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Multi-level surgery for obstructive sleep apnea. Lingual tonsillectomy vs. hyoid suspension in combination with radiofrequency of the tongue base

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Abstract
Purpose The aim of this study was to compare results in patients with obstructive sleep apnea (OSA) undergoing multi-level surgery with two different surgical approaches to treat tongue base obstruction.
Study design This is a prospective, controlled clinical trial at a tertiary referral center.
Methods Altogether, 108 patients were separated into two groups according to the findings during drug-induced sleep endoscopy. Patients with enlarged lingual tonsils (N=58; group A) underwent a lingual tonsillectomy (LT). Patients with small or absent lingual tonsils (N=50; group B) underwent a hyoid suspension type 2 (HS) in combination with a radiofrequency treatment of the base of the tongue (RFT TB). In addition, all patients underwent an uvulopalatopharyngoplasty with tonsillectomy.
Results At baseline, there were no significant differences between the groups. In group A, the mean apnea hypopnea index (AHI) decreased by 49.7 %, and in group B by 48.3 %. Patients with simultaneous tonsillectomies showed significant better results as compared to patients after prior tonsillectomies (success rate 76.6 vs. 27.3 %). By comparing subgroups (with and without simultaneous tonsillectomy), patients in group A showed better results in terms of AHI reduction than patients in group B, indicating that LT may be superior to HS+RFT TB in treating OSA within our multi-level surgery concept.
Conclusion Simultaneous tonsillectomy has a significant impact on objective results of multi-level surgery (MLS). Study results should be adjusted for this parameter. Having done this, MLS with LT seems to produce superior results as compared to HS+RFT TB. Nevertheless, our approach to treat patients differently according to their tongue base tonsil size did not substantially improve our surgical outcome as compared to a previous study.

Keywords Sleep apnea · OSA · Surgery · Multi-level surgery

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Introduction

Depending on the definition used, obstructive sleep apnea (OSA) affects up to 13.7 % of the adult population in western countries [1]. About 2 % of the adult female and 4 % of the adult male population are regarded as being in need for treatment [2]. OSA is affected with hypertension, cerebrovascular stroke, heart attack, metabolic syndrome, and other severe health impairments [3–7].

Standard treatment for moderate to severe OSA is ventilation treatment during sleep using continuous positive airway pressure (CPAP) or any of its modifications [8]. Although CPAP is very effective, compliance and treatment adherence remain a problem in at least one third of the patients [9].

In cases of non-compliance to CPAP, surgical treatment can be offered to those patients that are healthy enough to undergo an operation under general anesthesia and show suitable pathoanatomical findings that can be corrected by surgical techniques [10]. Combinations of different surgical techniques allow treatment of multiple obstruction sites within a single operation. According to the levels of obstruction first described by Fujita [11], the combination of at least one technique addressing the soft palate level with at least one

technique addressing the tongue base/hypopharynx level is called multi-level surgery (MLS) [12].

Various combinations of surgical techniques have been published so far [10, 13, 14]. At the soft palate level, most authors use an uvulopalatopharyngoplasty (UPPP) or one of its modern modifications. A tonsillectomy, if tonsils are still in place, seems to increase surgical success substantially [14]. At the tongue base level, various techniques exist. So far, the literature does not favor certain surgical procedures.

The present study was conducted to compare two different approaches to the tongue base level within a MLS concept in regard to effectiveness and complication rates.

Material and methods

Patients with OSA (apnea hypopnea index≥15) and combined palatal and retrolingual obstruction were recruited for the study. Informed consent was conducted prior to enrollment and an ethic approval was achieved from the local ethic committee.

Preoperative work-up consisted in a fully attended in-lab polysomnography (PSG) according to American Academy of Sleep Medicine (AASM) standard [15]. Evaluation was done as recommended by the AASM [16]. To evaluate daytime sleepiness, the Epworth Sleepiness Scale (ESS) was used [17]. The upper airway was evaluated during the awake and during drug-induced sleep endoscopy with midazolam (DISE) as described by the Amsterdam working group [18]. Only those patients with combined oropharyngeal and retrolingual sites of obstruction were included.

Palatal surgery consisted in a conventional uvulopalatopharyngoplasty (UPPP) [19] in combination with a tonsillectomy, if tonsils were still in place. Tongue base surgery was selected depending on the findings during DISE. If lingual tonsils were enlarged (Fig. 1), surgery consisted in a lingual tonsillectomy (LT) using the CO_2 laser (continuous mode, 7.5 W) (group A). If lingual tonsils were small or absent, a combination of hyoid suspension type 2 using Hörmann's technique [20] and radiofrequency treatment (RFT) of the base of the tongue was performed (group B). For RFT, we used the Celon device (Olympus, Germany, Hamburg) with 6 W and applied 16–20 lesions as reported previously [21]. All surgeries were performed within one step under general anesthesia.

Postoperative follow-up was at least 8 weeks. Patients again underwent a fully attended PSG as described above and filled in the ESS and a questionnaire asking for complications and adverse events. For determination of surgical success, Sher's criteria were used (reduction of apnea hypopnea index (AHI)>50 % and below 20) [22].

Polysomnographic parameters before and after multi-level surgery were compared in both study groups and subgroups using paired *t* test, except the variable AHI which has been log-transformed. *p* values <0.005 were regarded as statistically significant. All statistic analysis was performed using SAS9.3 (SAS Institute Inc., Cary, NC, USA).

Results

In between January 2012 and December 2014, altogether, 108 patients (97 male, 11 female) finished the protocol. At the time of surgery, patients were 49.1±10.2 years old, and their BMI was 29.0±4.9 kg m^{-2}. For the entire study population, the follow-up period was 3.1±1.4 months. AHI was significantly reduced by 48.4 % from 34.1±16.9 at baseline to 17.6±15.3 after surgery ($p<0.001$), the success rate was given with 55.6 %, and the ESS score fell as well significantly from 11.0±4.3 to 6.9±4.0 ($p<0.001$). BMI remained unchanged (29.0±4.9 vs. 28.9±4.5 kg m^{-2}; $p=0.390$).

In both study groups, there were patients who underwent tonsillectomy prior to our study. At baseline, there were no significant differences (Table 1) with patients still having their tonsils showing a slightly higher AHI and BMI before surgery.

After surgery, patients who underwent a simultaneous tonsillectomy performed much better than patients with prior tonsillectomies (Table 1). Reduction in AHI was 61.6 %, and the surgical success rate was 76.6 % in patients with simultaneous tonsillectomy, but only 27.2 and 27.3 % respectively in

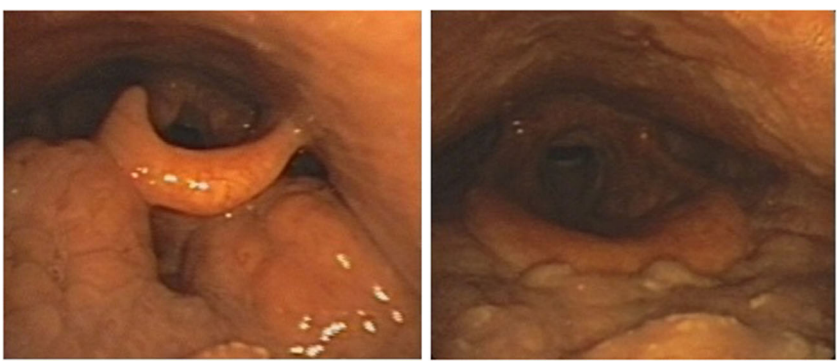

Fig. 1 Endoscopic view on the base of the tongue. *Left side*: enlarged lingual tonsils; *right side*: small lingual tonsils

Table 1 Polysomnographic and clinical outcome

	With TE	Without TE	*p* value
N	64	44	
Age	47.0±10	52.2±9.8	0.009
BMI	29.4±4.8	28.9±4.9	0.66
Female/male	7/57	4/40	
AHI pre	35.4±15.5	32.3±18.7	0.15
AHI post	13.6±12.6	23.5±17.0	0.002
Success (%)	76.6	27.3	
ESS pre	10.8±4.2	11.5±4.5	0.41
ESS post	5.9±3.3	8.4±4.5	0.001

p value refers to the comparison of subgroups of patients with and without simultaneous tonsillectomy

TE tonsillectomy, *BMI* body mass index, *AHI* apnea hypopnea index, *ESS* Epworth Sleepiness Scale

patients without tonsils. Postoperative AHI values were significantly lower in patients with simultaneous tonsillectomies. Daytime sleepiness improved significantly in both subgroups of patients ($p<0.001$) with postoperative values being significantly lower in the patients with concomitant tonsillectomies.

In total, 58 patients were assigned to study group A as they had enlarged lingual tonsils; another 50 patients were assigned to group B. The follow-up periods were 3.3±1.6 months (group A) and 3.1±1.4 months (group B), respectively. Table 2 shows the baseline data for the two different study groups. There were no statistically significant differences between our two study groups.

In group A, the AHI fell by 49.7 % and in group B by 48.3 %, respectively. The difference between the two groups was not statistically significant. In both study groups, the subjective benefit concerning daytime fatigue was comparable and statistically significant ($p<0.001$) (Table 2).

Table 2 Polysomnographic and clinical outcome

	Group A (LT)	Group B (HS+RFT TB)	*p* value
N	58	50	
Age	48.3±11.0	50.0±9.2	0.38
BMI	29.7±5.5	28.9±3.7	0.34
Female/male	7/51	4/46	0.7
AHI pre	34.5±19.4	32.9±14.0	0.7
AHI post	17.4±16.8	17.0±13.5	0.34
Success (%)	58.6	54.0	
ESS pre	10.4±4.0	11.8±4.5	0.079
ESS post	6.3±3.5	7.6±4.4	0.095

p value refers to the comparison of study groups A and B

LT lingual tonsillectomy, *HS* hyoid suspension type 2, *RFT TB* radiofrequency treatment of the base of the tongue, *BMI* body mass index, *AHI* apnea hypopnea index, *ESS* Epworth Sleepiness Scale

Looking on the two primary study groups, the same huge effect of simultaneous tonsillectomy was noticed in both groups. However, the rate of prior tonsillectomies was different, with 44.8 % in group A and only 36.0 % in group B. We therefore built subgroups of patients with and without prior tonsillectomies. The success rates in group A were 84.4 % with and only 30.8 % without concomitant tonsillectomy. Figures in group B (71.9 vs. 22.2 %) were significantly lower as compared to group A (Table 3). By analyzing these subgroups, LT (group A) turned out to be superior to hyoid suspension type 2 + radiofrequency treatment (HS+RFT) of the tongue base (group B) in regard to our primary study variable (reduction of AHI).

As complications, post-tonsillectomy bleedings were observed in five cases, two in group A and three in group B. Four cases required revision surgery for blood control. One case of hyoid suspension twice needed revision surgery due to a huge hematoma. Apart from postoperative pain, no other complications or adverse events were observed.

Discussion

There are various papers about multi-level surgery for OSA with success rates between 0 and 100 % [23, 24]. Unfortunately, they are difficult to match as there are substantial differences concerning the surgical techniques used, the baseline AHI, the baseline BMI, and the follow-up period. This inconsistency does not allow to detect the best combination of surgical techniques to treat OSA.

For palatal surgery, we choose conventional UPPP. We selected the surgical technique described by Wolfgang Pirsig [19] because it saves palatal muscles and mucosa as much as possible. The authors think this conservative technique might help to reduce postoperative complications and discomfort. Another reason for selecting Pirsig's technique was the given possibility to compare our present results with those of a previous series (see below) [25].

Table 3 Polysomnographic and clinical outcome

	Group A (LT)		Group B (HS+RFT TB)	
	With TE	Without TE	With TE	Without TE
N	32	26	32	18
AHI pre	37.2±17.8	30.9±21.1	33.3±13.0	34.3±14.9
AHI post	12.8±12.5	23.1±19.7	14.3±12.9	24.2±12.8
Success (%)	84.4	30.8	71.9	22.2
ESS pre	10.2±4.0	10.6±4.1	11.3±4.3	12.7±4.8
ESS post	5.3±3.1	7.5±3.6	6.4±3.3	9.7±5.3

LT lingual tonsillectomy, *HS* hyoid suspension type 2, *RFT TB* radiofrequency treatment of the base of the tongue, *AHI* apnea hypopnea index, *ESS* Epworth Sleepiness Scale

Today, various modifications of UPPP exist that extend surgery to the lateral pharyngeal walls and/or other palatal muscles. Some of these modifications showed superior results in terms of AHI reduction as compared to conventional UPPP. Maybe, these newer techniques will help to improve surgical success rates of multi-level surgery in the future.

In this study, our multi-level surgery protocol proved to be effective in treating OSA. For the entire group of 108 patients, the AHI has been reduced by 48.3 % with a surgical success rate using Sher's criteria of 55.6 %. Subjective data were promising as well with a highly statistically significant reduction in daytime sleepiness as measured with the ESS.

In an earlier paper, we performed a fixed combination of surgical techniques (uvulopalatal flap, tonsillectomy, hyoid suspension type 2, and radiofrequency treatment of the base of the tongue) in a group of 45 patients independently from the clinical findings at the base of the tongue [25]. In other words, we performed the hyoid suspension in patients with and without enlarged lingual tonsils. Apart from that, the surgical concept does not differ from the present study. Our new approach abandoned the fixed combination of surgeries in favor of a two-tailed concept depending on the clinical finding at the base of the tongue.

As in both studies, the surgeries have been performed under supervision by the same surgeon (TV) with all preoperative values being in the same range; we think that the data are well comparable.

The reduction of AHI in our previous study was 46.8 % (AHI pre 38.9 vs. post 20.7) with a success rate of 51.1 % and a follow-up period of 4.3 months after surgery. As in this study, simultaneous tonsillectomies showed a significant impact on surgical outcome in our previous series of patients. In the previous study, 37.8 % of patients had lost their tonsils prior to the study enrollment. In the present study, the rate of prior tonsillectomies is slightly higher at 40.7 %.

The new concept improved the surgical success rate by 4.4 % and the reduction of AHI by 1.5 %, although a lower rate of concomitant tonsillectomies. In conclusion, the authors think that the detection of enlarged lingual tonsils by performing a DISE may improve the surgical success of multi-level surgery for OSA.

One very interesting aspect of our study was to look at the effect of a concomitant tonsillectomy. We always performed tonsillectomies if the tonsils were still in place. Results (Table 1) show a huge impact of simultaneous tonsillectomy on outcome data. In other words, a simultaneously performed tonsillectomy seems to have much more influence on postoperative outcome than the primarily intended question, namely which is the best surgical tongue base procedure. Isolated tonsillectomies have been described to be very effective with success rates about 90 % in treating OSA [26, 27], with the effect being correlated to the size of the tonsils [28]. In addition, tonsillectomies seem to double the surgical success rates of UPPP surgeries [14].

The two groups of patients in this study were comparable concerning sex, age, BMI, and baseline AHI as there were no statistically significant differences of these values between the groups (Table 2). Nevertheless, we were not able to detect a significant advantage of one of the two combinations of surgical techniques. Looking cursorily on this result, we would need to state that both strategies (LT vs. HS+RFT TB) seem to lead to comparable results. However, by analyzing subgroups (group A with and without tonsillectomy; group B with and without tonsillectomy), we were able to show superior results in group A as compared to group B (Table 3). In other words, lingual tonsillectomy turned out to be more effective in treating OSA than hyoid suspension type 2 in combination with radiofrequency treatment of the base of the tongue. As the percentage of patients with prior tonsillectomies was higher in our study group A (44.8 vs. 36 %), the difference was not detected by only looking at the mean data of the entire study groups. Obviously, prior tonsillectomies need to be taken into account for any analysis of study data of sleep apnea surgery.

Table 4 Multi-level surgery papers with hyoid suspension as tongue base procedure

Authors	Sample size	Procedures of the soft palate	Procedures of the tongue base	Follow-up (months)	AHI pre	AHI post	Success (Sher)	ESS pre	ESS post	EBM
Neruntarat C. 2003	32	Flap	HS	8.1	44.5	15.2	78.0	14.1	8.2	4
Verse T et al. 2004	45	Flap	RFT, HS	4.7	38.3	20.6	51.1	10.4	7.1	4
Bowden MT et al. 2005	29	UPPP	HS	12.0	36.5	37.6	17.2	13.8	10.9	4
Baisch A et al. 2006	67	Flap	RFT, HS	1.0	38.3	18.9	59.7	9.7	6.6	3b
Verse T et al. 2006	45	Flap	RFT, HS	4.3	38.9	20.7	51.1	9.4	7.2	3b
Benazzo M et al. 2008	109	UPPP	HS	6	37.0	18.7	61.5	10.5	7.2	4
van Maanen JP et al. 2012	94	UPPP/ZPP	HS	No data	38.4	26.5	No data	No data	No data	4
All	421			1–12	38.40	21.93	55.95	10.82	7.49	C

Flap uvulopalatal flap, *UPPP* uvulopalatopharyngoplasty, *ZPP* Z-palatoplasty, *HS* hyoid suspension, *RFT* radiofrequency treatment, *ESS* Epworth Sleepiness Scale

We were not able to find other papers that included a lingual tonsillectomy in their multi-level surgery protocols. Therefore, we are not able to match our data with those of other working groups.

Concerning the hyoid suspension, our previous approach in 2006 [23] was very similar to the group B treatment in the present study. As expected, the current data do not differ substantially from the previous series. The current data are a little bit superior by trend (AHI reduction 46.8 vs. 48.3 %; success rate 51.1 vs. 55.6 %; prior tonsillectomies 37.8 vs. 36 %). Maybe, this difference can be explained by increasing surgical experience over time, as the surgery itself has not been changed during this time period.

Fortunately, there is more information about hyoid suspension as part of multi-level surgery for OSA in the literature. Table 4 summarizes the data we detected. Altogether, data of 421 patients taken from seven studies were included in the analysis [23, 29–34]. The mean AHI decreased by 42.9 % from 38.4 before surgery to 21.9 after surgery. The mean success rate using Sher's criteria was 56 %. The follow-up intervals varied from 1 to 12 months. Compared to our current series, we can state that our data (reduction of AHI 48.3 %; success rate 55.6 %) are very close to the mean values of what has been published so far in the literature. This makes the authors think that our surgical technique still seems to be appropriate.

The complication rate of our multi-level surgery concept is comparable to that in other reports [35]. Apart from post-tonsillectomy bleedings, the only significant complication observed was a huge hematoma that required revision surgery. This complication has already been described previously [36]. We monitor our patients for the first 4 h after surgery in the recovery room. Airway compromise or severe desaturation as described elsewhere [37] was not observed in our series.

Conclusion

Finally, we would like to conclude that a simultaneously performed tonsillectomy has a huge impact on surgical success rates. In this series, the effect of a concomitant tonsillectomy exceeded the effect of the choice of the tongue base treatment.

Cleaned for the tonsillectomy parameter, our data show a mild superiority of LT as compared to HS plus RFT of the tongue base within our multi-level surgery concept. We therefore think a proper preoperative evaluation of the size of lingual tonsils may increase the surgical outcome.

Conflict of interest The authors declare that they have no competing interests.

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Comment

Study results have been presented in part at the 85th annual congress of the German ENT society held in Dortmund, Germany, in May 2014.