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Can we improve clinical results of tonsillectomy using lasers?

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ABSTRACT

Current medicine uses a variety of high-tech devices to obtain maximum results with minimally invasive procedures. Our goal was to determine the benefits of laser medicine in tonsillectomy in comparison with traditional tonsillectomy, harmonic scalpel and radio frequency scalpel. Forty adult patients with chronic tonsillitis, scheduled for bilateral tonsillectomy, were divided into four groups in a prospective study. The left side tonsillectomy was performed using a traditional technique. The right side tonsillectomy was performed using four different methods: Ho:YAG laser, Er,Cr:YSGG laser, radiofrequency scalpel and harmonic scalpel. Peroperative bleeding and operation time were evaluated by the surgeon, development of pain during the healing period was evaluated by the patients and also histological examination of the resecates was performed. The results showed a significant increase of postoperative pain after the Ho:YAG and Er,Cr:YSGG laser procedure in comparison to traditional tonsillectomy. No significant differences in postoperative pain were found after the use of radiofrequency scalpel and harmonic scalpel. Average operation time and peroperative bleeding differed partially in all methods. In conclusion, all the tested methods offer a safe, uncomplicated alternative to traditional tonsillectomy; however, they do not bring any substantial benefit for the patient in reduction of pain during the postoperative period.

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Introduction

The first primitive method for performing tonsillectomy was described in the "Corpus Hippocraticum". Since then, the method had evolved and the traditional cold-steel method has been performed since about 1910, when the ligature to stop post-operative bleeding was introduced. Former methods to stop bleeding included gargling cold water and compressions, however, these methods were unsatisfactory and sometimes ended up with fatal consequences. In the twentieth century, newly developed devices were used in tonsillectomy. In 1935 McLaughlin published his experience with tonsillectomy using diathermoelectrocoagulation (McLaughlin, 1935). Then, in the second half of the 20th century, works by Leach et al. (1993) and Tay (1995) describing the use of a traditional electroknife were published. Later, first attempts to use cryotherapy and lasers were made. Around 1980, CO_2 laser was used (Grossenbacher, 1979), followed by KTP (Oas and Bartels, 1990; Auf et al., 1997; Saito et al., 1999), Nd:YAG (Maloney, 1991) and, later, diode lasers (Havel et al., 2012). At the beginning of the 21st century, there was a significant development of advanced technologies. During a ten-year period, the following tonsillectomy methods were tested: argon plasma (Bergler et al., 2000; Ferri and Armato, 2011), coblation (Toft et al., 2009; Alexiou et al., 2011), radiofrequency thermoablation (Maddern, 2002; Aksoy et al., 2010), harmonic scalpel (Lachanas et al., 2007; Alexiou et al., 2011), thermal welding (Chimona et al., 2008; Sezen et al., 2008) and other types of lasers. So far, however, none of the modern methods has been proven to have significant advantages over the traditional tonsillectomy that is still considered as "the golden standard".

With present-day technical advancements, medical instruments and techniques are becoming more accurate and less invasive. In this study, we wanted to determine whether the tested modern devices can be beneficial in improving tonsillectomy, since their application in tonsillectomy is still controversial. They can be used, but can they really bring benefit to the patient?

In our work, we focused on two relatively new types of lasers (Ho:YAG and Er,Cr:YSGG). The Ho:YAG laser (Gilling and Fraundorfer, 1998) is widely used for soft tissue operations in urology such as prostatectomies. The Er,Cr:YSGG laser (Boj et al., 2011) is a device with patented tissue cooling spray of air and water, intended primarily for dentistry where its use does not require local anesthesia. Both these lasers are market leaders in their primary indications. In the literature, we found no examples of these methods being used in tonsillectomy except for a study by Slouka et al. (2015) where ten types of lasers (Ho:YAG, KTP, NdYVO4, Th:DPFL, Er,Cr,YSGG, CO2 and diode lasers of 980, 940, 810 nm) were compared regarding peroperative bleeding, time of the procedure, orientation in the tissue and thermal damage depth. The Ho:YAG laser was evaluated there as the best-performing among the tested laser types in peroperative bleeding and operation time while the Er, Cr:YSGG laser had the smallest depth of the thermal damage, which are the reasons for the inclusion of these devices in our study.

Besides the two laser tools, harmonic scalpel (HS) and radiofrequency scalpel (RFITT) were included in the study as well. Considering their wide use in various fields of surgery, HS and RFITT need no introduction.

Materials and methods

Material

The study took place in the period from 1/2009 until 5/2013 at the ENT Clinic of the University Hospital in Pilsen. It was a prospective, partially blinded study that included patients with a diagnosis of chronic tonsillitis indicated for surgical treatment. The examined group included 40 patients who met the inclusion criteria (specified below). These were 32 women (80%) and 8 men (20%). Their average age at the time of surgery was 32.5 ± 11.6 (mean ± SD) (Table 1).

Patients were divided into 4 groups of 10 probands. For their left side tonsillectomy, traditional instruments were used. The right side tonsillectomy was performed using a fiber-guided Ho:YAG laser (Auriga, StarMedTec, Germany) in Group A; an Er, Cr:YSGG laser with patented tissue cooling water and air spray (Waterlase iPlus, Biolase, USA) in Group B; a radiofrequency scalpel (CelonLab ENT, Olympus, Japan) in Group C and a harmonic scalpel (SonoSurg, Olympus, Japan) in Group D (Table 2).

At the time of the surgery and one month after the surgery, each patient reported data to the questionnaire without the knowledge of the method performed on either side.

Inclusion criteria: Age over 18 years, diagnosis of chronic tonsillitis.

Exclusion criteria: Chronic diseases of pharynx (excluding tonsillitis), previous surgery or injury of pharynx, peritonsillar abscess, coagulation disorder or other hematologic disease, cleft palate or past history of surgery of pharynx, general contraindications for general anesthesia, pregnancy, lactation.

Table 1 – Characteristics of the study group.

	Group A	Group B	Group C	Group D	*p*-Value	Significance test
Operation technique	Ho:YAG	Er,Cr:YSGG	RFITT	Harm. scalpel	–	–
Sample size (*N*)	10	10	10	10	–	–
Gender (male/female)	1/9	2/8	2/8	3/7	0.95	Exact
Mean ± SD	32.2 ± 11.1	36.3 ± 13.7	32.8 ± 11.4	28.8 ± 10.4		
Age					0.57	One-way ANOVA
Min/Max	19/48	19/59	18/55	19/46		

Table 2 – Parameter settings of the devices.

Group A (Ho:YAG)	Power (W)	Frequency (Hz)	Mode ablation	Fiber diameter
	12	12		365 μm
Group B (Er,Cr:YSGG)	Power (W)	Frequency (Hz)	Water (%)	Air (%)
	6	75	20	20
Group C (RFITT)	Power (W)			
	16			
Group D (HS)	Power performance (%)			
	100			

Methods

Evaluation by the surgeon

Peroperative bleeding was assessed subjectively by the surgeon on the scale from 0 to 5 according to the extent of the use of conventional electrocoagulation to stop any bleeding that was not successfully stopped by the tested device. It does not concern minor tissue bleeding that stopped spontaneously. Blood loss was not measured in terms of volume because the Er,Cr:YSGG laser uses a cooling spray that would interfere with the measurement.

Postoperative bleeding was defined as any bleeding from the wounds between days 1 and 14 after the tonsillectomy.

Operation time was measured from introduction of retractor in patient's mouth until the last hemostasis check after the tonsillectomy.

Evaluation by patient

Postoperative pain was rated by the patients on a scale from 1 to 5 on the 1st, 2nd, 3rd, 4th, 7th and 14th day after surgery for left-side and right-side wound independently. (1 – no pain, 2 – moderate pain, 3 – bearable pain, can be endured, 4 – severe, very annoying pain, 5 – unbearable pain).

Patients were monitored for eventual development of other complications such as infection, swelling, earache, mumbling, difficult swallowing, leakage of food into the nasal cavity and gustatory disturbances. All surgeries and postoperative controls were performed by one physician.

Histological examination

Tissue samples were oriented to take sections perpendicular to the bottom of the excision, and parallel with the longitudinal axis of the tonsils. The tissue samples were routinely fixed in 10% buffered formalin, processed in autotechnicon and embedded in paraffin. 2 μm thick sections were cut and stained with hematoxylin and eosin. Thickness of devitalized zone was then evaluated, considering the following morphological features as signs of devitalization: pyknotic nuclei, eosinophilic cytoplasm, disrupted basal membranes and total destruction of cell structures. Equipment used: Olympus BX40, WH10×/22 eyepiece, lens Olympus Plan 10×/0.25.

Statistical evaluation

Statistical processing and testing was performed using STATISTICA data analysis software system (StatSoft, Inc. 2013. Version 12. www.statsoft.com.)

In order to respect the dependence of the right-side (alternative method) and left-side (traditional tonsillectomy) measurements, differences between the sides (R-L) were first calculated for each patient. Obtained differences were then tested for significantly nonzero means using two-tailed one-sample *t*-test at total $\alpha = 0.05$ (sum of both tails of the *t*-distribution).

In case of postoperative pain, the differences of pain scores reported during the postoperative period were averaged patient-wise and then processed. Besides the standard two-tailed test, right-sided 0.95 confidence intervals for means of the average differences were calculated, providing threshold values for significance of one-tailed one-sample *t*-test ($\alpha = 0.05$, H_0: $\mu <$ threshold) in order to estimate the maximal benefit of the treatment that is not contradicted by the data.

Ethics

The Ethics Committee of the Faculty Hospital Pilsen granted their approval to the study and data analyses. Written informed consent was obtained from all patients.

Results

Clinical evaluation

Examination of the differences in peroperative bleeding revealed statistically significant differences in the Ho:YAG laser (Group A, Fig. 1A), which offered almost bloodless procedure, and the harmonic scalpel (Group D), which achieved nearly the same result. Bleeding in the Er,Cr:YSGG laser (Group B) and radiofrequency scalpel (Group C) was comparable to the traditional method. None of the tested methods (including traditional tonsillectomy) was accompanied by extensive peroperative bleeding that would have clinical impact on the patient.

Concerning the average operation time (Fig. 1B), the Ho:YAG laser (Group A) shows significant reduction of unilateral tonsillectomy duration by 2 min in average. Contrastingly, the Er,Cr:YSGG laser (Group B) as well as the radiofrequency scalpel (Group C) required significantly prolonged operation time by an average of 4.3 and 1.6 min respectively. Application of the harmonic scalpel (Group D) was not accompanied by change of the average operating time.

Evaluation of the differences in postoperative pain between the laser methods, RFITT, harmonic scalpel and traditional tonsillectomy (Fig. 1C, Fig. 2) yielded a crucial knowledge. Surprisingly, Ho:YAG (Group A) and Er,Cr:YSGG (Group B) lasers showed significantly higher average postoperative pain

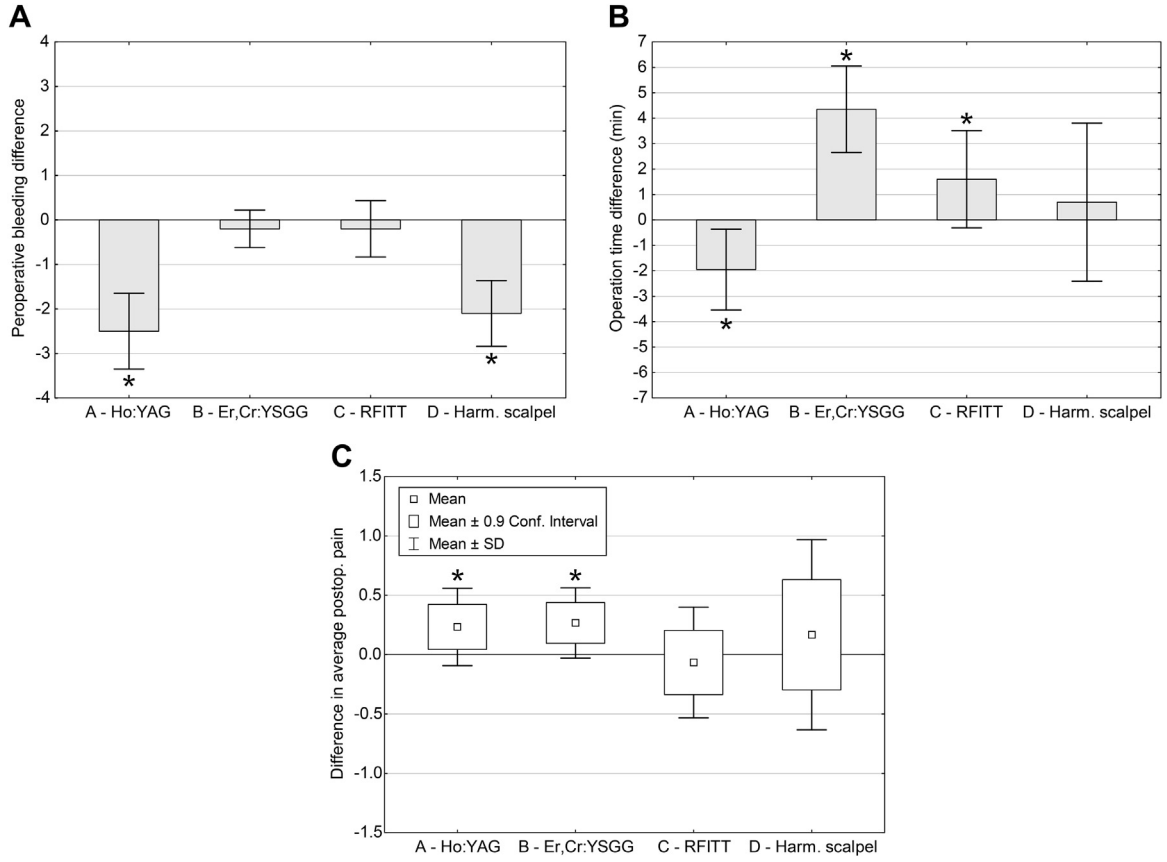

Fig. 1 – Clinical results of Ho:YAG, Er,Cr:YSGG, RFITT and harmonic scalpel in comparison to traditional tonsillectomy. A – peroperative bleeding, B – operation time, means ± SD are shown. C – average pain in postoperative period. Means of average pain difference between the right (laser or RFITT or harmonic scalpel-treated) and left side (traditional tonsillectomy) are shown. Boundaries of the 0.9 two-sided confidence interval for the mean are equal to boundaries of 0.95 one-sided confidence intervals and, therefore, represent critical values of one-tailed one-sample t-tests at $\alpha = 0.05$. Star symbols indicate statistically significant difference of the mean from zero.

than the traditional method. Since the average pain reported for RFITT and harmonic scalpel did not differ significantly from traditional tonsillectomy, significance threshold values of one-tailed *t*-test were calculated. Using these values, it can be concluded from the data with 95% confidence that the benefits of RFITT and harmonic scalpel are not better (i.e. more negative) than −0.34 and −0.28, respectively, representing maximal pain reduction of 8.5% and 7%, respectively, in relation to the scale 1–5.

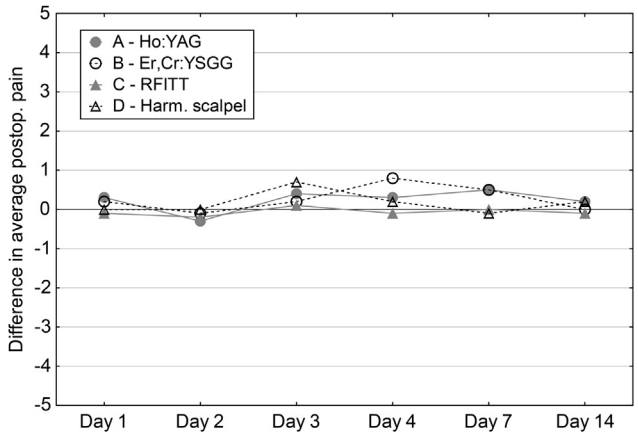

Fig. 2 – Evolution of postoperative pain in the experimental groups. Plotted values are mean differences between the right (tested device) and left side (traditional tonsillectomy).

Analysis of the frequency of postoperative bleeding (data not shown) did not reveal any new findings. Five percent of patients encountered postoperative bleeding (two in absolute numbers: 1 after traditional tonsillectomy, 1 after tonsillectomy with harmonic scalpel), which is not sufficient for evaluation in our limited sample.

Histological analysis

All the tested devices were quite gentle in terms of the damage inflicted on the surrounding tissue. Fig. 3 shows the devitalization zones for each operation method used.

Discussion

The Ho:YAG laser (Group A) is well suited for work in the oral cavity due to its universal fiber-suited ENT handpiece. The

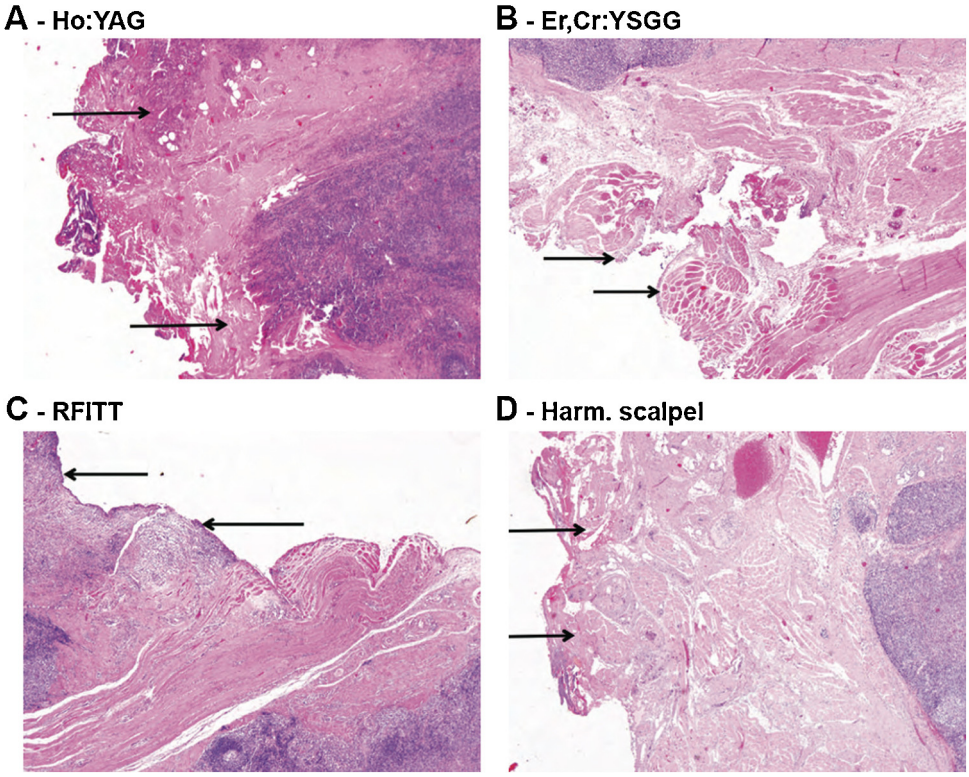

Fig. 3 – Histological evaluation of Ho:YAG, Er,Cr:YSGG, RFITT and harmonic scalpel in tonsillectomy. A – Ho:YAG (devitalization zone from 0.2 to 0.5 mm). B – Er,Cr:YSGG (devitalization zone 0.01–0.07 mm). C – RFITT (devitalization zone 0.1–1.0 mm). D – harmonic scalpel (devitalization zone 0.3–1.0 mm).

course of the operation, peroperative bleeding and operation time were all better than during classical tonsillectomy, but when the significantly higher postoperative pain is taken into account, the actual benefit for the patient is quite small. In the literature, reports of the application of the Ho:YAG laser in tonsillectomy are very scarce. The study performed by Fong et al. (1999) was rather experimental, thus making its results incomparable with our clinical findings. The work of Slouka et al. (2015), where the Ho:YAG laser was compared to KTP, Nd:YVO4, Th:DPFL, CO_2 and diode lasers of 810 nm, 940 nm, 980 nm for surgeries in the oral cavity, provided similar results to our current study regarding the course of the operation.

The Er,Cr:YSGG laser (Group B) is primarily designed for dental procedures, which determines the shape of its handpiece. Concerning the course of tonsillectomy, the Er,Cr:YSGG offers less benefits than Ho:YAG. While it still provides marginally less intensive peroperative bleeding than the traditional method, its significantly prolonged operating time even at the maximal power setting and mainly the significantly worse postoperative pain associated with the use of the Er,Cr:YSGG renders its application in tonsillectomy not advantageous for the patient. In the literature, several papers focused on dentistry (Matsumoto et al., 2002; Ryu et al., 2012; Perio, 2013) are available and only one Er,Cr:YSGG application similar to our study was reported concerning uvulopalatoplasty of the soft palate (Pavelec and Polenik, 2006), which, however, deals with a tissue with significantly less vascularity than palatal tonsils.

Working with the RFITT system (Group C) and harmonic scalpel (Group D) was technically without difficulty, but both instruments failed to show substantial changes in benefit for the patient, which is in accordance with previous studies (Aksoy et al., 2010; Alexiou et al., 2011).

Histological evaluation of the depth of the thermal damage of the tissue (Fig. 3) shows that all the methods cause only minor structural changes of the surrounding soft tissue. The clinical results suggest that the subtle differences in the condition of the tissue observed among the tested devices do not coincide with any clinical benefit of the tested tonsillectomy methods.

Concluding from the results, we can assume that rather than by the tissue preparation method itself, the discomfort of the patient is more likely to be affected by the anatomical location of the palatal tonsil, which implies permanent irritation of the exposed wound surface when swallowing, breathing, taking fluids, consuming solid meals and which also harbors local microbial populations. It cannot be ruled out that elimination of any of these factors or any deviation from the established operating procedure could bring some new solutions in the future, thus offering a less unpleasant course of medical treatment while maintaining its efficiency.

One of the possible future developments might be a completely new technique of tonsillectomy – preservation of

tonsillar bed and incomplete removal of the tissue, as suggested and tested by Palmieri et al. (2013) on a group of 20 patients in 2013. However, final conclusions will be possible after evaluation of larger multicenter studies.

Conclusions

All of the tested methods have proven to be safe and effective procedures, but the differences in the monitored parameters for each device did not show significant benefits for the patient using laser, radiofrequency scalpel or harmonic scalpel. These devices, therefore, do not represent a revolutionary way to minimize accompanying discomfort for patients and the current ''cold steel'' procedure remains the golden standard in tonsillectomy.

Conflict of interest

None declared.

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