Trans-oral robotic surgery versus coblation tongue base reduction for obstructive sleep apnea syndrome

Wei-Che Lan [1], **Wen-Dien Chang** [2], **Ming-Hsui Tsai** [1, 3, 4], **Yung-An Tsou** [Corresp. 1, 3, 4]

[1] Department of Otolaryngology Head and Neck Surgery, China Medical University Hospital, Taichung, Taiwan

[2] Department of Sport Performance, National Taiwan University of Sport, Taichung, Taiwan

[3] School of Medicine, China Medical University, Taichung, Taiwan

[4] Department of Audiology and Speech-Language Pathology, Asia University, Taichung, Taiwan

Corresponding Author: Yung-An Tsou
Email address: D6638@mail.cmuh.org.tw

Objectives. To compare the efficacy of trans-oral robotic surgery (TORS) with that of coblation assisted tongue base reduction surgery in patients with obstructive sleep apnea syndrome (OSAS). **Subjects and Methods.** The medical charts were retrospectively reviewed for all OSAS patients admitted to one institution for surgical intervention between 2012 and 2017. We analyzed 33 cases; 16 patients received TORS and 17 received coblation surgery for tongue base reduction. Both groups received concomitant uvulopalatoplasty. Surgical outcomes were evaluated by comparing the initial polysomnography (PSG) parameters with the follow-up PSG data at least 3 months after the surgery. Epworth sleepiness scale (ESS) and complications were also compared between the 2 groups.

Results. The success rate (≧50% reduction of pre-operative AHI and post-operative AHI <20) in the TORS group and coblation group were 50% and 58%, respectively, and there was no significant difference (p= .611). The AHI (mean ± SD) reduction in the TORS and coblation groups were 48.0 ± 38.9 events/h and 45.3±34.1 events/h, respectively; the between-group difference was not significant (p= .831). ESS improvement did not differ significantly between the TORS and coblation groups (3.4±3.0 and 2.8±4.3, respectively, p= .646). The rates of minor complication were higher in the TORS group (50%) than that of the coblation group (35.3%) without statistical significance (p= .393).

Conclusion. TORS achieved comparable surgical outcomes compared to coblation assisted tongue base reduction surgery in OSAS patients. Multilevel surgery using either TORS or coblation tongue base reduction combined with uvulopalatoplasty is an effective approach for the management of OSAS.

Trans-oral Robotic Surgery versus Coblation Tongue Base Reduction for Obstructive Sleep Apnea Syndrome

Wei-Che Lan[1], Wen-Dien Chang[2], Ming-Hsui Tsai[1, 3, 4], Yung-An Tsou[1, 3, 4]

[1]Department of Otolaryngology Head and Neck Surgery, China Medical University Hospital, Taichung, Taiwan.

[2]Department of Sport Performance, National Taiwan University of Sport, Taichung, Taiwan.

[3]School of Medicine, China Medical University, Taichung, Taiwan.

[4]Department of Audiology and Speech-Language Pathology, Asia University, Taichung, Taiwan.

Corresponding Author:

Yung-An Tsou[1, 3, 4]

Department of Otolaryngology Head and Neck Surgery, China Medical University Hospital, No.2, Yude Rd., North Dist., Taichung City 404, Taiwan.

Email: d22052121@gmail.com

Abstract

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p= .646). The rates of minor complication were higher in the TORS group (50%) than that of the coblation group (35.3%) without statistical significance (p= .393).**Conclusion.** TORS achieved comparable surgical outcomes compared to coblation assisted tongue base reduction surgery in OSAS patients. Multilevel surgery using either TORS or coblation tongue base reduction combined with uvulopalatoplasty is an effective approach for the management of OSAS.

Introduction

Obstructive sleep apnea syndrome (OSAS) is a common disorder which affects 3-7% of adult men and 2-5% of adult women.[1] OSAS results from upper airway collapse during sleep. Clinical symptoms include fragmented sleep and excessive daytime sleepiness. [2] Continuous positive airway pressure (CPAP) is thought to be the gold standard treatment for OSAS, [3] but some patients cannot tolerate it and may seek surgical treatment instead. [4] Different levels and degrees of obstruction in OSAS patients lead to variable response to surgical intervention. [5] In one study, Vroego et al. analyzed the upper airway collapse patterns in patients with sleep-disordered breathing by using drug-induced sleep endoscopy (DISE) and multilevel collapse was disclosed in 68.2% of all patients.[6] As the intricacies of airway collapse are better understood, due to improvements in diagnostic

and evaluative methods, multilevel surgery is becoming a more common method of successfully treating OSAS.[7, 8] Among these patients with multilevel collapse, the most frequently seen pattern was the concomitant collapse of palatal and tongue base (25.5%).[6] Uvulopalatopharyngoplasty (UPPP) is the most commonly reported surgery to address oropharyngeal obstruction. For dealing with tongue base obstruction, trans-oral robotic surgery (TORS) and coblation assisted tongue base reduction surgery were two of the most published tongue base tissue reduction procedures.

Several preoperative assessment strategies have been used. Friedman tonsil grading scale classifies the tonsil size into five grades (grade 0-IV) according to the location the tonsil relative to the surrounding structures.[9] Friedman tongue position (FTP) grading system is evaluated similarly to the modified Mallampati classification, but the tongue is evaluated in a neutral position without protrusion. Friedman staging system incorporates FTP, Friedman tonsil grading scale and BMI to classify OSAS patients into four stages: stage I includes patients with tonsils graded III-IV, FTP graded I-II and BMI<40 kg/M^2; stage III includes patients with tonsils graded 0-II, FTP graded III-IV and BMI<40 kg/M^2; stage IV includes patients with BMI>40 kg/M^2 or significant craniofacial or other anatomic abnormalities; stage II includes patients beyond stage I, III, IV.[10] Fiberoptic nasopharyngoscopy with Muller's maneuver, which mimics the pathophysiological status

of OSAS during wakefulness by asking the patient to block bilateral nostrils and inhale with mouth closed, can identify the level and degree of upper airway collapse.[11] Drug-induced sleep endoscopy (DISE), which is recognized as a breakthrough in evaluation of OSAS patients, can provide direct identification of airway collapse during intravenous anesthesia. The VOTE classification is utilized for the findings of DISE.[12]

For most patients with oropharyngeal obstruction, uvulopalatopharyngoplasty (UPPP) is one of the most common and effective surgical procedures. [13] However, oropharyngeal obstruction combined with tongue base obstruction is recognized as the most important reason for failure after pharyngoplasty procedures.[14] For tongue base obstruction, multiple procedures have been proposed and could be simply categorized into tongue base volume reduction and tongue suspension. Among these procedures, trans-oral robotic surgery (TORS) and coblation assisted tongue base reduction surgery proved to be the most published therapeutic methods in the field of the tongue base reduction. [15] TORS can provide a 3D visual field and the operator can easily access the tongue base area and perform surgery using delicately controlled robotic instruments. Nevertheless, the high cost of TORS makes operators and patients hesitant to make use of it.[15] Endoscopic coblation assisted tongue base reduction surgery has been reported to be a useful procedure for tongue base obstruction and it has a lower cost compared to TORS.

[16, 17] However, there is a lack of fair comparison studies regarding the treatment efficacy and safety between TORS and coblation assisted tongue base reduction. Therefore, this study was conducted to compare the subjective and objective outcomes of TORS with endoscope-guided coblation tongue base reduction.

Materials and methods

Medical charts were retrospectively reviewed for OSAS patients admitted for TORS or coblation tongue base reduction surgery to a single tertiary hospital between 2012 and 2017. Thirty three patients with age ranging from 18 to 62 years met the inclusion criteria (Table 1). Patients who were excluded were those without available postoperative polysomnography (PSG) data. PSG was performed at 3-12 months after the surgery. Patients who had previous upper airway surgery for OSAS were also excluded. This study was approved by the Institutional Review Board of the China Medical University Hospital (project approval number CMUH103-REC1-078).

Detailed profiles were constructed for each patient and included the following variables: age, sex, body mass index (BMI), tonsil grade, Friedman tongue position, Friedman stage, pre-operative and post-operative Epworth sleepiness scale (ESS). Post-operative ESS was recorded at the date for post-operative PSG. Nasopharyngoscopy with Muller's

maneuver and drug-induced sleep endoscopy (DISE) were performed in all patients to evaluate the site of obstruction and the pattern of the airway collapse.

The grades of airway collapse in Muller's maneuver were divided into four grades according to the percentage change in cross-sectional area: grade I ≦25% collapse, grade II ＞25% and ≦50% collapse, grade III ＞50% and ≦75% collapse, grade IV >75% collapse. VOTE classification was utilized for reporting DISE findings and the grade of collapse were classified as 0 (< 50% obstruction); 1 (50–75% obstruction) and 2 (> 75% obstruction). Patients undergoing surgery must have at least partial tongue base collapse confirmed by Muller's maneuver and DISE. Details were also recorded from pre-operative and post-operative PSG data, and included AHI, apnea index (AI), lowest oxygen saturation (min-SpO2), cumulative time percentage with SpO2< 90% (CT90) (Table 2). The success of the surgery was defined as achievement of ≧50% reduction of pre-operative AHI and a post-operative AHI <20. Perioperative parameters, including the length of stay in hospital, the numeric rating scale (NRS) for pain intensity assessment on the first postoperative day and complications, were recorded.

In this study, 16 patients received TORS and 17 patients received coblation surgery for tongue base reduction (Figure 1). All patients received conventional uvulopalatopharyngoplasty combined with tongue base reduction for multilevel

obstruction in these patients. All of the surgeries were performed by a single surgeon. The surgical procedure of trans-oral robotic surgery for tongue base volume reduction was performed similar to the previous published literature. [16, 18] General anesthesia was introduced via nasotracheal intubation. The anesthesia machine was positioned at the left side foot of the bed. The surgical cart of the da Vinci surgical system (Intuitive Surgical, Sunnyvale, California, USA) approached the patient from the right-hand side with an angle of 45 degrees to the bed. The scrub nurse stood next to the patient's left hand and the first assistant sat at the head of the bed. The operative surgeon was at the operative console and used open-surgery hand movements which were precisely replicated in the operative field by the robotic instruments. The laryngeal advanced retractor system (Fentex, Tuttlingen, Germany) was used to expose the tongue base area. The size of the tongue blade was chosen accordingly to well expose the tongue base. Under 30 degree 3D camera endoscope, tongue base tissue was grasped by robotic forceps and cauterized with spatula monopolar electrode. The midline posterior glossectomy began from the foramen cecum and advanced posteriorly to vallecula without injury to epiglottis mucosa, laterally to 1cm from the midline and 1.5 cm inferior to the tongue base surface. Endoscopic coblation assisted tongue base reduction surgery was performed similar to previous reports. [19, 20] Under general anesthesia with nasotracheal intubation, the Molt

mouth gag (Sklar**,** West Chester, Pennsylvania, USA) was applied to the left side of labial commissure. We placed a silk suture through the anterior tongue and the silk was held by a Kelly forceps. The first assistant could easily retract the tongue forward by holding the Kelly forceps. A 70 degree rigid endoscope (Karl Storz, Tuttlingen, Germany) was applied to expose the tongue base area and kept in position by an endoscope holder (Karl Storz, Tuttlingen, Germany). With the aid of the endoscope holder, the surgeon could perform the procedure bimanually and thus decrease the operation time and the morbidity related to blood loss. The Coblator II ENT Surgery System and PROCISE MAX coblation wand (Arthrocare ENT, Sunnyvale, California, USA) were used for the midline posterior glossectomy. The targeted resection area was the same as the TORS mentioned above. We used the Statistical Packages for the Social Sciences version 24.0 (IBM Corp.; Armonk, NY, USA) for statistical analysis of the data. The descriptive statistic was used to present the outcome values. The Mann-Whitney and Wilcoxon test were used for comparing numerical variables, and Fisher's test was used for categorical variables. A p value of less than .05 was considered to be statistically significant.

Result

Among the 33 patients in this analysis, 16 were in the TORS group (age of 39.4±12.3

163 years) and 17 patients were in the coblation group (age of 38.7±11.5 years). The male
164 comprised 93.8% in the TORS group and 76.5% in the coblation group. The body mass
165 index (BMI) at the time of admission was 28.1±3.8 kg/m^2 in the TORS group and 27.3±5.5
166 kg/m^2 in the coblation group. There were no significant differences in tonsil grading scale,
167 Friedman tongue position and Friedman staging system between the two groups before
168 surgery. The grades of collapse in Muller's maneuver and DISE were similar in both
169 groups. The Epworth sleepiness scale (ESS) was 11.6±4.6 in the TORS group and
170 10.8±5.1 in the coblation group. All patients received polysomnography (PSG) for pre-
171 operative evaluation. The baseline apnea-hyponea index (AHI) was 50.4±19.6 events/h
172 and mean apnea index (AI) was 34.3±20.3 events/h in the TORS group; corresponding
173 values were 44.8±28.8 events/h and 28.2± 26.7events/h, respectively, in the coblation
174 group. The mean lowest oxygen saturation (min-SpO2) was 73.7±7.0% and mean
175 cumulative time percentage with SpO2<90% (CT90) was 16.4±15.0% in the TORS group;
176 corresponding values were 74.0±10.0% and 13.6±16.1% in the coblation group.
177 Demographics, baseline PSG data for both groups are summarized in Table 2. There
178 were no significant between-group differences prior to treatment.
179 The comparisons within-group (Table 3) and between-group (Table 4) were analyzed,
180 respectively. Statistically significant improvement of ESS was observed in both groups.

ESS improvement did not differ significantly between the TORS and coblation groups (3.4±3.0 and 2.8±4.3, respectively, p= .646; 95% CI= -3.30～2.08, Figure 2). The AHI reduced significantly from 50.4±19.6 events/h to 25.5±19.4 events/h in the TORS group (p= .002). In the coblation group, the mean AHI reduced significantly from 44.8±28.8 events/h to 25.4±23.2 events/h (p= .005). The AHI reduction in the TORS and coblation groups were 48.0 ± 38.9 events/h and 45.3±34.1 events/h, respectively; the between-group difference was not significant (p= .831; 95% CI=-12.67～23.73, Figure 3). The mean AI reduced significantly in both TORS and coblation group (p= .005 and p= .018, respectively), but the mean AI reduction did not differ significantly between the groups as well (p= .481; 95% CI=-18.53～14.60, Figure 3). The min-SpO2 improved from 73.7±7.0% to 83.9±5.7% (p= .001) in the TORS group and from 74.0±10.0% to 80.6±12.5% in the coblation group (p= .045). The improvement of min-SpO2 was 10.2±7.9% in the TORS group and 6.6±12.5% in the coblation group. There were no significant statistic differences in the improvement of min-SpO2 between the two groups (p= .355; 95% CI= -4.11～10.82, Figure 4). The TORS group patients had more reduction of CT90 percentage, but the difference was not significant. The success rate in the TORS group and coblation group were 50% and 58%, respectively, and there was no statistically significant difference (p= .611; 95% CI=-4.93～13.79, Figure 4).

The average numeric rating scales (NRS) for pain evaluation on the first postoperative day were similar in both groups (p= .428). In the TORS group, the length of stay in hospital was longer compared with the coblation group (p= .002). There were no major complications (e.g., intra-operative or post-operative bleeding, airway compromise, prolonged intubation, pneumonia and pharyngeal laceration, tongue limitation) in either group. No tracheotomies were performed for airway management perioperatively. The rates of minor complication, including transient dysphagia, pharyngeal edema and dysgeusia, in the TORS and coblation groups were 50% and 35.3%, respectively.

Discussion

Our results demonstrate that the surgical outcomes of trans-oral robotic surgery (TORS) were comparable to coblation assisted tongue base reduction surgery in obstructive sleep apnea syndrome (OSAS) patients. The PSG outcomes and success rate were similar for the TORS and coblation groups.

Multilevel surgery is thought to be a successful management for patients suffering from obstructive sleep apnea syndrome (OSAS). Because of the better understanding of the complexity of the upper airway collapse during sleep in OSAS patients, surgeons can determine correct surgical management according to the site of obstruction and the

pattern of the airway collapse. [8, 17, 21]

In a retrospective study, 25 moderate-to-severe OSAS patients with retropalatal and tongue base obstruction received coblation endoscopic lingual lightening and modified uvulopalatopharyngoplasty (relocation pharyngoplasty). AHI decreased significantly from 45.7±21.7 to 12.8±8.2 events/hour (p<.001) postoperatively and the overall surgical success rate was 80%.[20] Coblation lingual tonsil removal technique proved to be an effective procedure in a cohort of Korean OSAS patients with retroglossal obstruction. The average AHI decreased significantly from 37.7±18.6 to 18.7±14.8 events/hour (p<.001) and the success rate was 55.6%.[19] Another study compared combined coblation endoscopic lingual lightening and relocation pharyngoplasty to relocation pharyngoplasty alone in OSAS patients (AHI>20, Friedman stage III), and reported that combined surgery had better improvement in AHI (-65.5 vs -53.2; p=.047) and higher surgical success rate than relocation pharyngoplasty alone (73% vs 50%; p=.04).[17]

O'Malley et al. developed a minimally invasive surgical procedure for management of tongue base neoplasms by using robotic surgical instruments.[22] Trans-oral robotic surgery (TORS) can offer clear 3D visualization and gain adequate access to tongue base, larynx and hypopharynx and provide meticulous tissue resection. A preliminary study in 2010 conducted by Vicini et al. reported that TORS for tongue base resection in

OSAS patients is practical and well tolerated. Ten patients were included and the AHI decreased from 38.3±23.5 to 20.6±17.3 events/hour.[18] Further study for demonstration of the feasibility of TORS performed in forty four patients with OSAS reported significant improvement of mean AHI (24.6±22.2 events/hour) and mean ESS (5.9±4.4).[23] The latest systematic review and meta-analysis by Meccariello et al. concluded that TORS seems to be a promising and safe technology for the management of OSAS and the mean failure rate was 34.4% (29.5–46.2%).[24]

A study by Friedman et al. in 2012 was thought to be the first comparative study for the comparison of coblation and TORS in OSAS treatment.[16] It compared the effectiveness of TORS with that of coblation assisted submucosal minimally invasive lingual excision (SMILE). All the patients in the study received concomitant z-palatoplasty. The AHI reduction in the TORS and SMILE groups were 60.5%±24.9% and 32.0% ± 43.3% (p = .012), respectively. The success rate in the TORS and SMILE groups were 66.7% and 45.5%, respectively; the between-group difference was not significant (p= .135). However, the techniques used by each group were different and not completely comparable.

To the best of our knowledge, there is a lack of fine and matched studies regarding the treatment efficacy and safety between TORS and coblation adopting similar technique in

253 tongue base resection. Our retrospective comparison of TORS with coblation in the
254 treatment of OSAS patients with multilevel obstruction found that both groups had similar
255 surgical results.

256 The demographics and preoperative polysomnographic data did not differ significantly
257 between the two groups (Table 2) at baseline. According to the within-group outcomes
258 showed in Table 3, statistically significant improvement of apnea-hyponea index (AHI),
259 apnea index (AI), Epworth Sleepiness scale (ESS) and minimum oxygen saturation (min-
260 SpO2) were noted in both the TORS and coblation groups. It confirmed that either TORS
261 tongue base resection or coblation assisted tongue base resection combined with
262 concomitant uvuolopalatoplsty can offer reliable surgical results. The cumulative time
263 percentage with SpO2 < 90% (CT90) were decreased in both groups but only significantly
264 reduced in the TORS group which could be related to small sample size or poor
265 correlation of CT90 to AHI.[25]

266 As detailed in Table 4, the mean reduction of AHI, AI, ESS, CT90 and mean improvement
267 of min-SpO2 were similar for the TORS and coblation groups. The rate of surgical success
268 in the TORS group were comparable to the coblation group (50.0% vs 58.8%, p= .611).
269 Hwang et al. compared the tongue base coblation resection to TORS in OSAS patients
270 and both groups were in combination with lateral pharyngoplasty.[26] They reported that

271 the surgical success rates did not differ significantly between the two groups (56.3% in
272 TORS vs 62.1% in coblation, p= .711). Our success rates are lower than those in that
273 study. However, the preoperative BMI of patients in that study was lower than in our study
274 group (25.8-26.8kg/m^2 vs 27.3-28.1kg/m^2). Moreover, preoperative mean ESS were
275 lower (8.5-9.7 vs 10.8-11.6) and mean min-SpO2 were higher (78.5-79.8 vs 73.7-74.0) in
276 their study than those in our study group, which might suggest the severity of OSAS
277 is greater in our patients. In our study, the average pain scores (numeric rating scales)
278 on the first postoperative day were comparable in both groups (p= .428). In the TORS
279 group, the length of stay in hospital was longer compared with the coblation group (p=
280 .002). There was no major complication in either group. The rates of minor complication
281 were higher in the TORS group (50%) than that of the coblation group (35.3%) without
282 statistical significance. According to a review article, slightly better outcomes were
283 observed in TORS compared to coblation, but the higher rate of minor complications and
284 the significant costs of TORS are two aspects which surgeons will need to consider.[15]
285 This study has some limitations. First, the retrospective analysis used in this study is a
286 possible source for selection bias. Second, it is difficult to make comparisons among
287 studies because of different surgical techniques utilized by TORS (e.g. midline posterior
288 glossectomy[27], lingual tonsillectomy[28]) and coblation (e.g. midline posterior

289 glossectomy[20], SMILE[29], channelling of the tongue[30], Interstitial injections with
290 needle coblation[31]). In the future, prospective, randomized, controlled trials that
291 incorporate similar surgical technique will be needed to evaluate the efficacy of TORS
292 compared with coblation tongue base reduction. Moreover, studies providing long-term
293 results in the treatment of OSAS are also warranted.
294

295 **Conclusion**

296 TORS resulted in comparable objective and subjective outcomes compared to coblation
297 assisted tongue base reduction surgery in OSAS patients. Multilevel surgery with either
298 TORS or coblation tongue base reduction combined with uvulopalatoplasty is effective in
299 reducing disease severity in moderate-to-severe OSAS cases.
300

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Table 1(on next page)

Inclusion criteria

AHI = Apnea-Hypopnea Index; DISE = Drug-Induced Sleep Endoscopy; CPAP = Continuous positive airway pressure

Table 1:

Inclusion criteria
≥ 18 years old
Symptoms of obstructive sleep apnea syndrome (snoring, disrupted sleep, daytime sleepiness)
Preoperative AHI > 20
Friedman tongue position grade 3 or 4
Partial or complete retropalatal and retroglossal collapse in Muller's maneuver and DISE
Cannot tolerate CPAP

AHI = Apnea-Hypopnea Index; DISE = Drug-Induced Sleep Endoscopy; CPAP = Continuous positive airway pressure

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Table 2(on next page)

Demographics, Baseline data of the 2 groups†

BMI=body mass index (weight in kilograms devided by height in meters squared); FTP = Friedman tongue position; DISE = Drug-Induced Sleep Endoscopy; ESS = Epworth Sleepiness scale; AHI = Apnea-Hypopnea index; AI = Apnea index; Min-SpO2 = minimum oxygen saturation; CT90 = cumulative time percentage with SpO2 < 90% † All values are presented as mean ± standard deviation

TABLE 2.

Demographics, Baseline data of the 2 groups†

	TORS group (n=16)	Coblation group (n=17)	p value
age, years	39.4±12.3	38.7±11.5	.861
Male: Female ratio, n (%)	15:1 (93.8:6.3)	13:4 (76.5:23.5)	.335
BMI, kg/m^2	28.1±3.8	27.3±5.5	.645
Tonsil grade	2.0±1.3	1.9±0.8	.764
FTP	3.4±0.6	3.3±0.6	.831
Friedman stage	2.4±0.6	2.7±0.6	.207
Grade of collapse in Muller maneuver			
Retropalatal area	3.1±0.9	3.6±0.6	.122
Retroglossal area	2.6±0.8	2.3±0.8	.349
Grade of collapse in DISE			
Velum	2.0±0.0	1.6±0.6	.423
Oropharynx	1.4±0.5	1.3±0.6	.807
Tongue base	1.4±0.5	1.3±0.6	.807
Epiglottis	0.8±0.8	0.3±0.6	.351
ESS	11.6±4.6	10.8±5.1	.917
AHI, events/hour	50.4±19.6	44.8±28.8	.517
AI, events/hour	34.3±20.3	28.2±26.7	.498
Min-SpO2, %	73.7±7.0	74.0±10.0	.932
CT90, %	16.4±15.0	13.6±16.1	.641

BMI=body mass index (weight in kilograms devided by height in meters squared); FTP = Friedman tongue position; DISE = Drug-Induced Sleep Endoscopy; ESS = Epworth Sleepiness scale; AHI = Apnea-Hypopnea index; AI = Apnea index; Min-SpO2 = minimum oxygen saturation; CT90 = cumulative time percentage with SpO2 < 90%

† All values are presented as mean ± standard deviation

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Table 3(on next page)

Within-group comparison of the treatment outcomes†

AHI = Apnea-Hypopnea index; AI = Apnea index; ESS = Epworth Sleepiness scale; Min-SpO2 = minimum oxygen saturation; CT90 = cumulative time percentage with SpO2 < 90%

† All values are presented as mean ± standard deviation * $p < .05$ is considered statistically significant

TABLE 3.

Within-group comparison of the treatment outcomes†

	TORS group (n = 16)			Coblation group (n = 17)		
	Preoperative	Postoperative	p value	Preoperative	Postoperative	p value
AHI	50.4±19.6	25.5±19.4	.002*	44.8±28.8	25.4±23.2	.005*
AI	34.3±20.3	13.6±16.7	.005*	28.2±26.7	14.7±23.8	.018*
ESS	11.6±4.6	7.6±3.5	< .001*	10.8±5.1	8.06±5.5	.017*
Min-SpO2	73.7±7.0	83.9±5.7	< .001*	74.0±10.0	80.6±12.5	.045*
CT90	16.4±15.0	5.7±7.8	.004*	13.6±16.1	8.8±19.3	.248

AHI = Apnea-Hypopnea index; AI = Apnea index; ESS = Epworth Sleepiness scale; Min-SpO2 = minimum oxygen saturation; CT90 = cumulative time percentage with SpO2 < 90%

† All values are presented as mean ± standard deviation

* p < .05 is considered statistically significant

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Table 4(on next page)

Between-groups comparison of the treatment outcomes

SD = standard deviation; AHI = Apnea-Hypopnea index; AI = Apnea index; ESS = Epworth Sleepiness scale; Min-SpO2 = minimum oxygen saturation; CT90 = cumulative time percentage with SpO2 < 90%; NRS = numerical rating scale

TABLE 4.

Between-groups comparison of the treatment outcomes

	TORS group (n=16)	Coblation group (n=17)	p value
AHI reduction, mean ± SD	48.0±38.9	45.3±34.1	.831
AI reduction, mean ± SD	64.2±40.6	53.2±42.1	.481
ESS reduction, mean ± SD	3.4±3.0	2.8±4.3	.646
Min-SpO2 improvement, %, mean ± SD	10.2±7.9	6.6±12.5	.355
CT90 reduction, %, mean ± SD	10.6±11.4	4.8±15.6	.268
Success rate, n (%)	8(50.0)	10(58.8)	.611
Day 1 pain score(NRS), mean ± SD	2.7±0.8	2.5±0.7	.428
Hospital stay, days, mean ± SD	5.5±1.1	4.3±0.7	.002
Major complication, n (%)	0(0)	0(0)	
Minor complication, n (%)	8(50.0)	6(35.3)	.393

SD = standard deviation; AHI = Apnea-Hypopnea index; AI = Apnea index; ESS = Epworth Sleepiness scale; Min-SpO2 = minimum oxygen saturation; CT90 = cumulative time percentage with SpO2 < 90%; NRS = numerical rating scale

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Figure 1

The study flow diagram

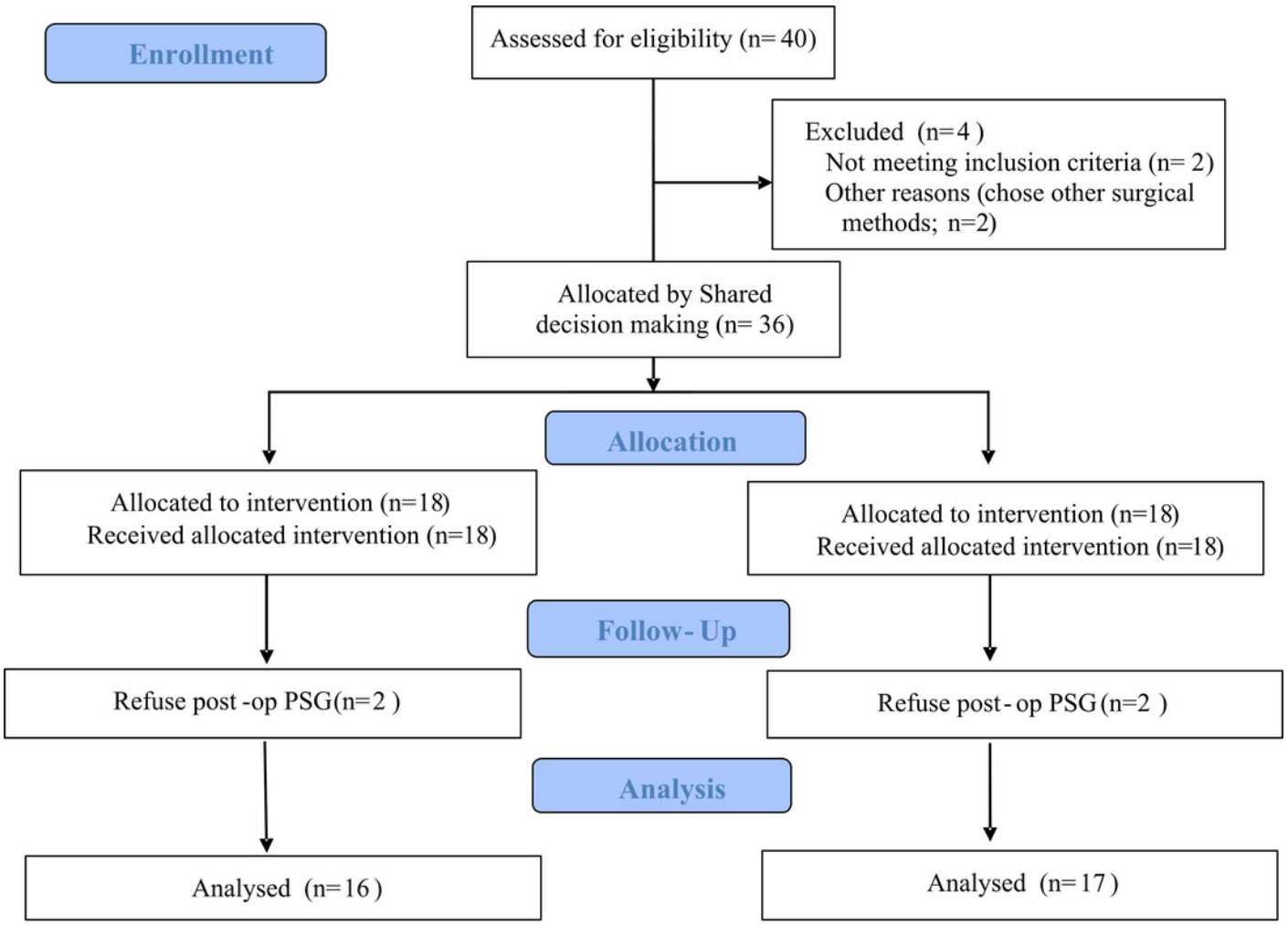

Figure 2

The treatment outcome of ESS between two groups

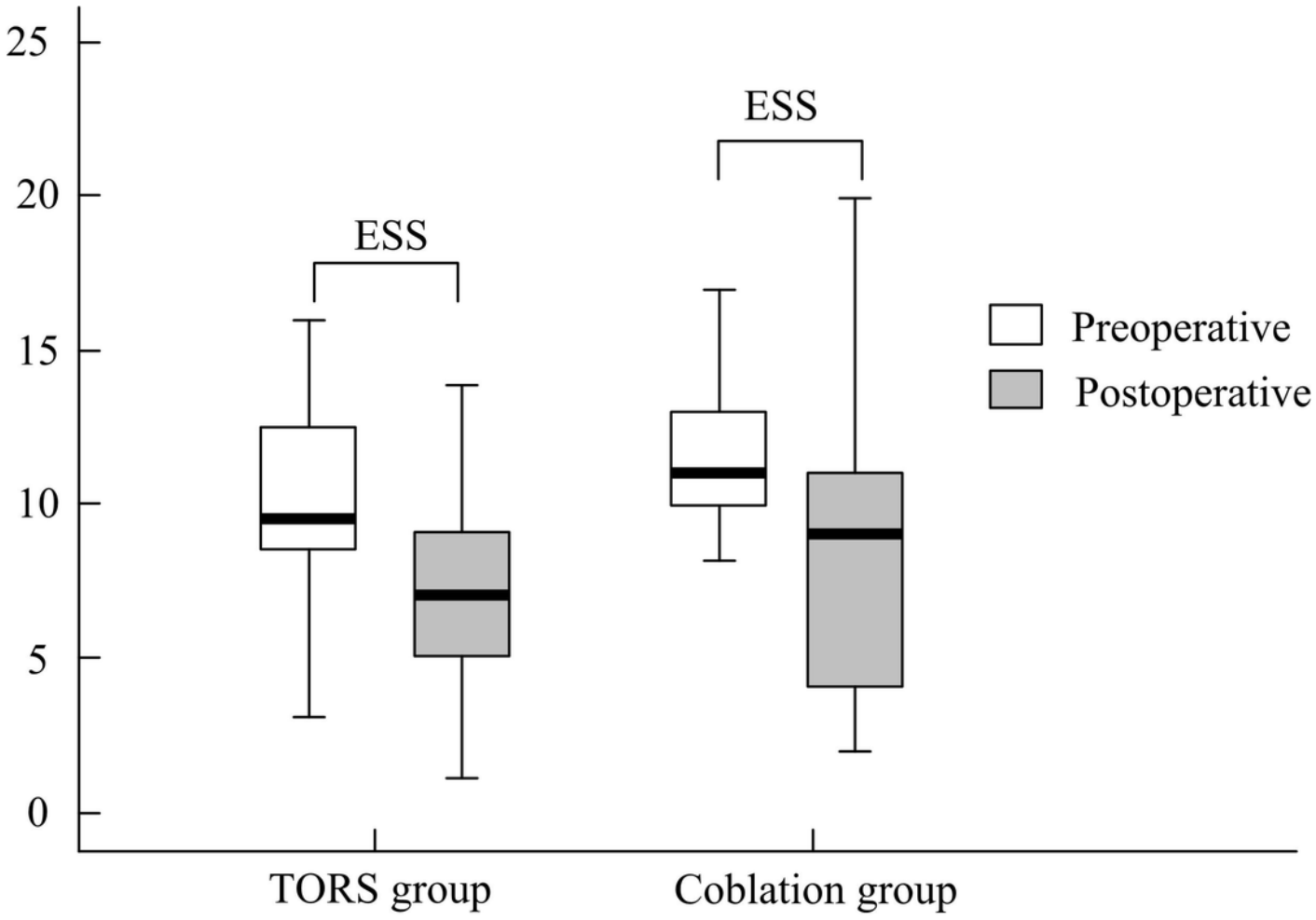

Figure 3

The treatment outcome of AHI and AI between two groups

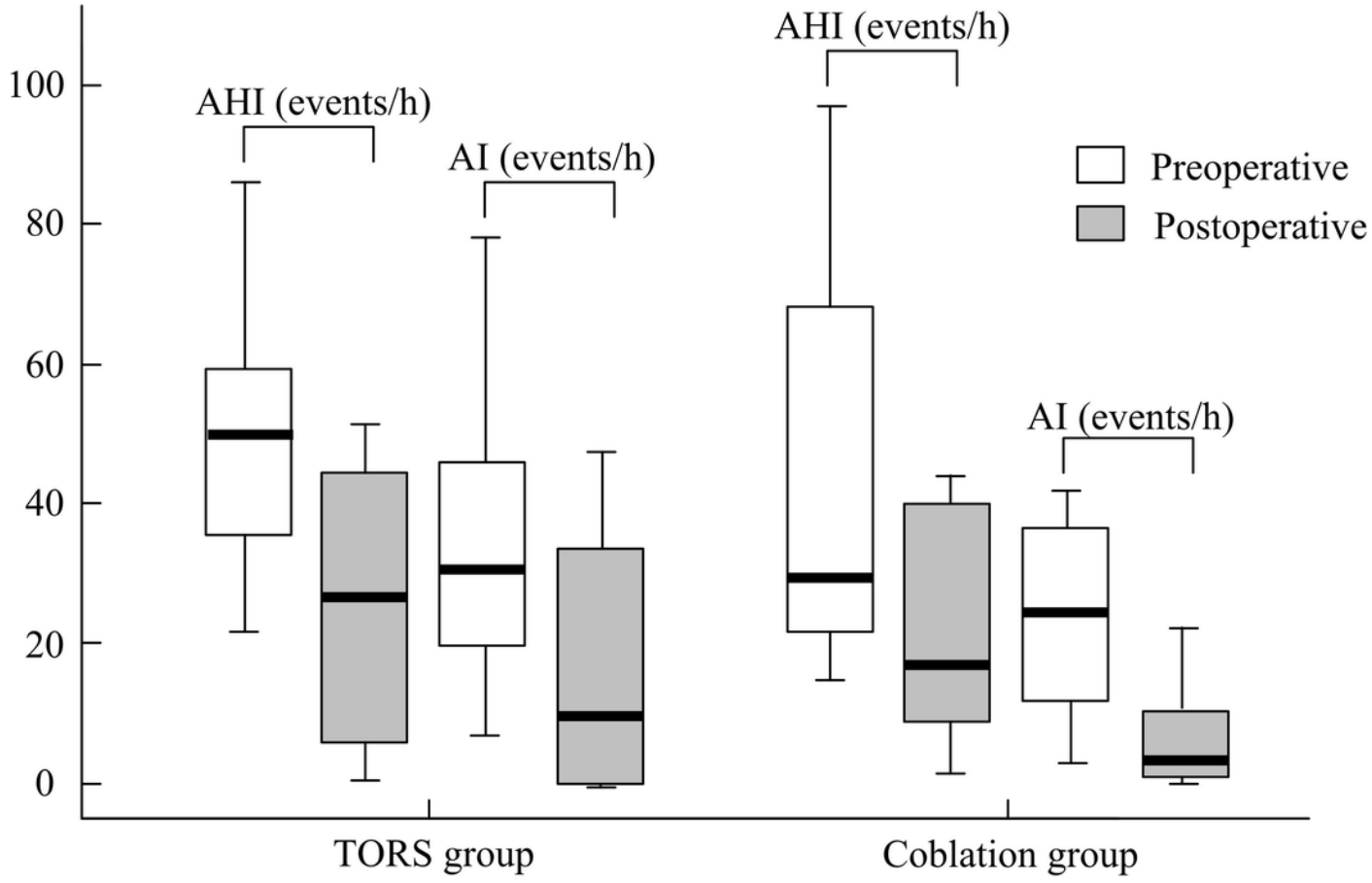

Figure 4

The treatment outcome of min-SpO2 and CT 90 between two groups