

Review

Photobiomodulation surgery of the soft palate

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Abstract: The purpose of the work: To familiarize specialist in the field of laser ENT surgery with the stages of the historical development of surgical care for patients with ronchopathy and obstructive sleep apnea syndrome, to evaluate the effectiveness of traditional uvulopalatoplasty methods and to justify the introduction into practice of the use of laser radiation for uvulopalatoplasty and its modifications. To increase the effectiveness of laser uvulopalatoplasty and its application in patients with ronchopathy and obstructive sleep apnea syndrome of any severity, a method of laser sculptural uvulopalatoplasty based on the use of carbon dioxide laser radiation in the "Super pulse" mode with a scanning device is proposed.

Keywords: obstructive sleep apnea syndrome, uvulopalatoplasty, CO₂-laser.

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1. Introduction

It has already been 70 years since, for the first time in 1952, the "father" of the treatment of patients with snoring, the Japanese surgeon Takenosuke Ikematsu (Takenosuke Ikematsu) from the city of Noda successfully resected the hypertrophied tissues of the soft palate and his tongue to a young bride, a 23-year-old girl whose loud snoring jeopardized marriage. As a result of this surgical intervention, postoperative scars reduced the length of the soft palate, pulling it up, expanded the lumen of the upper respiratory tract at the level of the soft palate, which ultimately ensured the disappearance of snoring. This operation T. Ikematsu proposed to call uvulopalatoplasty (UPR, UPP). To date, this method has become the basis of classical traditional surgical intervention performed for the treatment of patients with ronchopathy. In 1964, T. Ikematsu surgery was recommended for all patients with uncomplicated snoring [1].

The works of Ikematsu and his followers served as the basis for a new surgical intervention. In 1981, Shiro Fujita from Henry Ford Hospital in Detroit, Michigan, modified the Ikematsu method [2]. He suggested removing not only the hypertrophied tissues of the palatine curtain, but also the palatine tonsils with their arches. He suggested calling this operation uvulopalatopharyngoplasty (UPP), which was intended for the treatment of patients with complicated ronchopathy with a clinical picture of obstructive sleep apnea syndrome (OSA) of mild and moderate severity. However, this operation was not indicated for the treatment of patients with severe OSA. To date, UPP remains the most common method of treating patients with ronchopathy.

The effectiveness of these surgical interventions in patients with ronchopathy over the last decades of the last and the beginning of this century, according to credible foreign studies [3-10], amounted to: up to 80% in patients with ronchopathy with uncomplicated snoring, up to 50% in patients with mild OSA and less than 20% in patients with moderate OSA.

Despite the wide prevalence of these surgical interventions on the soft palate in patients with ronchopathy and OSA, they could not be considered completely satisfactory, which stimulated the continuation of the search for more effective methods of surgical treatment.

For the first time, Carefelt C. et al. (1986) applied high-energy laser radiation in the process of performing SCP to a patient with ronchopathy [11]. The authors, dissecting the mucous membrane of the soft palate with carbon dioxide (CO₂) laser radiation under local or general anesthesia, drew attention to the absence of bleeding from the wound tissues, which was represented by Carefelt C. et al. a very attractive technology that aroused the interest of many of their colleagues.

Four years later, the French surgeon Kami N.M. (Yves Victor Kamami) [12] performed on an outpatient basis under local anesthesia for a patient with uncomplicated snoring, using CO₂ laser radiation instead of a traditional surgical scalpel, i.e. for the first time he performed laser uvulopalatoplasty (DAR, LUPP). A year later, Johns M.W. (1991) reported the successful completion of the operation described by Kami Y.V. to several patients with mild to moderate OSA ronchopathy [13].



In 1993, Ellis P.D.M. proposed a more conservative, in his opinion, magnifying glass method [14], based on pulling the palatal curtain by successive scarifications. The purpose of the operation was to increase the tension of the palatine curtain by excising a narrow strip of the mucous membrane from the palatine uvula to the border with the hard palate. After laser evaporation of the tissue structures of the submucosal layer, the excised fragment of the mucous membrane was proposed by the author to be returned to its place, fixing it with separate sutures to the bottom of the wound. Similar actions were also carried out on the other side of the palatal curtain.

A year later, Farrington T. et al. [15] modified the Ellis P.D.M. operation by offering laser radiation to vaporize a narrow and long fragment of the mucous membrane with the underlying structures of the submucosal layer along the entire length of the soft palate: from the base of the palatal uvula to the border between the soft and hard palate on both its surfaces. The healing of the open wound surface occurred by secondary tension. At the same time, the scar provided tension of the palatine curtain. In the literature, the LUPP method proposed by Farrington T. with co-author, received the name "English method".

In the same 1994, Kami Y.V. published the results of the use of a magnifying glass performed on 46 patients suffering from frequent episodes of nocturnal apnea [16]. In 40 out of 46 operated patients (87%), the treatment was effective. The operation, called Krespi Y.P. [17] "the French method", was a fast, safe and very effective method of treating patients with ronchopathy and OSA.

Depending on the individual characteristics of the patient, but above all, on the severity of OSA and some other features of the disease, Kamami Y.V. used two methods proposed by him: one-stage and two-stage options.

The operation with the use of CO₂ laser radiation differed favorably from traditional methods of SCP, with a very short duration, absence of blood loss and transience of inflammatory reactions of the operated tissues. At the end of all its stages, the soft palate became quite rigid, and snoring completely or almost completely stopped. Normalization of breathing during sleep and restoration of its continuity ensured full rest of the patient, which ultimately had a positive effect on his general condition, working capacity and quality of life. However, it should be noted that during the 3 weeks of the immediate postoperative period, patients complained of significant pain in the area of surgery, which was obviously due to the excessive thermal effect of laser radiation on the operated tissues.

A year later, the LOUP and its variant, the LOUP, began to be widely used by otorhinolaryngologists in many US cities. However, already in the same year, 1994, the specialists of the American Sleep Disorders Association (ASPA) proposed to limit the use of LUPP methods for the treatment of patients with ronchopathy and OSA [18].

Nevertheless, Krespi Y.P.; Lauretano A.M. et al.; Walker R.R.; Verse T. et Pirsig W.; Litter M. et al. [19-23] and some other authors, having studied the results of LUPP, came to the conclusion that it is advisable to perform this operation in patients with uncomplicated course of ronchopathy. At the same time, they strongly recommended refraining from performing magnifying glasses in patients with mild, moderate, and, especially, severe OSA.

However, by the beginning of the XXI century, a stable opinion began to be clearly formed that any surgical intervention, including laser, performed by a patient with ronchopathy with OSA, causes a deterioration in the clinical course of the syndrome, often increasing the intensity of snoring and increasing the frequency of episodes of nocturnal apnea. Many surgeons began to limit the indications for not only laser, but also traditional surgical interventions in patients with ronchopathy and OSA, and more often refuse to perform them [24-25].

The publications of Friberg D. et al had a certain influence on the formation and development of this trend. (1997, 1998) [26-27]. The results of their numerous histological studies of soft palate tissues in patients who underwent surgical, including laser, intervention for ronchopathy allowed us to assume the influence of surgical tissue trauma on the formation of disease recurrence and postoperative complications.

A little later, in 2010, the American Academy of Sleep Medicine (AASM) proposed a resolution on the need to develop standards for evaluating the effectiveness of treatment methods for patients with ronchopathy and OSA. They were recommended to conduct a sociological study without fail, at least twice. The first was intended for the primary diagnosis of OSA and clarification of its severity, and the second – for an objective assessment of the effectiveness of the treatment method.

Despite the restrictive recommendations, an active search for new, other effective methods of treating patients with ronchopathy was actively continued. The development and popularization of laser technology, the emergence of new laser radiation generators, the discovery of the effects of the influence of specific characteristics of laser radiation on various tissues and environments of a living organism have certainly stimulated the development of laser surgery, including the development of new laser operations on upper respiratory tract tissues.

Finkelstein Y. et al. (1997) [28] compared the results of the use of UPP and UPP performed in 174 patients with severe OSA with ronchopathy. At the same time, 100 patients underwent surgery



using the traditional method, and 74 – using a CO₂ laser. It was found that in patients who underwent a magnifying glass, in the postoperative period, the pain syndrome was more pronounced and bothered significantly longer than in patients who underwent traditional SCP. After LUPP, the authors noted the effect of "circular" scarring of soft palate tissues in patients, which led to a decrease in the airway lumen at the level of the palatine curtain. In their opinion, the appearance of scar tissue is due to the effect of excessive laser radiation, which caused excessive local thermal damage to the operated tissues.

Remacl M. et al. (1999) [29] used a "Sharplan" CO₂ laser model capable of generating radiation with a power of up to 15 watts in the SuperPuls (SP) mode: that is, the generation of ultrahigh-frequency radiation pulses that can be used both in constant and any of the modulation modes. This technical capability made it possible to minimize the thermal load on the tissues surrounding the evaporated fragment, and, consequently, to significantly reduce pain in the patient during the operation and in the postoperative period, to shorten the healing time of the laser wound, ensuring its healing by restitution, and reducing the possibility of scar tissue development in the wound. At the same time, dissection and evaporation of tissues by carbon dioxide radiation in the SP mode completely preserves the hemostatic effect, making the operation as bloodless as when using the usual radiation mode.

Performing layer-by-layer ablation (evaporation) of a rectangular or rounded portion of the mucous membrane and structures of the submucosal layer from the base of the uvula to the palatine fossa of the anterior (oral) surface of the soft palate, Remacl M. et al. the surface of the soft palate muscle was left intact. Then they coagulated and vaporized the tissues of the distal third of the tongue and vaporized the velar arches. The coagulation of tissues was carried out with a defocused beam, and their vaporization (evaporation) was carried out with maximally focused radiation generated on the surface in the SP mode.

The magnifying glass method proposed by Remacle M. et al. and combining the advantages of English and French methods, but avoiding their potential drawbacks, was designed to carry out laser correction of palatal curtain tissues. Therefore, like previous researchers, the authors recommended using it to treat patients with uncomplicated snoring.

Nevertheless, based on the research results of Finkelstein Y. et al. [28]; Lauretano A.M. et al. [20]; Verse T. et Pirsig W. [22]; Email M. et al. [29]; Littner M. et al. [23]; and a number of other publications devoted to the analysis of the results of traditional and laser surgical interventions performed to relieve patients from night snoring, AASM came to the conclusion about the equivalent effectiveness of traditional surgery and LUPP in patients with uncomplicated snoring. It was also pointed out that the presence of even a mild degree of OSA should be considered as a contraindication to performing both traditional and laser surgery.

It cannot be excluded that this recommendation was partly due to the lobbying of manufacturers of devices designed and intended for the treatment of patients with ronchopathy and OSA by creating an increased pressure of the air flow passing through the upper respiratory tract of a sleeping person, i.e. for the implementation of so-called CPAP therapy and some other devices to combat snoring by non-surgical methods. Unfortunately, this trend continues to be observed to this day.

However, the already accumulated experience of using LUPP in patients with ronchopathy and, even, OSA, demonstrates the absence of blood loss and the short duration of laser surgery, the transience of postoperative inflammatory processes that occur during surgical trauma of the mucous membrane and underlying tissues, the safety of surrounding tissues, gradually, as clinical observations accumulate, which contributes to an increase in the number of supporters, convinced of the expediency and effectiveness of the use of laser radiation as the main surgical instrument when performing SCP and UFPF in patients with mild and moderate OSA, and in some cases, severe [30-37].

In order to prevent the effects of excessive power of carbon dioxide laser radiation, attempts were made to use the radiation of solid-state, semiconductor and other lasers, a wide variety of which by this time had already found application in other areas of surgical practice. The search for optimal laser radiation in all respects and the devices that generate it continues to the present time.

In 2002, Blotsky A.A. and Pluzhnikov M.S. [38] proposed to use Nd:YAG laser radiation, the active substance of which was an artificially grown garnet crystal with aluminotrium and neodymium additives. Radiation from the generator to the surface of the operated tissue is transmitted via a quartz polymer fiber. The authors have provided three options for their proposed method of operation. The choice of each of them depends on the characteristics of the pathological processes occurring in the tissues of the soft palate, and the individual characteristics of the patient.

In order to minimize surgical damage to the soft palate tissues and at the same time enhance its rigidity, V.F. Melnik (2003) [39] proposed not to dissect, but to coagulate the tissues of the back and front surfaces of the soft palate by pinpoint exposure to somewhat defocused Nd:YAG laser radiation. The depth of tissue coagulation did not exceed 4-5 mm. The parameters of laser radiation and the time of its exposure at each specific point were determined by the operating



surgeon depending on the nature and severity of pathological processes occurring in the tissues. According to the author, an adequate choice of laser radiation energy for point photocoagulation not only minimizes tissue injury, but also determines the optimal characteristics of the forming scars, which further ensure the sufficiency and uniformity of the compaction and tension of the palatine curtain.

For the treatment of patients with ronchopathy and OSA Karpishchenko S.A. et al. (2014) [40] carried out LUPP using radiation with a wavelength of 0.8-1.06 microns generated by models of LED lasers. The operation, the course of the postoperative period and the evaluation of the effectiveness of treatment in patients with ronchopathy and OSA in general were similar to the technique of performing surgery with Nd:YAG laser radiation.

Fotona company proposed to use radiation with a wavelength of 2940 nm generated by an Er:YAG laser for the treatment of patients with ronchopathy and OSA and patented a method for the treatment of patients with ronchopathy "NightLase" (2011) [41]. To achieve the effect of point coagulation, 7 to 15 thousand radiation pulses per session were applied to the tissue surface. To achieve a stable therapeutic effect of point laser coagulation by pulsed radiation of the Er:YAG laser, it is necessary to repeatedly, at intervals of 2 to 6 weeks, expose the tissues of the soft palate, anterior and posterior palatine arches, palatine tonsils and lateral surfaces of the tongue. The undoubted advantage of this method was the absence of the need to perform preliminary anesthesia of the tissues to which the laser effect will be applied and the easy tolerability of this surgical laser intervention by patients. The disadvantages of the method include the duration of treatment, due to the need for at least three sessions of laser exposure with intervals between them from 15 to 45 days.

At the same time, the radiation of erbium, both neodymium and semiconductor lasers from the source to the surface to be affected is transported through a fiberglass fiber. At the same time, a loss of radiation power naturally occurs. At the exit from the light guide, the radiation becomes defocused, which significantly reduces the density of the energy absorbed by the tissues and requires an increase in the exposure time to achieve coagulation of each specific tissue site. This significantly complicates the rational choice of the parameters of the laser radiation used, which ultimately determine the final result of this surgical intervention.

Simultaneously with the search for new LOUP methods based on the use of laser radiation generated by solid-state and semiconductor laser installations, the search for improvement of LOUP methods using carbon dioxide laser radiation continued.

In 2019, Camacho M. et al. proposed their own version of the LUPP [42]. Using CO₂ laser radiation, the authors removed a small fragment of the mucous membrane of the lower edge of the soft palate, while retaining the tongue, which was fixed to the remaining part of the palate, after which a bilateral tonsillectomy was performed, stitching the anterior and posterior palatine arches (palatine and palatopharyngeal muscles). After surgery, the rigidity of the palatine curtain significantly increased in patients, which contributed to a decrease in the intensity of snoring until its complete cessation.

In 2021, V.B. Knyazkov et al. [43] proposed a new original method of laser sculptural uvulopalatoplasty (uvulopalatopharyngoplasty) (LSUPP, LSUPFP) using carbon dioxide laser radiation (RF Patent for invention No. 2760295 of 12.04.2021). A preliminary study of the results of its clinical application showed the safety of the proposed method of surgical intervention on the soft palate and its sufficiently high effectiveness in patients with ronchopathy, even with severe OSA.

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