 54.7 ± 16.9 minutes (range, 24–99 minutes), and the mean robot utilization time was 28.2 ± 8.3 minutes (range, 12–43 minutes). The mean volume of tissue excised from the tongue base during surgery was 9.8 cm³ (range, 1.26–30 cm³). Mean body mass index index before surgery was 28.8 (range, 24.3–36.01). The mean hospitalization duration was 2.89 ± 2.1 days postoperatively (range, 1–12 days). No statistically significant difference was found among the demographic data (gender and age), comorbidities, admission time, and the type of surgery.
No major complications were documented. Minor complications encountered were postoperative bleeding that required readmission but did not require revision surgery for hemorrhage control in two (5%) patients (POD 8 and 12), and swallowing difficulties due to severe pain in 28.2% of patients (POD 5–40), which resolved after administration of pain relief medication. None of the patients needed nasogastric tube insertion. Twenty-one patients were evaluated with sleep studies before and after surgery. All of those patients had improvements in their polysomnogram results, with mean AHI reduction of 55.04% (±22.14) (range, 5.26%–89%). The mean AHI prior to surgery was 33.5 ± 17.6, whereas the mean AHI postoperatively was 15.48 ± 9.14. Overall surgical success (defined as AHI < 20 and a decrease in AHI by 50%) was documented in 71.4% patients (15/21), and two patients were relieved completely from OSA symptoms (AHI < 5).

### Long-term Swallowing Outcomes

Screening for the presence of delayed swallowing problems was performed using the SDQ at a minimum of 11 months following surgery. The mean time for swallowing evaluation was 27.4 ± 9.43 months (range, 11–42 months). Twenty-five patients completed the questionnaire. The mean score was 9.26 ± 10.05 (range, 0–37). Thirty-two percent (8/25) of the patients had a score greater than 11, indicating the presence of a swallowing disturbance. The most common complaint according to the SDQ was food stuck in the throat.

Swallowing evaluations were done via the FEES test and summarized using the SPSS scale (n = 14). We considered examination that scored equal or higher than 3 as a pathologic test. Ten out of 14 patients had a pathological score, whereas four patients scored 2. The mean score was 3.21 ± 1.12 (range, 2–6). The most common pathological finding during the FEES test was vallecular residue, documented in 85% of patients. The second most common finding was early spillage, in 57%, followed by penetration and aspiration in 35% and 7%, respectively (Table IV). The SPSS had no significant correlation to surgical type and surgery success (P = .789, P = .7135, respectively). SPSS relation to tongue volume removed during surgery, could not be determined due to insufficient data (Bayesian Pearson correlation = 1.054).

During the postoperative period, most of the patients (71%) developed a crater-like appearance seen by fiberoptic examination (Fig. 1E,G), whereas 29% demonstrated a relatively more natural look of the BOT without depression (Fig. 1A,C). The mean SPSS score was 3.1 ± 3.66 for the crater group compare to 2.75 ± 47 in four patients in whom the tongue reduction did not change its overall appearance. In all patients within the crater group, food residue was noticed. Because of the small study cohort, we could not perform valid statistic analysis, but only refer to tendency (Fig. 1). The sensitivity of the SDQ to predict a pathologic SPSS test was 60% (four cases of false negative), whereas its specificity was 75% (one case of false positive).

| TABLE III. |
| Type of Surgery Performed |

<table>
<thead>
<tr>
<th>No. of Patients</th>
<th>Base of Tongue</th>
<th>Uvula</th>
<th>Tonsils</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>+</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>+</td>
<td></td>
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<tr>
<td>7</td>
<td>+</td>
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<td></td>
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<td>1</td>
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*Site indicates anatomic site where surgery was done to improve airway paten.
DISCUSSION

Base of tongue is recognized as the most significant site affecting OSA. TORS has gained popularity in a number of fields over the last decade including OSA surgeries. The TORS approach provides the surgeon with improved dexterity and precision, as well as three-dimensional vision with depth perception. Dysphagia immediately postoperatively is usually caused by pain. Most authors agree that the dysphagia or odynophagia symptoms are temporary and resolve with no need for intervention.

The underrecognition and low levels of awareness to the presence of swallowing disturbances by patients, caregivers, and health professionals results in underreporting, low frequency of complaints, and a delay in the diagnosis of these problems. Early detection and effective intervention can help prevent the serious consequences of dysphagia.19,20

The swallowing disturbances questionnaire (SDQ) was developed and validated for detecting dysphagia symptoms in patients suffering from various etiologies. The SDQ questionnaire substantially reduced type I errors (specifically, missing an existing swallowing problem). The SDQ has since been recognized as a validated tool to detect early dysphagia.21 Most of our patients who underwent TORS for OSA visit the outpatient clinics for periodic checkups, but issues related to swallowing difficulties are not always addressed for any number of reasons, such as the lack of awareness of swallowing disturbances by the patient or the healthcare professional, the use of compensatory swallowing techniques, and the fact that patients give higher priority to other major health problems that need to be discussed with the physician. By distributing the SDQ to patients who underwent TORS for OSA, it would be possible to obtain information on their swallowing status and identify more of those who need further evaluation. Thirty-two percent of our patients had a score greater than 11, indicating the presence of a swallowing disturbance. The most common complaint according to the SDQ was food stuck in the throat, and our most common pathological finding during the FEES test was vallecular residue, which was seen in 85% of patients. Two explanations can justify this finding. The first is the socket created by tongue reduction and late scarring and diminished sensitivity at the BOT due to neural damage, which can explain also the second most common swallowing pathology in our study, and the second is early spillage seen in 57% of patients. Although the literature review describes only reasonable short-term swallowing outcomes with no long-term sequelae of TORS for BOT, we found that upon searching specifically for these problems the answer may be different. We may perhaps replace airway obstruction and difficulty in breathing with tissue deficiency and swallowing impairment. Patient’s selection is very important in our opinion, and only those with very severe OSA should be recommended TORS for BOT reduction. An attempt should be made during surgery to avoid crater formation in the BOT and the vallecular region. The study joined together results from several TORS for OSA reports. The basis to all was the reduction of the BOT by TORS. Other sites involving airway obstructions were addressed also including the tonsils, uvula, and palate (Table III). It is hard to isolate the cumulative effect of each of these anatomical sites on postoperative swallowing performances. The statistical analysis, however, did not show difference in the scores of the SDQ and the SPSS between patients who underwent BOT reduction alone and the patients who had more surgeries.

CONCLUSION

TORS for BOT reduction for OSA has a negative effect on the long-term quality of swallowing. Self-assessment questionnaire, such as the SDQ, can help detect those who suffer from swallowing impairment. Postoperative objective swallowing tests are essential not only in the immediate postoperative period, but also during late routine follow-up. Vallecular food residue and early spillage can be found in up to 85% and 57% of cases, respectively. To prevent future serious complications, these patients should be referred to therapy by a speech and language pathologist who specializes in swallowing. Proper patient selection and detailed information regarding surgery’s possible late swallowing effects are important factors before scheduling BOT reduction via TORS for OSA treatment.

BIBLIOGRAPHY


