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Original Research

Minimally-Invasive Combined Nd:YAG and Er:YAG Laser-Assisted Uvulopalatoplasty for Treatment of Obstructive Sleep Apnea

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Abstract

Objective: In this article, efficacy of minimally-invasive outpatient laser-assisted uvulopalatoplasty (LAUP) procedure (NightLase® LAUP) to reduce apnea–hypopnea index (AHI) in patients with obstructive sleep apnea (OSA) is evaluated.
Background: OSA is a serious condition, but its treatment is often not effective or is poorly accepted by patients. Newer modes of therapy that are more effective and also more accepted by patients need to be developed. The latest treatment approaches involve a minimally-invasive LAUP procedure. This procedure involves thermal processing of the relaxed soft palate and surrounding tissues using neodimium-doped yttrium aluminum garnet (Nd:YAG) and erbium-doped yttrium aluminum garnet (Er:YAG) lasers, resulting in favorable collagen shrinkage and development of new collagen fibers. Procedure has previously been reported to safely and effectively reduce snoring, as well as increase the volume of the oropharyngeal airway, and is well accepted by patients.
Materials and methods: The efficacy of the minimally invasive LAUP procedure, combining Nd:YAG laser ($\lambda = 1064$ nm) and Er:YAG laser ($\lambda = 2940$ nm) applied to the soft palate for treatment of OSA on 27 patients with different severities of OSA was evaluated based on AHI measurements before and after only three 20-min sessions in an outpatient setting over a period of 45–60 days.
Results: A decrease in AHI for all the patients with different severities of OSA tested in this study was achieved, with 66.3% average improvement (32–100%). Fifty percent or more improvement was achieved in 78% (21) of all patients.
Conclusions: Based on our observations, the NightLase® LAUP treatment of OSA represents an effective and safe therapeutic method. Further research and longer term prospective trials are needed to improve the evidence base for the potential integration of this treatment method into the current guidelines for treatment of OSA.

Keywords: sleep breathing disorder, snoring, obstructive sleep apnea, laser-assisted uvulopalatoplasty, LAUP, Nd:YAG, Er:YAG

Introduction

Obstructive sleep apnea (OSA) is a common chronic condition that causes repetitive episodes of partial or complete collapse of the upper airway during sleep, with a consequent reduction or cessation of airflow.[1,2] The obstructive episodes (apneas or hypopneas) cause a deficient supply of oxygen, which results in breathing efforts against the collapsed airway, typically until the person is awakened. Studies report that the prevalence among general population is 9–38% and is higher in men. The condition generally increases with increasing age and can be as high as 90% in men and 78% in women in certain elderly population groups.[3]

OSA is associated with numerous diseases and risks, among them cardiovascular, neurological, reproductive, and behavioral. Undiagnosed and untreated OSA symptoms can lead to increased cardiovascular disease, different metabolic

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diseases, increased tiredness and sleepiness during the day, personality changes, workplace errors, impotence in men, traffic accidents, and more. With proper identification and treatment of OSA, we can decrease the potential health consequences and economic burden.[4–10]

Polysomnography (sleep study) is the gold standard in the diagnosis of OSA, with which patients' physiologic data are recorded during overnight sleep, among them also airflow. Apnea is defined as a cessation of breathing for 10 sec despite inspiratory effort. If airflow is reduced by 30 percent or more in over 10 sec, and at the same time oxygen desaturation is evaluated as 4% or more, this episode is defined as hypopnea. As a result of the sleep study, apnea–hypopnea index (AHI) is reported, which is defined as the number of times that airflow is reduced or stops per hour of sleep and is used to categorize the severity of OSA.[7,11,12] Apart from the AHI, other factors need to be considered when deciding for the treatment, such as age, excessive daytime sleepiness, and other concomitant diagnoses.[6,13]

Based on the severity of sleep-disordered breathing (SDB), a suitable therapy is determined. There are multiple treatment options for SDB such as OSA, which can be classified into behavioral, apparative, and surgical methods. Behavioral methods include weight loss, avoiding certain sleep positions (e.g., on the back), cessation of smoking, and limiting alcohol consumption. However, they are characterized by an extremely low success rate, which can be attributed to lack of motivation and effort.[12] Apparative methods to treat OSA include respiratory treatments aimed at modifying and increasing the airway volume by utilizing a variety of possible modification pathways and appliances. Generally we can classify these in terms of simplicity and effect with a linear correlation from tongue stabilizing device, mandibular advancement device (MAD), and the positive airway pressure (PAP), with PAP devices remaining the golden standard for managing and treating severe OSA.[14] The major problem of these appliances is lower long-term acceptance rates[15] and high incidence rates of involuntary removal and common and problematic side effects. The latter include, but are not limited to, excess salivation, dryness of mouth, gum irritation, and even occlusal changes with long-term use of MAD.[16,17]

Continuous positive airway pressure (CPAP) is a method that can be highly effective in treatment of OSA.[18] However, the CPAP is merely preventing the occurrence of symptoms and is not considered a treatment for the actual pathology. Despite its effectiveness, CPAP has poor acceptance among patients due to discomfort during its use and can therefore result in lower efficacy and poor adherence rates (40–85%).[19–22] Many patients who cannot tolerate CPAP, fail other medical treatments, or require a long-term solution eventually seek surgical management. Patients with AHI of $\sim$30 are usually considered for the primary surgical treatment. Surgical treatments of OSA include a wide array of nasal, oral, oropharyngeal, and nasopharyngeal procedures.[18] Radical surgeries aim at removing the excess tissue and result in stiffening or scarring of the tissue. They can be associated with morbidity and are therefore not among the most favorable procedures. Uncertain outcomes and possible complications after uvulopalatopharyngoplasty (UPPP) procedures have led to the development of a minimally invasive version of laser-assisted uvulopalatoplasty (LAUP), used for treatment of snoring and OSA, which focuses on shrinking of the palatal tissue instead of surgically removing it.[23,24]

The ''palatal stiffening'' LAUP focuses on thermally processing the relaxed soft palate, resulting in favorable fibrosis and/or collagen shrinkage and development of new collagen fibers,[25] thus producing the desired shortening and stiffening of the soft palate. This is an outpatient procedure, during which erbium-doped yttrium aluminum garnet (Er:YAG) laser is delivered to the tissue with energy densities below the ablation threshold, typically requiring no anesthesia. Apart from occasional brief dry or sore throat sensation or mild temporary altered palatal sensation, which typically resolves within a few hours, this procedure appears safe and well accepted by patients, with no reported additional adverse effects.[25–40]

The latest treatment approaches involve the NightLase® LAUP procedure, an outpatient treatment with a combined protocol using both neodimium-doped yttrium aluminum garnet (Nd:YAG) laser and Er:YAG laser systems to treat the soft palate with effect in the area of palatopharyngeal and palatoglossal muscles, tensor veli palatini muscle, levator veli palatini muscle, and uvula. Absorption of Nd:YAG and Er:YAG lasers in the tissue results in a temperature increase inside the tissue, causing collagen fibers to reform, resulting in a tightening of the tissue in the oropharynx while leaving the mucosa intact. Due to the contraction of the soft tissue with origin in posterior border of the hard palate, the treated tissue is moved upward and forward, resulting in improved upper airway volume. The heat-shock effects on collagen fibers are instantaneous, but continue to manifest throughout the processes of collagen remodeling and neocollagenesis.[38] Clinical experience with such a protocol to reduce the symptoms of SDB has previously been reported and has shown a reduction in both total snoring time and snoring score, as well as an increase in cone beam computed tomography (CBCT)-determined airway volume.[38,39] Therefore, the aim of this study was to evaluate the efficacy of the NightLase® LAUP method in the treatment of different severities of OSA by determining the improvement (decrease) in AHI events following the treatment.

Materials and Methods

Patient selection

A retrospective analysis of the charts of 29 patients (20 male, 9 female) from 3 centers was performed. The inclusion criteria for the analysis were patients with a diagnosis of OSA based on AHI measurements (AHI >5), of either sex, aged 18 years old or higher. The exclusion criteria included patients younger than 18 years, pregnant women, patients with a diagnosis of central apneas or larynx obstruction, patients taking photosensitive drugs, patients with alcohol misuse habits, patients already surgically treated or in the course of other treatments (including oral appliances), patients who were not able to perform the three sessions or follow-up appointments, and noncooperating patients. Two male patients were excluded from further analysis (AHI <5). Photographic images of the oropharyngeal area were taken before and after each treatment. The treatments were performed in accordance with the Declaration of Helsinki for humans. Informed consent forms were signed

by all the patients included in the study; however, due to the fact that the analysis was done retrospectively, ethical approval was not obtained before the study.

AHI measurements

AHI measurement was performed before the first laser treatment and from 1 week to 1 month after the third laser treatment. A home sleep testing device (MediByte; Braebon) was used in 81% of patients, while in 19% of patients AHI was determined with in-lab sleep study (overnight stay in the hospital). The devices report AHI score—the number of times that airflow is reduced or stops per hour of sleep, which was used to categorize the severity of OSA and to evaluate the efficacy of the treatment. Up to 5 events per hour is usually defined as normal in the adult population, 5–15 per hour as mild, 15–30 as moderate, and >30 per hour as severe SDB.[7,11,12] Percentage of improvement in AHI was evaluated for each patient based on the difference between AHI after the series of three treatment sessions compared to the situation just before the initial treatment. Efficacy of the treatment was further evaluated by determining the proportion of patients (for all patients and also within each OSA severity group) with more than 50% improvement along with a decrease to AHI below 5 after the treatments.

Laser treatment and light parameters

Patients were treated using a dual-wavelength laser system (LightWalker®; Fotona d.o.o., Slovenia), integrating both Nd:YAG ($\lambda = 1064$ nm) and Er:YAG ($\lambda = 2940$ nm) laser wavelengths (Fig. 1a). The laser system used in this study has been FDA cleared for intraoral soft tissue surgery (coagulation and ablation) and LAUP in addition to other indications.

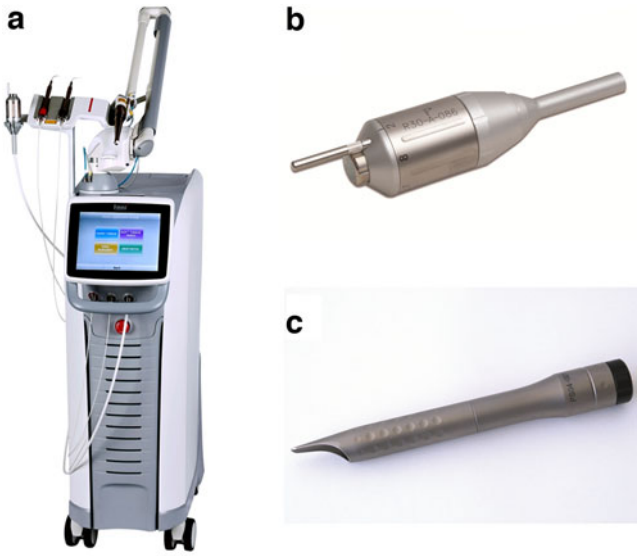

FIG. 1. Dual-wavelength laser system (LightWalker®; Fotona d.o.o., Slovenia) **(a)** with 1064 nm Nd:YAG R30-A handpiece **(b)** and 2940 nm Er:YAG PS04 handpiece **(c)** used for the NightLase® LAUP treatment for OSA. Er:YAG, erbium-doped yttrium aluminum garnet; LAUP, laser-assisted uvulopalatoplasty; Nd:YAG, neodimium-doped yttrium aluminum garnet; OSA, obstructive sleep apnea.

In this study the minimally-invasive LAUP procedure was used in the manner similar as described by Shiffman and Lukac.[38] First, nonablative deep (up to ~5 mm depth) thermal processing or coagulation of the mucosa was performed using an Nd:YAG R30-A (Fig. 1b) laser handpiece with the following parameters: 10 W of power, 8 Hz repetition rate, 25 ms pulse duration, 40 J/cm^2 fluence, and 2 mm spot size used in a defocused way to produce an 8 mm spot size at the tissue. Laser light was delivered in horizontal lines in back and forth motions across the soft palate and uvula, following pattern in Fig. 2a. Five full passes were delivered per each line, with 900–1200 pulses as the end-point, depending on the patient's pharyngeal anatomy. Second, nonablative superficial coagulation (0.1–0.4 mm deep) of the soft tissue was performed with an Er:YAG noncontact PS04 handpiece with round spot size with diameter of 7 mm (Fig. 1c) using 4–5.15 W of power, 1.5 Hz repetition rate, 7–9 J/cm^2 fluence (energy density), and Fotona SMOOTH® mode/pulse. Fotona SMOOTH pulses were delivered to irradiate the palatopharyngeal and palatoglossal arches, soft palate, and uvula in a pattern shown in Fig. 2b. Bursts of four to six pulses were delivered per each spot before moving to the adjacent spot with minimal overlap to gradually increase the temperature in the mucosa without causing any ablation. Multiple passes (6) following the same pattern were performed across the entire right side of the oropharynx and mirror imaged to the left side. Seven thousand to 9000 total number of pulses were delivered as the end-point, with possible variations in number of spots and total number of pulses based on oropharyngeal anatomy (width and length of soft palate, uvula,

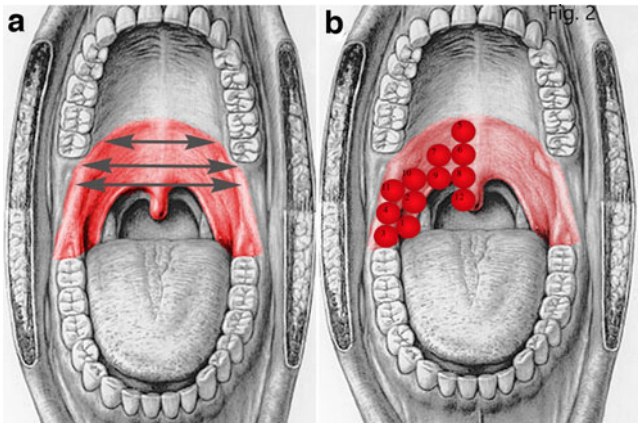

FIG. 2. During the NightLase® LAUP treatment for OSA Nd:YAG laser was delivered in horizontal lines in back and forth motions with multiple passes per each line to achieve thermal processing of the tissue **(a)**. Second, additional nonablative superficial coagulation was achieved using Er:YAG laser, delivered spot by spot (depicted by round spots, 1–12) with up to 6 consequent Fotona SMOOTH® pulses (bursts) per each spot until moving to the next spot. Multiple passes were performed across the entire right side of the oropharynx and mirror imaged to the left side **(b)**. The number of spots may vary based on the oropharyngeal anatomy of the patient. Er:YAG, erbium-doped yttrium aluminum garnet; LAUP, laser-assisted uvulopalatoplasty; Nd:YAG, neodimium-doped yttrium aluminum garnet; OSA, obstructive sleep apnea.

and arches). Overall, three 20-min sessions were performed with 3–4 weeks in between the sessions. Occasional application of topical anesthesia was used if necessary.

After the treatment, patients were instructed to drink a minimum of 8 oz. of room temperature water to rehydrate the tissues in case of ''dry throat'' sensation. If this protocol is followed, the short-term complications are short lived, as in hours or minutes.

Statistical analysis

Simple statistical analysis using paired *t*-test was performed to compare AHI values before and after the treatment and single-factor ANOVA to determine if there were differences between % improvement in patients with different severities of OSA.

Results

Analysis was performed on 27 patients (18 male and 9 female) between 25 and 78 years of age (median 53 years), with body mass index between 20.5 and 39 (info provided for 63% of patients). Twenty-two percent of all patients had previously been diagnosed with one or more comorbidities, mostly high blood pressure (five patients), heart disease (one patient), and hyperlipidemia (one patient). AHI measurements before the treatment were between 6 and 60. Based on initial AHI measurements, 26% of patients were classified as having mild OSA (7 patients, $6 < \text{AHI} < 12.4$) and 37% as moderate OSA (10 patients, $15 < \text{AHI} < 25$) and severe OSA (10 patients; $32 < \text{AHI} < 60$), respectively.

Both during and immediately after each single treatment session mucosa appeared intact (Fig. 3). After three NightLase® LAUP treatments, a visible tightening and elevation of the oropharyngeal tissues were often observed (Fig. 4), which were more pronounced in some and less in other patients.

After the treatment the AHI measurements were lower for all patients (Fig. 5). Based on AHI score only, 80% of patients initially diagnosed with severe OSA could be reclassified to the moderate OSA group and 10% of patients to the mild OSA group after the treatment. Only the patient with the highest initial AHI (60) remained in the severe OSA group, but nevertheless experienced a drop in AHI (45%). Moreover, 50% of patients initially diagnosed with moderate OSA now had an AHI below 5 (no OSA), 40% were reclassified to the mild OSA group, and only one stayed within the moderate OSA group (32% AHI drop) (Fig. 5).

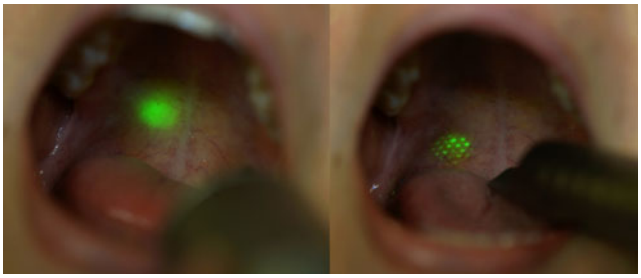

FIG. 3. Intraoperative photographs of NightLase® LAUP treatment with Nd:YAG (*left*) and Er:YAG (*right*) laser. Both during and immediately after the treatment mucosa appeared intact. Er:YAG, erbium-doped yttrium aluminum garnet; LAUP, laser-assisted uvulopalatoplasty; Nd:YAG, neodimium-doped yttrium aluminum garnet.

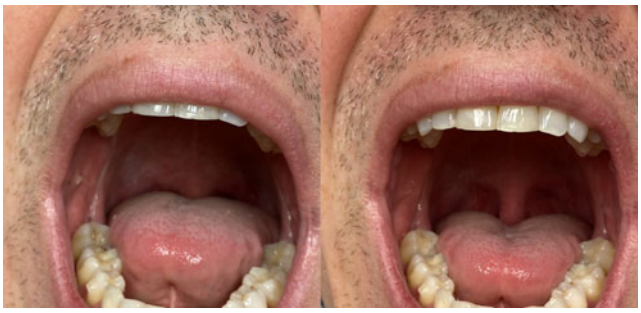

FIG. 4. Images of one of the patients before (*left*) and after (*right*) three NightLase LAUP laser treatments over a period of 45–60 days. LAUP, laser-assisted uvulopalatoplasty.

Compared to the situation before the treatment, the mean AHI was significantly lower in all the OSA severity groups ($8.2\times10^{-7} < p < 4.3\times10^{-5}$, $\alpha = 0.01$). In fact, the results showed an average of 66.3% improvement (min = 32.0%, max = 100%) compared to the AHI before the treatment; with 64.1% (min = 43.0%, max = 100%), 67.6% (min = 32.0%, max = 94.6%), and 66.6% (min = 45.3%, max = 88.2%) improvement in patients with mild, moderate, and severe apnea, respectively. The difference between severity groups was not significant ($p = 0.94$) (Table 1).

After the treatment, 50% or more improvement was achieved in 78% (21) of all patients. Seventy-four percent of patients (20) experienced more than a 50% decrease in AHI, along with a decrease to an AHI value lower than 20. Thirty-seven percent of patients (10 patients; 4 with mild, 5 with moderate, and 1 with severe OSA) experienced more than a 50% decrease in AHI, along with a decrease to AHI lower than 5, and were therefore considered as cured from OSA. The greatest efficacy measured in % of patients cured (>50% improvement in AHI and AHI <5) was observed in the mild OSA group (4 out of 7 patients), followed by the moderate OSA group (5 out of 10 patients); however, the group size was not the same (Table 2).

Interestingly, taking into account only >50% improvement in AHI, the highest efficacy was observed within the severe OSA group, with 90% of patients showing more than 50% improvement after the treatment (Table 2).

Short-term complications were limited to desiccation of the treated soft tissues resulting in temporary sore or dry throat sensation, which was usually diminished within a few hours. None of the patients reported postoperative complications or adverse effects up to 2 years after the treatment.

Discussion

Snoring and OSA are increasingly common and involve a significant social and economic impact. Since OSA constitutes risk factors for many other conditions, such as arterial hypertension, myocardial infarction, and strokes, it is suggested that patients with a corresponding anamnesis need to be treated early on.[6] Both nonsurgical and surgical options are efficacious in diligently selected patients. Nevertheless,

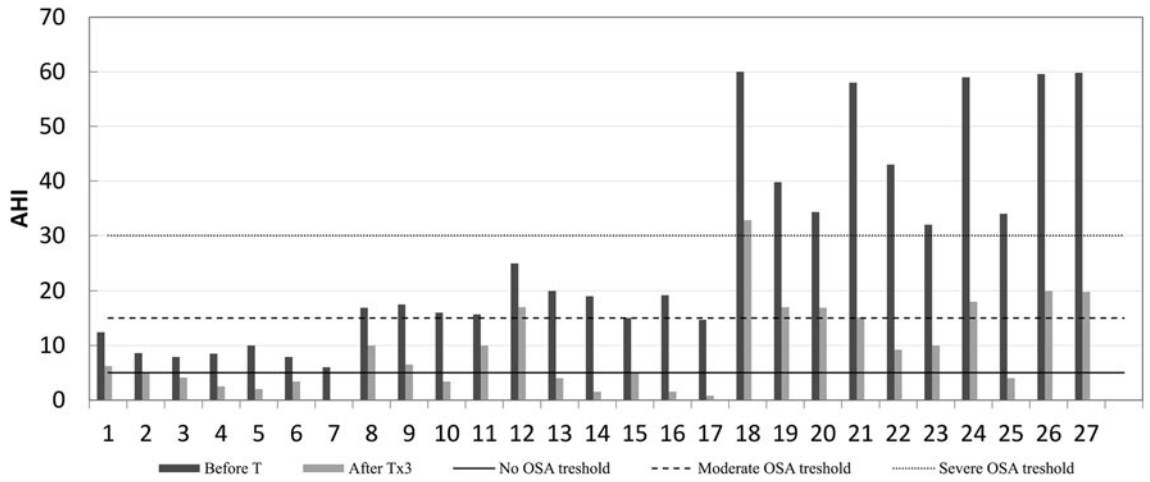

FIG. 5. AHI measurement before and after 3 NightLase® LAUP laser treatments for 27 patients with mild (Patients No. 1–7), moderate (Patients No. 8–17), or severe (Patients No. 18–27) OSA. The complete treatment consisted of three 20-min sessions over a period of 45–60 days. Horizontal lines depict thresholds of mild, moderate, and severe OSA. AHI, apnea–hypopnea index; LAUP, laser-assisted uvulopalatoplasty; OSA, obstructive sleep apnea.

patients are currently faced with a heavy burden to either use something that is not very effective yet still tolerable like behavioral changes or oral appliances[12,14–17] or have an extremely efficient solution that causes significant discomfort. So in the gamble between efficacy and acceptability we are lacking in solutions that would be both highly effective and accepted.

Based on the previous studies using this minimally invasive LAUP procedure, where this approach has been reported to safely and effectively reduce symptoms of SDB and successfully increase both the airway volume and the minimal cross-section area,[38] we speculated that it could also be efficient in treating patients for OSA. During the NightLase® LAUP procedure, the Nd:YAG laser wavelength acts as an effective coagulator. The 1064-nm wavelength of the Nd:YAG is characterized by low absorption in water and bone, but higher absorption in pigmented soft tissues and hemoglobin. To further enhance the shrinkage of collagen and neocollagenesis in the superficial layers of mucosa, Er:YAG, which is highly absorbed in water, is applied to the areas previously treated with Nd:YAG.[38]

Using the described procedure, a visible tightening and elevation of the oropharyngeal tissues are often observed,[38] which were seen also in this study and were more pronounced in some and less in other patients. In addition, a decrease in AHI for all patients with OSA tested in this study was observed, with an average 66.3% improvement, irrespective of the severity of OSA. A 50% or more improvement was achieved in 78% (21) of all patients, which is comparable to many other currently used surgical or nonsurgical methods.[12] Interestingly, and against our initial expectations, when taking into account only >50% improvement in AHI, the highest efficacy was observed within the severe OSA group, with 90% of patients showing more than 50% improvement after the treatment, making this procedure a possible therapy also for the severe OSA patients. Moreover, for 37% of patients (10 patients; 4 with mild, 5 with moderate, and 1 with severe OSA), we managed to achieve a more than 50% decrease in AHI, along with a decrease to an AHI value lower than 5, and we could therefore consider them as cured from OSA. The greatest efficacy measured in % of patients cured was observed in the mild OSA group, followed by the moderate OSA group; however, the group size was not the same. Lower accessibility/visibility of the soft palate regions to be treated, which is often observed in patients with more severe OSA resulting in less successful treatment, could be the reason that patients with lower preoperative AHI appear to have greater success with the treatment.[12]

Table 1. Percentage (%) of Improvement in Apnea–Hypopnea Index After NightLase Laser-Assisted Uvulopalatoplasty Treatment for Patients Diagnosed with Different Severities of Obstructive Sleep Apnea

AHI % improvement							
Mild OSA		*Moderate OSA*		*Severe OSA*		*All patients*	
Mean	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*
64.1	20.5	67.6	24.0	66.6	12.8	66.3	18.9

The complete treatment consisted of three 20-min sessions over a period of 45–60 days.

AHI, apnea–hypopnea index; OSA, obstructive sleep apnea; SD, standard deviation.

NightLase® LAUP using only Er:YAG has so far only been demonstrated to effectively help with snoring; however, majority has not measured AHI or did not demonstrate a decrease in AHI with the treatment.[34] The fact that a combined protocol using both Nd:YAG and Er:YAG was used in this study might have contributed to a better improvement in AHI; however, additional studies to compare the different protocols would be needed. According to the Adult OSA Task Force of the American Academy of Sleep Medicine (AASM), the clinical guidelines for treating OSA begin with a confirmed diagnosis followed by offering PAP treatment for mild, moderate, and severe OSA, positioning the CPAP as the primary and golden standard treatment.[18] While the patients should be aware of alternative treatment

Table 2. Efficacy (Proportion of Patients) of NightLase® Laser-Assisted Uvulopalatoplasty Treatment in Patients with Different Severities of OSA

	% of patients within group				
Groups	*>50% improvement*	*AHI <20 post-op*	*AHI <5 post-op*	*Cured to AHI <20*	*Cured to AHI <5 (efficacy)*
Mild OSA ($n=7$)	71.4	/	86.0	/	57.1
Moderate OSA ($n=10$)	66.7	/	50.0	/	50.0
Severe OSA ($n=10$)	90.0	80.0	10.0	80.0	10.0
All patients	78.0	93.0	44	74.0	37.0

Patients with 50% decrease in AHI, along with a decrease to an AHI <5, were considered as cured from OSA. The complete treatment consisted of three 20-min sessions over a period of 45–60 days. AHI, apnea–hypopnea index; OSA, obstructive sleep apnea.

strategies in accordance with different risks, anatomical factors, and patient preferences, the CPAP is presented as the best currently available treatment method.[18] While without a doubt effective in treating OSA, extremely low CPAP compliance rate makes it less suitable as the first line of treatment, due to the high number of patients with inability to tolerate the treatment, either due to discomfort, disturbed sleep routine, necessity of nightly use, unwilling dislocations of the mask during sleep, or any other of the plethora of reasons that are cited as the cause for discontinuation of PAP treatment, including nasal discomfort, congestion, rhinitis, dermatitis, epistaxis, mask leak, aerophagia, barotrauma, and claustrophobia.[20] Moreover, PAP has recently been linked with complex sleep apnea occurrence and was estimated at around 9% for CPAP users.[21,22] The same is true for other appliances, yet what they compensate for on the discomfort front, they lose on effectivity, while invasive methods should always be considered as a last-line-of-defense option.[15–17,19,20]

Based on the findings of this study and in addition to the findings of previous studies,[25–37] NightLase LAUP could potentially fill the existing gap and offer to the field of SDB a new treatment option. As it is entirely noninvasive, the mucosa remains intact, which reduces the possibility of complications.[38] Treatment is tolerable without anesthesia, with only up to 10% of patients requesting for topical lidocaine spray at the first session, but not during the successive sessions.[34] Moreover, the treatment does not rely on nightly use of appliances or patient tolerance or compliance to treatment. With the proper clinical assessment, patient counseling and selection, and a multidisciplinary team, this method could be suitable as a first-line treatment option as proposed in a typical decision tree used in our office for the NightLase® LAUP treatment (Fig. 6). Management strategies for OSA are generally primary and adjunctive in that they may be used alone or in combination with other treatment modalities.[20] A suitable treatment can be chosen based on the severity of SDB (snoring and/or OSA). In the case of high dropout rates and/or persistence of OSA-related symptoms with alternative methods, NightLase® LAUP treatment could potentially also be used in combination with or following any other type of behavioral, apparative, or surgical treatment. Further investigation would be needed to evaluate the efficacy of such approach.

As with any treatment, there are potential risks with laser treatment. However, the risks are minimal and certainly less than most currently used methods if the protocol is followed correctly. Apart from occasional dry or sore throat sensation or mild temporary altered palatal sensation in the post-op period, which was observed also in previous studies,[28,31,34,35,38] none of the patients reported short-term postoperative

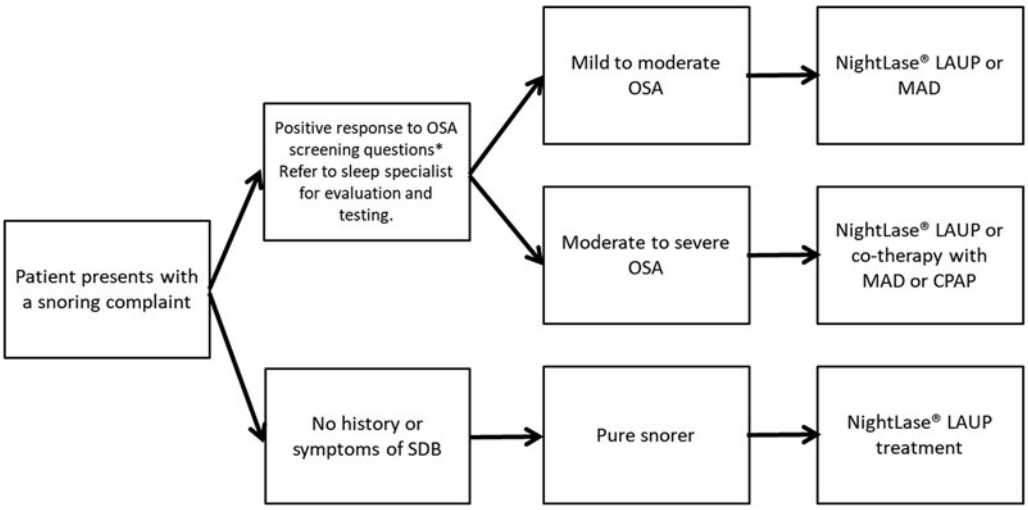

FIG. 6. Decision tree for the use of NightLase LAUP treatment for snoring/OSA. * Any of the standard questionnaires used for OSA screening (e.g., Berlin, ESS, STOP, STOP-Bang, and so on). CPAP, continuous positive airway pressure; ESS, Epworth Sleepiness Scale; LAUP, laser-assisted uvulopalatoplasty; MAD, mandibular advancement device; OSA, obstructive sleep apnea; SDB, sleep-disordered breathing.

complications or adverse effects. According to the previous studies[25–37] and in over 9 years of clinical use of this and similar protocols in our dental office for treatment of snoring, there have been also no long-term complications, such as scarring, difficulty in swallowing, or voice changes, which are frequently reported after surgical procedures used in OSA treatment.[40]

One of the limitations of the present study was that AHI was used as a single ''end-point'' demarcating success, but a combination of patient-centered (scoring systems) and objective (polysomnography) outcomes would be preferable. In addition, these end-points should ideally be interpreted together with at least some of the patient's other symptoms and anatomical characteristics (snoring score and reduction, Mallampati classification, Friedman tongue position, respiratory disturbance index, Müller's maneuver, etc.) and influence on quality of life (satisfaction questionnaire, Epworth sleepiness scale, etc.).[19,20,36] Further research and longer term prospective trials are therefore needed to improve the evidence base for the use of this treatment method for OSA. Nevertheless, our results can be supported with the previous studies using nonablative Er:YAG procedures confirming collagen shrinkage with histological analysis of the soft palate of rats[25] and a CBCT analysis demonstrating increase in oropharynx airflow.[38,39]

Even though AHI was only measured up to 1 month after the last treatment session, even better results could potentially be expected after 2–3 months when the process of neocollagenesis would be well established.[34,36] According to the previous studies, the result of the NightLase treatment will typically last anywhere from 6 to 24 months and is easily touched up at follow-up appointments.[34,37,38] Long-term effect of this treatment would need to be determined, but the analysis of charts was done retrospectively and the treatments and/or further objective evaluation of the outcome had been discontinued. It is also important to stress that if the obstruction responsible for OSA is not located in the oropharynx but, for example, in the nose or in the level of hyoid bone, the treatment will not be effective because these regions will not be irradiated with this protocol. Careful selection of patients with a multidisciplinary approach is therefore crucial.

Conclusions

Based on our observations, minimally-invasive LAUP using a combination of Er:YAG and Nd:YAG (NightLase® LAUP) is a safe and effective approach that has the potential to become a standard method for treating SDB. With further studies in a multidisciplinary team to further evaluate the efficacy and adequacy, this therapy could potentially be integrated into the current guidelines for treating OSA.

Author Disclosure Statement

H.S. reports personal fees from Fotona LLC, outside the submitted work. No competing financial interests exist for J.K. and N.M.C.

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