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MISCELLANEOUS

Bipolar radiofrequency induced thermotherapy of the tongue base: its complications, acceptance and effectiveness under local anesthesia

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Abstract We assessed adverse events and complications of bipolar radiofrequency induced thermotherapy of the tongue base (RFTB) in patients with socially unacceptable snoring (SUS) or obstructive sleep apnea syndrome (OSAS) and determine its acceptance and effectiveness when conducted under local anesthesia. This investigation consisted of (1) a prospective, open-enrolment study of 24 consecutive patients with snoring and OSAS at the tongue base level only (Fujita III), assessed by sleep endoscopy. Polysomnography, questionnaires, and visual analog scales (VAS) were used to assess outcome. (2) In addition, a retrospective review of 83 patients, who underwent RFTB (in 59 cases as part of a multilevel treatment), was performed to evaluate adverse events and complications. Twenty-two of the 24 patients completed postoperative questionnaires and VAS, and ten patients had postoperative polysomnography. Reduction in snoring ($P = 0.0003$), hypersomnolence ($P = 0.002$), and globus ($P = 0.031$) was significant. A positive trend in AHI ($P = 0.001$, $n = 3$) is shown in patients with moderate to severe OSAS. Concerning postoperative adverse events and complications, only two patients had a mild and transient tongue deviation directly after the procedure, which resolved within an hour postoperatively (adverse event rate 1.8%). No postoperative complications such as infections, abscesses, hematomas, or ulcerations of the tongue base occurred. This study demonstrates that bipolar RFTB in patients with obstruction at the tongue base only (Fujita type III) as visualized by sleep endoscopy is a safe and simple procedure under local anesthesia and can be effective in patients with SUS. No complications during this study were observed. Its effect on OSAS has been shown by other authors, although long-term effects are not stable. The RFTB can be considered as first choice treatment in case of snoring and mild OSAS in Fujita type III obstruction. In the case of moderate to severe sleep apnea, RFTB can be considered as an additional treatment.

Keywords Bipolar radiofrequency · Thermotherapy · Obstructive sleep apnea · Snoring · Tongue base

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Introduction

Several surgical techniques such as uvulopalatopharyngoplasty (UPPP) and radiofrequency induced thermotherapy (RFITT) of the soft palate have been widely used for the treatment of velopharyngeal obstruction in obstructive sleep apnea (OSAS) [1, 2]. Available tongue base procedures that alleviate obstruction of the lower pharynx include mandibular osteotomy with genioglossus advancement (GA), maxillomandibular advancement (MMA) [3], partial midline tongue resection, and hyoidthyroidpexia (HTP or hyoid suspension) [4, 5]. These invasive approaches, especially MMA, can be very effective in treating severe OSAS.

However, these techniques require general anesthesia, longer hospitalization, and appear to result in a higher postoperative morbidity and remain held in reserve for severe OSAS only. For mild to moderate OSAS, these procedures are too extensive and there is a need for less invasive procedures in case of mild pathology.

Tissue volume reduction of the tongue base with RFITT was first introduced as a minimally invasive technique of SDB in 1999 by Powell et al. [6]. Several studies showed improvement in objective and subjective OSAS features [6–15]. The therapeutic effect of submucous coagulation is thought to imply volume shrinkage, but two MRI studies show different outcomes. Powell et al. [6] found a mean reduction in tongue volume of 17%, with a maximum of 29%. Stuck et al. [16] could not verify a reduction in tongue volume or an increase in retrolingual space. Benefits of RFITT seem to be more a result of stabilization of treated tissue by the scarring process. Another advantage is its application in a daycare setting under local anesthesia, with or without sedation. The method has shown to be safe and simple. Nevertheless, with the monopolar technique patients still require multiple treatment sessions. Bipolar thermo-technology, as compared to monopolar technology seems to reduce morbidity, such as secondary thermal damage, because less energy needs to be applied and treatment duration is reduced to several seconds per lesion. In this study, we analyze our clinical experiences with the bipolar RFITT technique (Celon®) in a daycare setting under local anesthesia and evaluate our adverse events and complication rate.

Patients and methods

This is a prospective, nonrandomized study, involving a consecutive series of patients with snoring and mild, moderate, and severe OSAS with RFTB in an outpatient clinic.

Patients

Eligible patients had at least narrowing or obstruction at tongue base level, observed by sleep endoscopy with midazolam. All patients had full polysomnography preoperatively; only patients having an AHI index > 15 or severe complaints of hypersomnolence had a postoperative polysomnography. The RFTB as solitary treatment was performed in patients with obstruction at the tongue base only (Fujita type III); other sites of obstruction had been ruled out. Some patients had previous unsuccessful pharyngeal surgery for OSAS (Table 1). The RFTB was combined with other surgical treatment(s), in case of retropalatal obstruction (large tonsils and long edematous uvula) and severe multilevel obstruction as visualized during sleep endoscopy. In the latter group only adverse events and complications were analyzed.

Methods

Polysomnography

The OSAS was discriminated from socially unacceptable snoring (SUS) during one night of standard polysomnography testing. The characteristics of the patient population studied are shown in Table 2. For sleep registration patients stayed one night in the hospital. A CNS-Sleep I/T-8 recorder was used, which records the sleep architecture (derived from electroencephalogram, eye movements, and submental electromyogram), respiration (thoracic and abdominal measurement), oxygen saturation, movements of limbs, and the intensity of the snoring. An *apnea* is defined as a cessation of oronasal airflow during minimally 10 s and a *hypopnea* as a 50% reduction in oronasal airflow accompanied by a decrease of > 4% in ongoing paO_2 [17]. The apnea–hypopnea index (AHI) is the mean number of apneas and hypopneas per hour of sleep, and signifies the severity of OSAS. Recommended diagnostic criteria for OSA include an AHI of 5 or more and evidence of disturbed or unrefreshing sleep, daytime sleepiness, or other daytime symptoms. Suggested AHI cut points are 5, 15, and 30 events/h and, respectively, indicate mild, moderate, and severe levels of OSAS [17].

Epworth Sleepiness Scale

A baseline and postoperative (> 6 weeks) Epworth Sleepiness Scale (ESS) score was evaluated. The ESS reflects the likelihood of dozing in specific circumstances in addition to daytime sleepiness. Healthy subjects score an average of 7. To indicate disturbed or unrefreshing sleep we use a cut point of ESS > 7.

Visual analog scales

Traditional 10-cm VAS with anchors such as “no problems” and “unbearable or severe problems” was used

Table 1 Previous pharyngeal surgery

Surgical procedure	Frequency
UPPP	Seven patients
RFITT soft palate	One patient (3×)
Hyoidthyroidpexia	One patient

Table 2 Baseline characteristics and treatment outcomes

	Snoring ($n = 9$)	Mild OSAS ($n = 8$)	Moderate OSAS ($n = 4$)	Severe OSAS ($n = 1$)	Total ($n = 22$)	*P* value
No. of treatments	8 pt 1× 1 pt 2×	1 pt 1× 6 pt 2× 1 pt 3×	2 pt 1× 2 pt 2×	1 pt 4×	11 pt 1× 9 pt 2× 1 pt 3× 1 pt 4×	
Age	45.4 ± 9.7	48.4 ± 7.0	45.5 ± 9.0	56	47.4 ± 9.4	
BMI (kg/m^2)	26.5 ± 3.8	25.4 ± 7.3	25.1 ± 2.7	25.7	26.7 ± 2.8	
Sex (% male)	66%	100%	87.5%	100%	82%	
AHI pre	2.5 ± 1.8	9.7 ± 4.1	17.6 ± 1.9	34	9.3 ± 8.4	
AHI post	9 ($n = 1$)	9.8 ± 7.5 ($n = 6$)	9.7 ± 7.1 ($n = 2$)	18.5	11.0 ± 8.3 ($n = 10$)	
AHI improvement	−5.9 ($n = 1$)	−0.4 ± 3.7 ($n = 6$)	8.9 ± 5.4 ($n = 2$)	15.5	1.6 ± 5.9 ($n = 10$)	1.000
Follow-up (days)					117.8 ± 61.6	
ESS pretreatment	6.6 ± 6.8	5.2 ± 3.7	5.3 ± 4.4	4	5.7 ± 5.0	
ESS posttreatment	2.4 ± 3.4	4.4 ± 3.6	4.8 ± 2.6	3	3.6 ± 3.3	
ESS improvement	4.2 ± 6.3	0.8 ± 2.5	0.5 ± 2.5	1	2.1 ± 4.6	0.065
Follow-up (days)					360 ± 132	

AHI apnea hypopnea index per hour, *ESS* Epworth sleepiness scale, *BMI* body mass index (kg/m^2)

*Significant ($P < 0.05$)

to assess each patient's complaints and evaluations of study variables including the following: snoring, hypersomnolence, pain, globus (foreign body sensation), and swallowing.

Radiofrequency induced thermotherapy procedure

A radiofrequency generator (Celonlab ENT power control unit) was used for delivery of bipolar radiofrequency energy. The surface of the tongue was disinfected with 0.5% chlorhexadine and subsequently sprayed with 10% xylocaine. Ten milliliters of lidocaine HCl 1.5% and epinephrine 1:200,000 were used as local anesthetic. If required, intravenously applied midazolam (mean 6.5 mg) was used for sedation under pulse oximetry monitoring. Six application sites for the first treatment were selected (Fig. 1a, b) and energy was delivered with a disposable probe through the dorsal surface of the tongue (Fig. 2).

Patients who underwent the procedure under local anesthesia in daycare were observed for at least 3 h postoperatively. Preoperatively patients received 2,500 mg amoxicillin with clavulanate potassium, continued for a week postoperatively. Follow-up visits with clinical examinations were scheduled at 7 days and 6–8 weeks after surgery. If required, a second treatment session was performed minimally 6 weeks after the primary session. Polysomnography testing was performed minimally 6 weeks after the final treatment in case of a pretreatment AHI $> 15\ h^{-1}$ or when desirable. Termination of the treatment or scheduling of an additional treatment

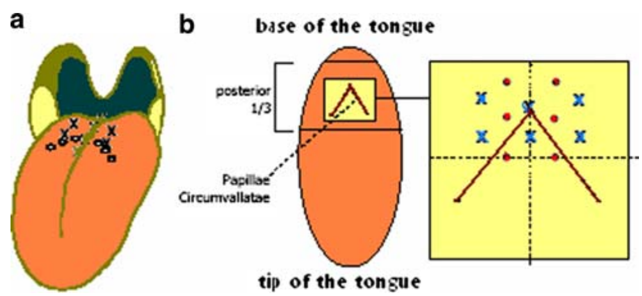

Fig. 1 **a** RFITT of the tongue base. *Open circle*: papillae circumvallatae. *X*: 1st treatment sites. **b** Treatment area at the tongue base has an extension of 3 cm × 3 cm and circumscribes the circumvallatae papilla. The coagulations are placed at a distance of 1.5–2 cm of each other. *X*: 1st treatment sites, *filled circle*: 2nd treatment sites

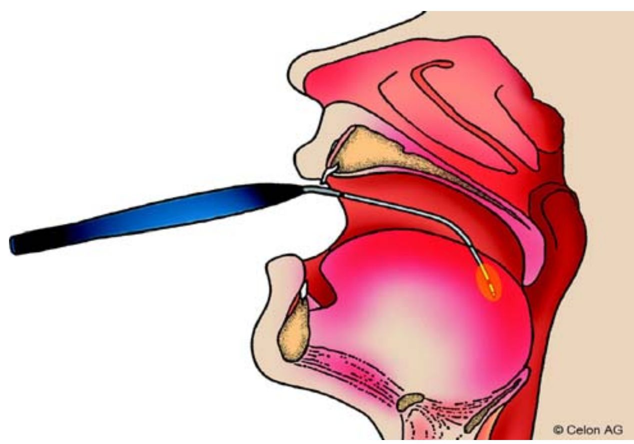

Fig. 2 Introduction of the probe through the dorsal surface of the tongue base

depended on the results of the control polysomnography testing and subjective improvement of snoring or hypersomnolence.

Statistics

Differences between pre- and posttreatment variables were tested with the Sign-Rank test. Success is defined as an AHI decrease of at least 50% or a drop below the threshold of 20, or apnea index (AI) decrease below 10. With SUS, success is accomplished when the bed partner feels satisfied and no supplementary treatment is necessary because snoring and hypersomnolence levels have decreased sufficiently. Incidents, not intrinsic to the surgical procedure, which may have a negative effect on the surgical outcome or postoperative morbidity can be classified into four grades of severity: Grade I: adverse event that resolves if left untreated or requires a simple bedside procedure. Grade II: minor complication that usually requires an additional intervention that involves a risk of its own, but is eventually resolved. Grade III: a major complication that is associated with a residual or a lasting disability. Grade IV: any complication that results in death [18].

Results

Baseline evaluation

Between June 2003 and December 2004, 83 patients, 11 women and 72 men, underwent RFTB. RFTB as solitary treatment under local anesthesia was carried out in 24 patients and in 59 patients combined with or after other surgical treatment(s) under general anesthesia, as solitary treatment (13 pt), RFITT of the soft palate (8 pt), nasal surgery (8 pt), UPPP (15 pt), HTP (5 pt), or HTP combined with UPPP (7 pt) or genioglossus advancement (3 pt). The RFTB as solitary treatment was performed 36 times and RFTB as part of multilevel treatment group 65 times (totally 111 sessions). Two patients were lost to follow-up before completion of the study, because they did not fill in the questionnaires and turned out to be untraceable.

RFTB treatments

The mean number of RFTB treatment sessions per patient was 1.5 (range 1–3). The total amount of energy delivered per treatment session was 504 J (7 W in 12 s = 84 J per lesion; diameter of lesion size 4.9 mm) in less than 2 min.

Therapeutic outcomes in patients with solitary RFTB ($n = 22$)

Preoperatively increased daytime sleepiness (ESS greater than 7) was present in six patients (12.5 ± 3.6). In four of these patients ESS values decreased below 7 (4.25 ± 3), one patient showed an increment from 9 to 12 and one patient did not show any change (ESS remained 10). Sixteen patients showed an ESS < 7 (mean ESS preoperatively 3.2 ± 2.5 and postoperatively 2.5 ± 2.1). There was no significant improvement in ESS values for the entire group ($P = 0.065$) although a trend in improvement was seen in patients with severe daytime sleepiness. The BMI values remained similar pre- and postoperatively (26.8 ± 2.8). Baseline variables and treatment outcomes are summarized in Table 2.

Subjective complaints of snoring, hypersomnolence, and globus, calculated by VAS, significantly improved ($P = 0.0003$, $P = 0.065$, and $P = 0.03$, respectively) after RFTB. No deterioration in swallowing or speech was observed. The VAS for pain was 5.7 ± 3 one day postoperatively, and pain sensations diminished after 3 ± 1.6 days with administration of diclophenac. The VAS results are shown in Table 3. Nine of 22 patients (41%) were considered successfully treated by means of sufficient reduction in snoring levels objectified by the bed partner and subjective complaints of hypersomnolence. Six patients needed only one treatment, while three others were “cured” after a second session. Six patients did not show improvement after two treatment sessions and thus three patients underwent UPPP (and tonsillectomy) and RFITT of the soft palate. AHI parameters, VAS snoring, and VAS hypersomnolence remained unchanged. Five patients refused further treatment after one session. Several reasons were mentioned like “unpleasant intervention” and “distance to the hospital too far”. The patient with severe OSAS (AHI 34) showed already a reduction in AHI of 7.1 (AHI 26.9) after one session but experienced a slight increase in VAS snoring (5–7). He subsequently underwent three following RFTB treatment sessions and the third polysomnography showed a further decline of the AHI to 18.5; a total reduction in AHI of 15.5 after four treatment sessions.

Changes in AHI were not significant, although the Jonckheere–Terpstra test showed a significant positive trend ($P = 0.001$) for the moderate and severe OSAS group, only 3 (33%) of the 10 patients who had a postoperative polysomnography, showed a reduction in AHI > 50% and could be considered as surgically successful. Two patients showed an increase in AHI (3–9 and 15–21), but showed a decrease in hypersomnolence and

Table 3 Results of visual analog scales for functional parameters

	Pretreatment	Posttreatment	Improvement	*P* value
Snoring	7.3 ± 2.7	4.7 ± 2.8	2.6 ± 2.9	0.0003*
Hypersomnolence	4.7 ± 4.0	2.6 ± 2.9	2.1 ± 3.0	0.002*
Globus	3.1 ± 3.8	1.6 ± 2.7	1.5 ± 2.8	0.031*
Swallowing	1.7 ± 3.0	1.2 ± 2.4	0.5 ± 1.6	0.250
Satisfaction	3.3 ± 2.5	5.8 ± 3.6	− 2.5 ± 2.7	0.0002*
Follow-up (days)		360 ± 132		

Numbers are calculated for the whole group

*Significant ($P < 0.05$)

VAS snoring (respectively, ESS from 17 to 0 and 5 to 3, together with a VAS from 7.7 to 3 and VAS from 9 to 2). One patient showed deterioration of AHI values after two treatments (14.3–17.4) together with an increase in hypersomnolence (ESS from 9 to 12). He had already undergone UPPP and could not tolerate an oral device. Existence of light retrognathia in this case might have played a negative role. Changes of AHI of < 20% were considered as within the ordinary night to night variability in this report.

Adverse events and complications

No postoperative complications such as infections, abscesses, hematomas, or ulcerations of the tongue base occurred. Two patients had a mild and transient tongue deviation directly after the procedure, which resolved within an hour postoperatively (adverse event rate 2/111 = 1.8%). Only one serious complication after multilevel surgery and RFTB was seen. This patient developed speech problems postoperatively due to a right-sided paresis of the hypoglossal nerve, which was likely due to HTP.

Discussion

This is the first paper that describes the experiences with bipolar RFTB under local and general anesthesia. Several studies on monopolar RFTB, with different designs and results, have been performed for the last few years and are reviewed in Table 4. With bipolar application technology both electrodes are integrated in an application handset and thus secondary thermal damage to the patient during monopolar treatment can be avoided, because current flow is restricted to the point of surgical intervention. A standardized coagulation effect on tongue base tissue is extremely important hence the hypoglossal nerve and neurovascular bundle may be damaged if lesions show up larger. The bipolar system shows to be safe within the treatment schemes we used. The radiofrequency power is adapted to the current condition of the tissue during the coagulation process and overdosing or even carbonization can be avoided since power input is best suited to the desired result of the treatment as a function of each moment in time. We used 504 J per treatment session (six lesions) instead of 1,250–3,680 J as in monopolar treatment.

Effectiveness of RFTB treatment for OSAS and snoring

Powell et al. [6] showed a reduction in AHI from 39.5 to 18.6 with a cure rate of 40% in patients whom prior UPPP had failed. Long-term results (28 months) showed a worsening (not significant) trend of AHI parameters [19]. If follow-up data had been compared with initial AHI values, the long-term effect of RFTB would not have been significant. They state that weight gain and preoperative obesity contributed to the relapse of SDB [19]. Snoring levels increased significantly while ESS values remained stable. Surprisingly, a slight increase in speech problems was found during follow-up although these complaints were not observed directly postoperatively. An extended follow-up study (minimum 1 year) of patients previously studied by Woodson et al. [13] suggests that multilevel RFITT shows significant prolonged improvements in daytime sleepiness, AHI, and psychomotor alertness [20]. Only 29 of the initial 80 patients were studied (36.3%), which means there is a considerable selection bias due to loss to follow-up. Of the analyzed patients, 12 of the 26 patients (46%) initially received RFITT, 9 of the 26 patients (34.6%) crossed over after CPAP, and 8 of the 30 patients (26.7%) crossed over after sham placebo. The CPAP and sham placebo group also received less energy compared to those initially receiving RFITT (3,500 ± 1,800 J vs. 10,400 ± 1,300 J) and no comparison was made with the former sham placebo group. Together with the small sample size this study has too little statistical power to support evidence of significant

Table 4 Review of articles on RFITT of the tongue base

Authors	Study design RFITT	Patients	AHI pre	AHI post	QOL	ESS pre	ESS post	Cured	Det
Kezirian et al. [25]	Prospective, nonrandomized observational	51 (iso)	?	?	?	?	?	?	?
Steward [15]	Retrospective case control series	22 (ml) 11 (CPAP)	30.3 ± 5.0	26.6 ± 16.8 (s*)	FOSQ (s*) SRT (ns)	11.4 ± 4.1	7.0 ± 3.2 (s*)	10/22 (45%) [A] 13/22 (59%) [B]	4
Steward et al. [14]	Prospective, nonrandomized	25 (iso + ml)	21.3 ± 11.1	?	FOSQ (s*) SNORE 25 (s*)	11.9 ± 4.6	10.0 ± 4.1 (ns)	?	?
Woodson et al. [13]	Randomized, placebo-controlled two-site trial	26 RFITT 26 CPAP 28 placebo	21.3 ± 11.1 19.8 ± 9.9 15.4 ± 7.8	Changes −4.5 ± 13.8 (ns) −1.8 ± 11.5	Effect sizes FOSQ (s*) SNORE 25 MRT/FRT SF 36, MCS, PCS (ns)	11.9 ± 4.6 (RFITT) 12.6 ± 5.0 (CPAP) 11.6 ± 3.5 (placebo)	Changes −2.1 ± 3.9 (RFITT) −2.3 ± 5.2 (CPAP) −1.0 ± 3.1 (placebo)	?	?
Riley et al. [12]	Prospective, nonrandomized	20 (iso) ventral and dorsal	35.1 ± 18.1	15.1 ± 17.4 (s*)	?	12.4 ± 2.9	7.3 ± 3.0 (s*)	12/20 (60%) [A] 13/20 (65%) [B]	1
Stuck et al. [24]	Retrospective review, complications 1998–2002	150 (iso) 140 (ml)	20.5 ± 18.5	?	?	?	?	?	?
Fischer et al. [11]	Prospective, nonrandomized	15 (ml) tonsils/ soft palate/ tongue base	32.6 ± 17.4	22.0 ± 15.0	VAS (ns snoring)	11.1 ± 4.7	8.2 ± 4.7 (s*)	5/15 (33.3%) [B]	1
Friedman et al. [10]	Retrospective review	134 (UPPP) 143 (UPPP + iso)	35.4 ± 25 (s*) 43.9 ± 23.7	?	VAS ?	?	?	?	?
Stuck et al. [9]	Prospective, nonrandomized	20 (iso)	32.1 ± 13.7	24.9 ± 16.8 (ns)	VAS (s* snoring)	7.94 ± 5.07	4.9 ± 3.3 (s*)	6/20 (30%) [A]	2
Woodson et al. [8]	Two separate, prospective, matched nonrandomized, open enrollment, multicenter study	69 (iso) 99 (CPAP)	40.5 ± 21.5 (iso)	32.8 ± 22.6 (iso: s*)	SNORE 25 (ns) SF-36 FOSQ (s*)	11.1	7.4 (s*)	11/69 (16%) [B]	13?
Nelson [7]	Prospective, nonrandomized, open-enrollment study	10 (UPPP + iso) 7 (UPPP)	29.5 ± 14.8	18.8 ± 14.6 (ns)	?	?	?	5/10 (50%) [B]	?

Table 4 continued

Authors	Study design RFITT	Patients	AHI pre	AHI post	QOL	ESS pre	ESS post	Cured	Det
Pazos et al. [22]	Retrospective review, complications 1998–2000	25 (iso)	?	?	?	?	?	?	?
Powell et al. [6]	Pilot study, prospective, nonrandomized	18 (iso)	39.5 ± 32.7	17.8 ± 15.6 (s*)	SF-36 (ns)	10.4 ± 5.6	4.1 ± 3.2 (s*)	7/18 (39%) [B]	2

AHI apnea hypopnea index, *[A]* therapeutic success: reduction of AHI > 50%, with a postoperative AHI < 15 h^{-1}, *[B]* therapeutic success: reduction of AHI > 50%, with a postoperative AHI < 20 h^{-1}, *Det* deterioration, *iso* isolated tongue base treatment, *ml* multilevel treatment, *ns* not significant, *s** significant ($P < 0.05$), *FOSQ* functional outcomes of sleep questionnaire, *SRT* slowest reaction time (1/ms), *MRT* median reaction time, *FRT* fastest reaction time, *SF-36* general health survey 36 questions, *SNORE 25* symptoms of nocturnal obstructive relative events, *MCS* mental component summary, *PCS* physical component scales, *VAS* visual analog scales

prolonged improvements after RFITT. Our long-term data (260 ± 132 days) showed a positive trend in decrement of AHI values after RFTB for patients with moderate to severe OSAS, although no significance was found overall. A preoperative ESS score > 7 could be a positive predictor for treating patients, but because of the low number of patients this remains unclear and no correlation was shown with high AHI values. Yet, we consider RFTB a valuable therapy in case of tongue base obstruction. Complete resolution of obstructive events and snoring cannot be expected, but considerable declines in AHI, especially in moderate to severe OSAS, are possible because there is greater room for improvement in more severe OSAS [20].

Forty-one percent of our patients were satisfied after one or two RFTB sessions. Patient's satisfaction seemed largely influenced by thorough preoperative advice and patient's future expectations. Deterioration of SDB may ultimately be caused by gradual maturation and softening of scar tissue, losing its fibrotic and astringent qualities [19].

A discussion point remains whether the amount and positions of application sites should be limited or changed in order to avoid over/under treatment of particular areas of the tongue, in order to pursue optimization of surgical results. Stuck et al. [21] found that the application of 600 J monopolar RFTB (85°C) lead to a maximum lesion diameter (7.7 mm after 24 h) and length (9.7 mm after 24 h) in a human tongue. Also of interest is the application of RFITT at the insertion of the genioglossus with the intention of producing volumetric contractions that counteract the effect of loss of tone during sleep. Riley et al. [12] showed a significant decrease in AHI (from 35.1 to 15.1) with this ventral approach. The attributable effect of this new technique on OSAS remains unclear because of its combination with the dorsal approach. At the same time we have to be aware of the coagulation effect in the vicinity of the ostium of the submandibular duct. Lesion sizes of 1.2 cm^2 (800–900 J) have shown to be safe at the tongue base surface, but treating the ventral surface might put the submandibular duct at risk.

Prediction of treatment outcome in OSAS is difficult due to various influences on the collapsibility of the upper airway. The upper airway should be considered as one dynamic entity, with parts that are more collapsible than others. The philosophy is that upper airway collapsibility should be treated and this is in part achieved by RFITT. Over time its collapsibility might increase again mostly because of the ageing process.

Table 5 Review of articles on RFITT of the tongue base

Authors	Joule per session monopolar 80–85°C	Total sessions	Total lesions	Complications	Grade	AE and Comp per lesion (PL) per session (PS)	AB	Steroids
Kezirian et al. [25]	1,250–1,860	94	214	Two ulceration	1	AE: 0.9% (PL) AE: 2.1% (PS) Comp: 0%	Y	N
Steward [15]	2,250–3,000	93	~ 279	Three ulceration Two hematoma	1 1	AE: 1.8% (PL) AE: 5.4 (PS) Comp: 0%	Y	Y
Steward et al. [14]	1,515–2,348	115	~ 288	Three hematoma One ulceration	1 1	AE: 1.4% (PL) AE: 3.5% (PS) Comp: 0%	Y	Y
Woodson et al. [13]	1,770–2,500	81 Placebo 117 RFITT	219 328	Three hematoma (placebo) Three hematoma (RFITT) One ulceration (unknown soft palate or tongue base)	1 1 1	Placebo AE: 1.4% (PL) AE: 3.7% (PS) Comp: 0% RFITT AE: 1.2% (PL) AE: 3.4% (PS) Comp: 0%	Y	Y
Riley et al. [12]	1,500–2,000	276	92	One temporary neuralgia	1	AE: 0.4% (PL) AE: 1.0% (PS) Comp: 0%	Y	N
Stuck et al. [24]	1,600–4,200	457	~ 2,285	Three ulceration Four recurrent dysphagia One temporary palsy hypoglossal nerve One abscess	1 1 1 2	AE: 0.4% (PL) AE: 1.8% (PS) Comp: 0.04% (PL) Comp: 0.2% (PS)	Y	N
Fischer et al. [11]	3,000	16	48	No tongue base complications		AE: 0% Comp: 0%	Y	Y
Friedman et al. [10]	First 3,000 Other 1,500	284	1,487	One ulceration Two temporary palsy hypoglossal nerve Two abscess One paralysis hypoglossal nerve	1 1 2 3	AE: 0.2% (PL) AE: 1.1% (PS) Comp: 0.2% (PL) Comp: 1.1% (PS)	Y	Y
Stuck et al. [9]	2,800	272	68	Two ulceration Four recurrent dysphagia + edema One abscess	1 1 2	AE: 2.2% (PL) AE: 8.8% (PS) Comp: 0.4% (PL) Comp: 1.5% (PS)	Y	Y when edema observed
Woodson et al. [8]	1,760–3,680	355	1,100	Seven ulceration Three edema One thrush One abscess Several temporary palsy hypoglossal nerve	1 1 1 2 1	AE: > 1.0% (PL) AE: > 3.4% (PS) Comp: 0.1% (PL) Comp: 0.3% (PS)	?	?
Nelson [7]	4,000	28	112	No tongue base complications		AE: 0% Comp: 0%	?	?

Table 5 continued

Authors	Joule per session monopolar 80–85°C	Total sessions	Total lesions	Complications	Grade	AE and Comp per lesion (PL) per session (PS)	AB	Steroids
Pazos et al. [22]	1,500	25	50	Four temporary neuralgia Two edema (airway at risk) Two abscess	1 2 2	AE: 8% (PL) AE: 16% (PS) Comp: 8% (PL) Comp: 16% (PS)	Y	Y
Powell et al. [6]	1,543	5.5	99	One ulceration One recurrent dysphagia One abscess	1 1 2	AE: 1.1% (PL) AE: 2.0% (PS) Comp: 0.6% (PL) Comp: 1.0% (PS)	N	N

AE adverse event (grade I), *Comp* complication (grade II + III + IV), *PL* per lesion, *PS* per session, *AB* antibiotics, *N* no, *Y* yes

Adverse events and complications of RFTB treatment

Extraordinary is the high adverse event (16%) and high complication rate (16%) per session observed by Pazos and Mair [22]. Other authors have shown RFTB to be a safe procedure with reported adverse event rates between 0 and 2.2% (per lesion) and 0 and 8.8% (per session) and complication rates between 0 and 0.6% (per lesion) and 0 and 1.5% (per session) (Table 5). We observed an adverse event rate of only 1.8% and a complication rate of 0%. Stuck et al. [23] reported that since postoperative antibiotic prophylaxis has been used, no tongue base abscesses have occurred after 425 treatments. Postoperative airway compromise due to tissue edema has not been a problem during several years of practice, even without administration of corticosteroids [6, 12, 24, 25]. We came across a similar finding. In the report of Pazos and Mair the high incidence of tongue base abscesses may have been caused by the 5-day burst of postoperative corticosteroids [22]. Only one abscess occurred when no steroids were used [24]. Friedman et al. state that the etiology of abscess formation might be secondary to myotoxicity to bupivacaine use [10, 26]. Personal techniques and used protocols (swabbing, number and location of the lesions, amount of energy) may also influence the complication rate. Although its occurrence is low, development of a tongue base abscess is a potential and dangerous complication. Airway compromise due to postoperative swelling does not seem to occur, but prolonged adequate postoperative monitoring of patients with severe OSAS is advisable.

Study limitations

No control group is used to rule out the placebo effect and more patients are needed to demonstrate a significant subjective improvement of the AHI, in case of moderate or severe OSAS. The rationale for a post-treatment polysomnography in cases of preoperative SUS and light OSAS remains questionable. Variability seems larger in the case of an AHI < 15 and substitute indicators of OSAS may not be associated with improvement in patient-relevant outcomes such as hypersomnolence and snoring. Therefore, repeated investigation and long-term follow-up of patients treated with RFTB is mandatory.

Conclusion

This study demonstrates that bipolar RFTB in patients with obstruction at the tongue base only (Fujita type

III) as visualized by sleep endoscopy is a safe and simple procedure under local anesthesia and can be effective in patients with SUS. No complications during this study were observed. Its effect on OSAS has been shown by other authors, although long-term effects are not stable. The RFTB could be considered as first choice treatment in case of snoring and mild OSAS. In the case of moderate to severe sleep apnea, RFTB could be considered as an additional treatment.

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