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Evaluation of a Non-contact Diode Laser Coagulation vs. Electrocautery in Hemostasis in Lid Surgery

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Abstract

Appropriate hemostasis is a fundamental principle of modern surgery. The operations of the eyelids are very demanding in terms of precision of the equipment used to induce hemostasis. Nowadays one of the most frequently used methods for inhibition of intraoperative bleeding is bipolar electrocoagulation. However, this method has its limitations, of which the process of charred tissue adhesion to the tip of the probe, what significantly hinders the surgery, is the most vital one. With the increasing use of lasers in medicine, more and more often systems of laser contact cutting and coagulation are used. Unfortunately, despite the higher precision of performance, they have the same drawback as electrocogulation, namely the adhesion of charred tissue.

In our study we compare the efficacy of a bipolar contact electrocoagulation with the non-contact method using a diode laser during dermatochalasis surgery of 60 eyes in 30 patients. There have been shown a clear shortening of time to achieve hemostasis in the eyes treated with laser coagulation. With no contact with the bleeding tissue, laser coagulation precisely and without delay inhibits bleeding, which significantly shortens the time of surgery. Cost-efficiency of diode lasers, as well as no need for sterilization of the laser probe further enhance the advantages of this method, which in the case of eyelid surgery has better performance results than electrocoagulation.

INTRODUCTION

Appropriate hemostasis is a fundamental principle of modern surgery, and electrocoagulation is the most popular method of achieving it (1,2,3).

Electrocautery is a process involving the destruction of the surrounding tissue by thermal energy generated by a metal probe through which electric current flows. This phenomenon is used in medical devices used for inhibition of bleeding of both small and large vessels, as well as for cutting tissue. The effect depends on the applied power of electric current. Both unipolar (monopolar) and bipolar electrodes are used. In the case of unipolar electrode the tissue around the tip of the probe is coagulated, the second electrode of large surface is placed under the buttock. In bipolar method the current flows only between the two ends of the tweezers which function as opposed electrodes (4,5,6).

Changes caused by high temperature cause charring of tissues and their adhesion to the tip of cauterization (Figure 1). This results in a prolongation of the procedure because there is a need for continuous purification of the tip. There is also a decrease in the efficiency of inhibition of intraoperative bleeding due to decreased electrical conductivity of the probe tips. We can observe a decrease in the precision of hemostasis, what results in a further prolongation of the surgery and may cause secondary bleeding (7,8). In the past, some authors have attempted to prevent this process through the use of irrigation combined with electrocoagulation (9,10, 11).

Figure 1

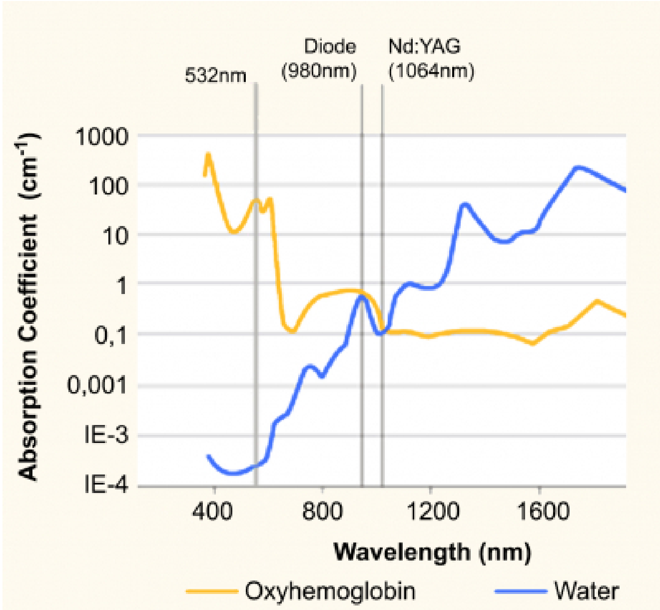
Charred tissue debris adhered to the electrocautery tips

In recent years there has been a continuous increase in the use of lasers in ophthalmology and modern surgery (12,13). The laser light causes a similar, though not identical, effect on tissue like electric current does. The surgery uses its properties of coagulation, ablation, evaporation and cutting tissue. Which of these reactions predominates is determined by the wavelength of the laser light, power applied, exposure time, as well as the tissue optical properties (absorption, scattering, reflection) (14,15). Due to the relatively low prices and small size, diode lasers are beginning to be widely used in surgical procedures (13).

The wavelength of 980nm has a high absorption of both hemoglobin and water, which favors very good coagulating properties of this kind of light (16, 17, 18) (Figure 2). So far, however, there have been used contact cutting-coagulation systems, broadly applicable, among others, in the dental surgery (19). However, the residues of charred tissue at the tip of the optical fiber adversely affect the comfort of using this type of tips. For this reason, we made the tip for non-contact coagulation of vessels, compatible with the typical diode laser 980 nm. To our knowledge this is the first publication assessing the use of non-contact system of laser coagulation.

Figure 2

Absorption dependence of wavelength for oxyhemoglobin and water



MATERIALS AND METHODS

30 patients aged from 51 to 83 years with clinically the same dermatochalasis of both eyes (the skin excess of the upper eyelid), underwent the surgery to remove skin excess of both upper eyelids affecting visual comfort (Figure 3).

Figure 3

Patient with dermatochalasis scheduled for surgery

The patients consisted of 10 men and 20 women. The size and shape of the removal on the right and the left side was the same. Alternately, there was used a standard electric coagulation of 30W and non-contact laser coagulation with the power of 10W and continuous mode. These powers of both devices were previously experimentally determined to obtain the same clinical effect of hemostasis in the form of stopping the bleeding with minimal charring of tissue. In each of 30 patients, the upper eyelid was coagulated at one side with a bipolar electrocautery, and the other side was treated with the non-contact laser coagulation with diode laser 980 nm. Coagulation time was measured for both devices from the start of coagulation (after removal of the skin flap of the upper eyelid) till a dry wound was obtained.

The laser system consisted of a portable diode laser with a maximum power of 15W and a weight of 2 kg, a multimode optical fiber having a diameter of 800um and a non-contact tip with dimensions of 20x20x60 mm. The tip consisted of a collimator and a focuser (Figure 4, Figure 5). The collimator was intended to make the light rays coming from the fiber become a parallel beam. Focuser consisted of a focusing lens, with a focal length of 45 mm (Figure 6). Thanks to it, parallel beam outgoing from the collimator was converged within 45mm in front of the tip. We designed this distance to be convenient to use with the tip held in the surgeon’s hand, and the hand placed on the patient’s face. The focal point had the size of 1mm.

Figure 4

Laser probe structure

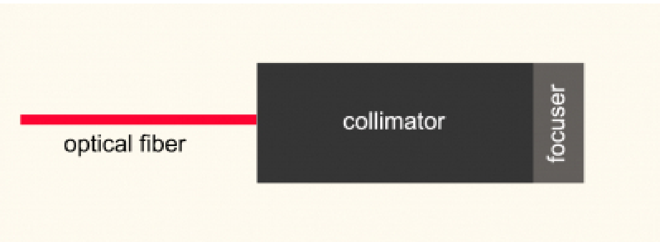


Figure 5

Laser probe

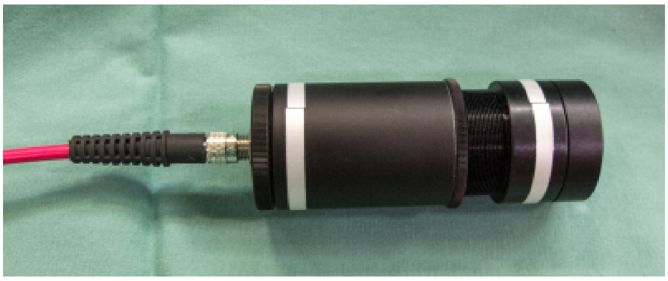


Figure 6

Focused laser pilot beam over the liquid nitrogen vapours to visualize the focal point

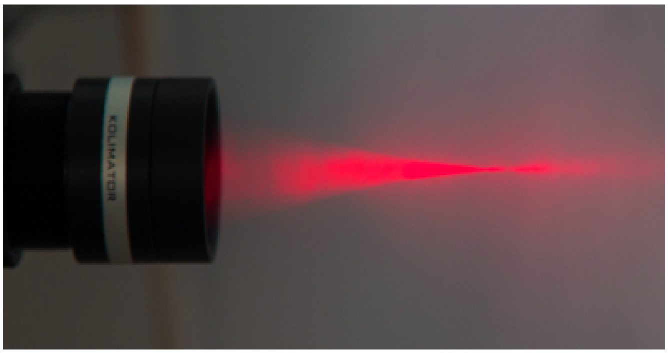


Figure 7

Laser non-contact coagulation in use

Program Statistica 10.0 (StatSoft Inc., 2011) was used for statistical analysis. Conformity assessment of the distribution of the variables tested with normal distribution were made using the Shapiro-Wilk test. Due to the fact that the variables do not differ significantly from the normal distribution, statistical analyses were performed using parametric tests. For the comparison of the time of surgery of the two methods there was used t-test (Student) for variables related, and for the comparison in the independent plan (gender) there was used test t (Student) for variables unrelated. The surgery time correlation analysis of the age of the patients was performed using Pearson's correlation coefficient r. Assumed significance level was $\alpha = 0{,}05$. Statistically significant results were these, when the calculated test probability p satisfied the inequality $p < 0{,}05$.

RESULTS

Table 1 shows the results of surgery times with statistical parameters.

Table 1

Results of surgery times with statistical parameters

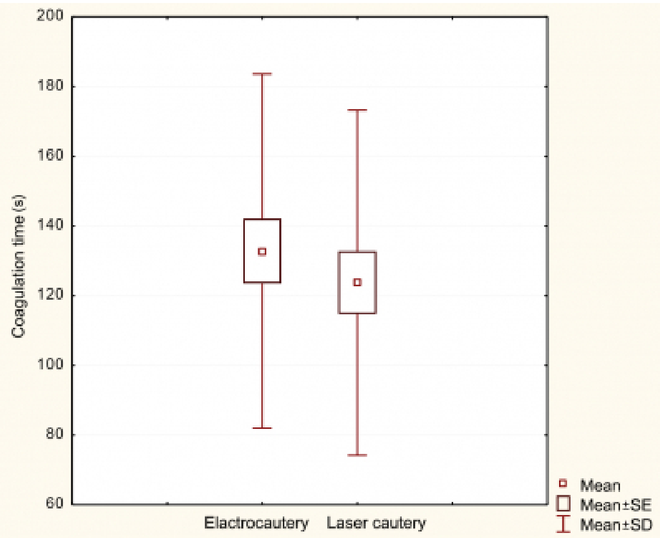
Method	Paired differences		t	p
	Mean	SD		
Electrocautery (E)	132,8	50,8	5,9	<0,05
Laser coagulation (L)	123,7	49,5		

SD – standard deviation
t – t-statistic
p – p-value

The result of analysis shows statistically significant differences in average time of the surgery compared with both methods (t = 5,9; p<0,05). Average time of the procedure using electrical method amounted to E = 132,8 seconds (at SD = 50,8), while the average time calculated for the laser method was lower by about 9 seconds and was L = 123,7 seconds (SD = 49,5) (Figure 8).

Figure 8

Coagulation time - dependence of the method



The results of the analysis depending of the patient's age at the time of the procedure for each of the methods were far from significance. Also, gender did not affect the duration of the procedure using electrocautery (p = 0,61), as well as laser coagulation (p = 0,63).

DISCUSSION

Hemostasis is defined as all mechanisms employed to prevent the outflow of blood from the blood vessels, both in normal conditions and in cases of damage, providing at the same time the correct flow in the bloodstream. The concept of hemostasis includes both blood coagulation and fibrinolysis. Both processes occur simultaneously, even at the time of clot formation. Adequate hemostasis is a prerequisite for any surgical procedure on vascularized tissue (20,21). Operations in the area of the eyelids, especially those within the scope of the plastic surgery, require a special, good control of bleeding due to the final aesthetic effect (22,23). Currently, a standard tool in the maintenance of normal hemostasis in medical procedures is electrocautery. It generates locally high temperature resulting in local tissue charring and vasoconstriction leading to, as a result of hematological processes, clot formation that stops bleeding. It sometimes happens that the clot gets secondarily unsealed and then secondary bleeding occurs. It is especially the case when charred tissue adheres to the tips of the electrodes, and during the separation of the electrodes from the coagulated surface the re-bleeding occurs. The above process and the need for continuous tip cleaning extends the time of surgery.

In the present study, the average time of coagulation with electric device was about 9 seconds longer than in the case of non-contact method using laser. This was the result of a lack of contact between the tissue and the tool. There was no need to clean the tip and secondary bleeding did not appear. Good coagulation characteristics of 980nm diode laser is also due to the high absorption of this wavelength by hemoglobin and water (18). Because of the high precision of performance -laser focus has a diameter of 1 mm, almost no charring of tissue occurred. Rather a dominating evaporation process was observed. All these factors contributed to the shortening of the time required to reach the proper hemostasis on laser operated side. The above advantages of the diode laser in the induction of hemostasis is further emphasized in other publications (15,17,18). By making surgery on both sides in each patient, on one side using electrocoagulator and the laser on the other, there was eliminated the impact on the results of individual differences of tendency to bleed. Other authors, to eliminate the above described disadvantages of electrocautery used the additional irrigation systems, but their use did not affect the shortening of surgery time, because it was necessary to perform additional actions during their use (9,10,11). Laser non-contact system used in this study did not require any extra steps, and it even reduced them. Also, no need to sterilize the laser probe is important for the surgeon. The tip of the set is draped with a sterile sleeve, and the tip itself has no contact with the tissue. In the case of electrocoagulation, every time it was necessary to set a new sterile tweezers with electrical cable. To achieve an adequate, comparable, hemostasis in the electric set it was necessary to use three times higher power than in the laser set (30W vs. 10W respectively). This is probably due to this fact that less charring of the tissue in the case of using a laser occurred. The cost of the laser system, thanks to the constant lowering of prices of diode lasers is comparable to bipolar electrocautery set.

CONCLUSIONS

This study showed a higher efficiency of contactless laser coagulation versus contact, bipolar electrocoagulation. With no contact with the bleeding tissue and the specific properties of the wavelength of 980nm, laser coagulation foci inhibit bleeding precisely and without delay, which significantly shortens the surgery time. Cost-efficiency of diode lasers as well as no need for sterilization of the laser probe further enhance the advantages of this method, which works better than electrocautery in the surgery of the eyelids.

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