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SCIENTIFIC INVESTIGATIONS

Trans-Oral Robotic Tongue Reduction for OSA: Does Lingual Anatomy Influence the Surgical Outcome?

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Study Objectives: To evaluate both the influence of the volume of the excised base of tongue (BOT) on the surgical outcome after robotic tongue reduction in patients affected by obstructive sleep apnea (OSA) and the role of the lymphatic or muscular predominance within the removed tissue.

Methods: Fifty-one patients with OSA were included in this study. All patients were treated with a robotic tongue base reduction. Data registered for the analysis were: age, sex, preoperative body mass index, preoperative and postoperative apnea-hypopnea index (AHI), delta AHI (preoperative AHI − postoperative AHI), total volume of the excised BOT, total thickness of excised BOT, isolated lymphatic thickness and soft tissue thickness (including muscular component) of the excised BOT, and lymphatic/soft tissue ratio (lymphatic thickness / soft tissue thickness).

Results: A statistically significant reduction of AHI values was seen postoperatively, and a success rate of 74.5% was recorded. However, no significant correlations between delta AHI and tongue volume in cubic centimeters, lymphatic/soft tissue ratio, and total thickness were found.

Conclusions: These findings reinforce the general opinion that OSA is not only influenced by anatomic factors but other phenomena may play a fundamental role in its genesis. A deeper understanding of OSA pathogenesis is needed in order to tailor an individual treatment strategy that could lead to a more effective therapy.

Keywords: base of tongue, obstructive sleep apnea, OSA, trans-oral robotic surgery, TORS

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BRIEF SUMMARY

Current Knowledge/Study Rationale: Obstructive sleep apnea is known to be caused by anatomic and physiological factors. The aim of this study is to evaluate the influence of the base of the tongue and its histological components on the effectiveness of trans-oral robotic surgery.

Study Impact: The results highlighted by this study underlines the importance of nonanatomic factors in the genesis of obstructive sleep apnea and express the need for a better understanding of the pathology and a more precise selection of candidates for sleep surgery.

INTRODUCTION

Obstructive sleep apnea (OSA) is a common disorder that affects more than 2% to 4% of the adult population. It is a serious social health problem with significant implications on quality of life as well as long-term health. OSA has consistently been shown to cause a multitude of neurobehavioral issues and is an independent risk factor for cardiopulmonary diseases that significantly increase the risk of death.[1,2] Among the most important pathophysiologic causes the following should be cited:

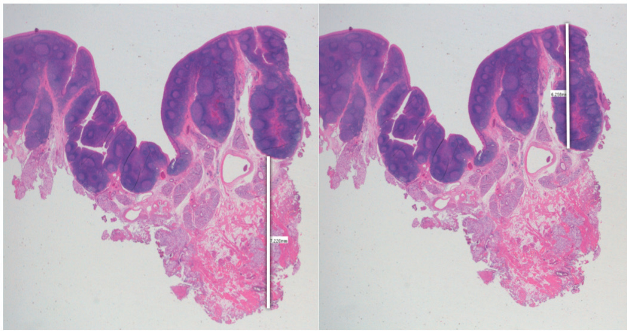
1. An anatomically compromised or collapsible upper airway (high passive critical closing pressure of the upper airway [Pcrit])[3];
2. Inadequate responsiveness of the upper airway dilator muscles during sleep (minimal increase in electromyography muscular activity to negative pharyngeal pressure)[4,5];
3. Premature awakening to airway narrowing (a low respiratory arousal threshold)[6–10];
4. Oversensitive ventilatory control system (high loop gain).[10–12]

The gold standard treatment for OSA remains continuous positive airway pressure (CPAP). However, large proportions of patients do not tolerate or show consistent compliance with CPAP and require an alternative treatment.[13]

In selected patients, trans-oral robotic surgery (TORS) has been shown to be a promising and effective option for the treatment of OSA allowing the resection of the base of the tongue (BOT) and supporting several surgical techniques.[14,15]

However, the most appropriate selection of patients for TORS is currently the main issue. For instance, the risk of TORS failure rate was reported to be significantly higher in patients with body mass index (BMI) > 30 kg/m^2.[16]

Figure 1—Excised BOT specimens stained with hematoxylin and eosin.



The measurements of lymphatic and soft tissue portions are highlighted (white lines).

Some studies have also shown correlations between upper airway volumes measured by imaging techniques and polysomnographic parameters.[17–22] Thus, these anatomic findings might imply that surgical success could also be related to upper airway volumes.

The aim of this study is to evaluate the influence of the volume of the excised BOT on the surgical outcome after TORS, and the influence of lymphatic or muscular predominance within the removed tissue.

METHODS

The medical charts of consecutive patients who underwent TORS for OSA at the Otolaryngology Head-Neck Surgery and Stomatology Unit of the Hospital Morgagni-Pierantoni in Forlì, Italy were evaluated retrospectively.

The patients were randomly selected from the dataset including patients with OSA treated surgically from June 2010 to April 2015 at the ENT unit of the Hospital Morgagni-Pierantoni, Forlì, Italy.

Patients met inclusion criteria if they were 18 years of age or older, had failed CPAP as a nonsurgical treatment alternative, and had an apnea-hypopnea index (AHI) of 20 events/h or above.

Patients who had undergone prior airway surgery, such as uvulopalatopharyngoplasty or tonsillectomy, were not eligible for the trial. Incomplete or recent cases, with a postoperative polysomnographic evaluation shorter than 1 year, were also excluded.

Preoperative workup included preoperative drug-induced sleep endoscopy. Patients who were found to have significant multilevel collapse at the palatal, lingual, and pharyngeal levels with complete obstruction of the tongue base (lymphatic and nonlymphatic hypertrophy) were included in this study. A total of 51 patients were included in this study.

All patients were treated with a robotic tongue base reduction as previously described with temporary tracheostomy, tonsillectomy, expansion sphincter pharyngoplasty, and septoturbinoplasty.[23,24]

Data registered for the analysis were: age, sex, preoperative BMI, palatine tonsils grade at clinical examination, preoperative and postoperative AHI, delta AHI (preoperative AHI − postoperative AHI), total volume of the excised BOT, total thickness of excised BOT, lymphatic and soft tissue thickness (including muscular component) of excised BOT, and lymphatic/soft tissue ratio (lymphatic thickness / soft tissue thickness).

Postoperative polysomnography was performed 1 year after surgery in all patients. All the sleep studies were carried out with an unattended type 3 home sleep study (Polymesam 8-channel) and reviewed and scored by the same expert in sleep medicine according to the American Academy of Sleep Medicine Guidelines.[25]

Apnea was defined as the cessation of nasal airflow of more than 90% for a period of ≥ 10 seconds in the presence of respiratory efforts. A hypopnea was scored whenever there was a > 30% reduced oronasal airflow for at least 10 seconds, accompanied by ≥ 4% oxygen desaturation from preevent baseline.

Measurement of the volume of tissue removed was performed by means of a graduated syringe filled partially with water into which the excised BOT was placed, thus causing the level of the water to rise. Volume displacement was measured in cubic centimeters (cm^3).

Excised BOT specimens were fixed in 10% neutral buffered formalin for a minimum of 24 hours, followed by paraffin embedding, cut at maximum thickness and stained with hematoxylin and eosin for microscopic examination. The most representative slide showing the point of the more hyperplastic and thicker lymphoid component was selected for each case.

The measurements were made in millimeters taking into account that the surface of the BOT mucosa is rather irregular, drawing lines perpendicular to the mucosal surface. On the same section, the measurement of the component of the soft tissues was carried out from the limit of lymphoid tissue until the deep margin (**Figure 1**).

The definition of surgical response and success was a reduction from the preoperative AHI of at least 50% (response) and a value less than 20 events/h (success).

The association of delta AHI with tongue volume, tongue thickness, and lymphatic/soft tissue ratio was analyzed using univariate linear regression test.

Adjusted odds ratios (95% confidence intervals) were calculated for independent variables. Pearson correlation coefficients were also tested.

The pretreatment and posttreatment AHI values were compared by *t* test. A two-sample *t* test was also used to compare the excised BOT volume of two groups: patients with successful outcomes (postoperative AHI < 20 events/h) (group A) and patients with postoperative AHI > 20 events/h (group B).

Probability values lower than .05 were considered statistically significant. Statistical analyses were performed with SPSS version 2.0 (IBM Corporation, Armonk, New York, United States).

This study was approved by the Institutional Review Board of the Hospital Morgagni-Pierantoni in Forlì, Italy.

Table 1—Age, male/female ratio, BMI, pretreatment and posttreatment AHI values, resected tongue volume, lymphatic/soft tissue ratio and, total thickness of the resected tongue volume, and success rate of treated patients.

No. Patients	Age (years)	Male/ Female Ratio	BMI (kg/m²)	AHI (events/h)		Tongue Volume (cc)	Lymphatic/ Soft Tissue Ratio	Total Thickness (mm)	Success Rate (%)
				Pretreatment	Posttreatment				
51	55.47 ± 11.56	38/13	29.12 ± 8.9	39.97 ± 16.78	15.10 ± 11.36	11.72 ± 5.05	1.22 ± 1.58	11.69 ± 3.15	74.5

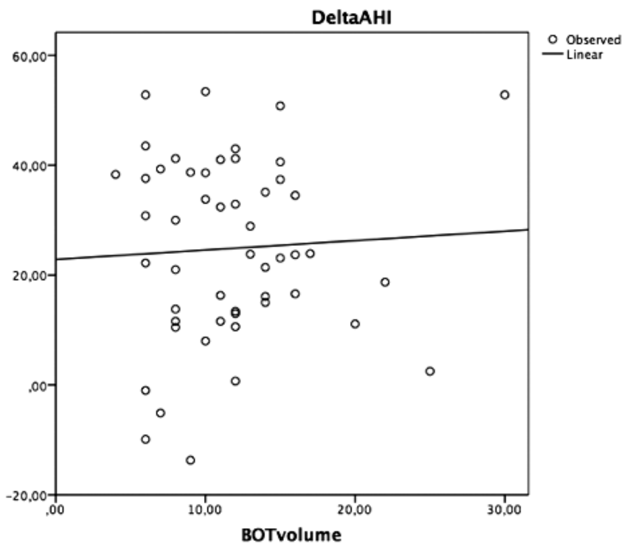
AHI = apnea-hypopnea index, BMI = body mass index.

Table 2—Pretreatment and posttreatment AHI values compared by *t* test.

	Mean	SD	*P*
Pretreatment AHI (events/h)	39.97	16.78	.01
Posttreatment AHI (events/h)	15.10	11.36	

AHI = apnea-hypopnea index, SD = standard devation.

Figure 2—Univariate linear regression test correlating delta AHI to BOT volume.



AHI = apnea-hypopnea index, BOT = base of tongue.

RESULTS

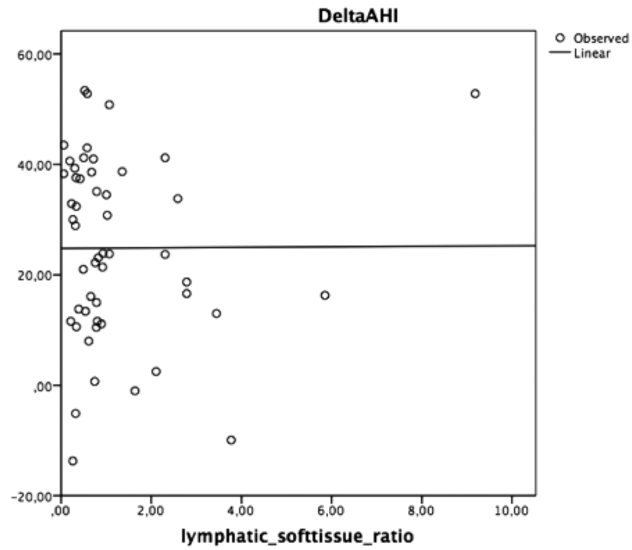
Table 1 shows data about age, M/F ratio, BMI, pretreatment and posttreatment AHI values, resected tongue volume (cm³), lymphatic/soft tissue ratio and total thickness (mm) of the resected tongue volume, and, success rate (%) of treated patients. Palatine tonsils grade at clinical examination was less than 3 in all patients.

An average of 11.72 cm³ of resected tongue volume was recorded in our series.

A statistically significant reduction of AHI values was seen postoperatively (from 39.97 ± 16.78 to 15.10 ± 11.36 events/h), and a success rate of 74.5% was also recorded (**Table 2**).

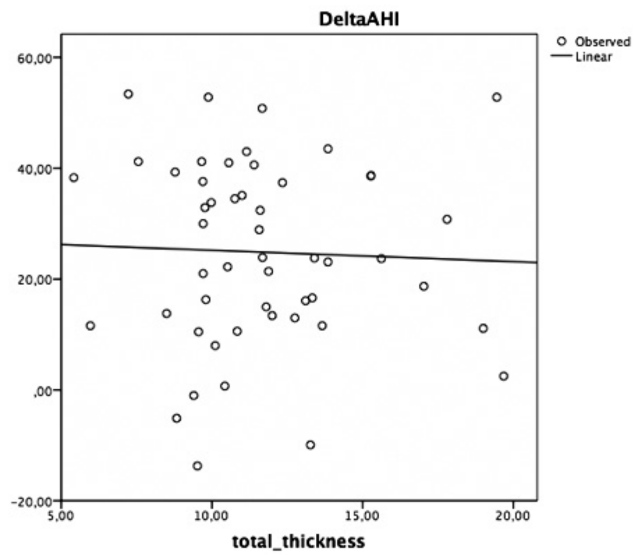
However, no significant correlations between delta AHI and tongue volume (cm³), delta AHI and lymphatic/soft tissue ratio, delta AHI and total thickness were found (**Figures 2–4**).

Figure 3—Univariate linear regression test correlating delta AHI to lymphatic/soft tissue ratio.



AHI = apnea-hypopnea index.

Figure 4—Univariate linear regression test correlating delta AHI to BOT total thickness.



AHI = apnea-hypopnea index, BOT = base of tongue.

Moreover, no significant difference of excised BOT volume between group A and group B was found (**Table 3**).

Table 3—Comparison of values of excised BOT volume between group A (postoperative AHI < 20 events/h) and group B (postoperative AHI > 20 events/h).

Group	No. Patients	Tongue Volume (cc) Mean	SD	*P*
A	13	11.84	5.15	NS
B	38	11.38	4.95	

AHI = apnea-hypopnea index, BOT = base of tongue, SD = standard deviation.

DISCUSSION

Several factors seem to influence the surgical outcome in patients undergoing TORS for OSA. In particular, patients presenting with BMI < 30 kg/m^2, AHI < 60 events/h, Friedman stage II-III, and absence of lateral pharyngeal wall collapse generally benefit more from TORS than other phenotypes.[16,26]

However, few studies have focused their attention on the correlation between anatomic measures and surgical success. Chiffer et al. found that MRI-measured changes in the volume of the pharyngeal lateral walls correlated with changes in AHI.[27]

In the past decade, the use of drug-induced sleep endoscopy has allowed detection of BOT collapses in patients affected by OSA more precisely.[28] Considering the importance of retrolingual collapse, the aim of our work was to evaluate the role of the BOT and its histologic composition in the prediction of success in patients treated with trans-oral robotic tongue reduction for OSA. In our series, a surgical success rate of 74.5% was seen, in line with other authors' experiences.[14]

Despite the retrospective nature of our study and the relatively small sample, taking into consideration that TORS was part of a multilevel surgical approach, and considering the limits of histological measures techniques, the following considerations can be made.

From our results, it seems that both the total volume of the resected BOT and its lymphatic/muscular percentages did not influence the clinical outcomes 1 year after surgery. Moreover, no significant difference of excised BOT volume between patients with successful outcomes and failures was found.

Furthermore, histologic examination of our samples did not highlight a macroscopic distribution of fat within the resected BOT. This evidence appears in contrast with other authors' experience that underlines the influence of tongue fat on the severity of OSA in obese patients.[29]

However, a recent study by Chen et al. demonstrated that tongue base thickness, measured by ultrasound monitoring during natural sleep, does not correlate with the severity of OSA.[30] These findings reinforce the general opinion that OSA is not only influenced by anatomic factors but other causes may play a fundamental role in its genesis. For instance, low responsiveness of the upper airway dilator muscles during sleep,[4,5] low respiratory arousal threshold,[6–10] and the presence of high loop gain[10–12] may influence the surgical outcome and therefore must be considered during patient selection process.

However, several surgical techniques can be performed on BOT by means of TORS. In this study, all patients underwent a BOT reduction method by Vicini et al.[23] The resection of BOT performed with midline or other extended techniques may potentially lead to different surgical outcomes and for this reason further studies are warranted to validate our findings.[15]

Taking this into account and considering the heterogeneous patterns of OSA patients, a deeper understanding of the OSA pathogenesis is needed to tailor an individual treatment strategy that could lead to a more effective therapy.

CONCLUSIONS

Our results suggest that the volume of the resection and the histologic composition of the removed BOT do not influence the outcome of TORS in patients affected by OSA. A deeper understanding of the OSA pathogenesis is needed to tailor an individual treatment strategy that could lead to a more effective therapy.

ABBREVIATIONS

AHI, apnea-hypopnea index
BMI, body mass index
BOT, base of the tongue
CPAP, continuous positive airway pressure
OSA, obstructive sleep apnea
Pcrit, passive critical closing pressure of the upper airway
TORS, trans-oral robotic surgery

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DISCLOSURE STATEMENT

Work for this study was performed at the ENT unit of Ospedale Morgagni Pierantoni, Forlì, Italy. All authors have seen and approved the manuscript. The authors report no conflicts of interest.