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Research Article

The Nature of the Propagation of Thermal Impact during in the Energetic Cataract Surgery

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Abstract

The experiment studied the degree of heating of working handpieces used in modern ultrasonic and laser cataract surgery. The nature of the propagation of the thermal effect from the power tips at various operating modes in liquid and air is determined.

Keywords: *Ultrasound and Laser Cataract Surgery; Thermography*

Introduction

Cataract is the main cause of blindness and visual disability. The basic technology for cataract removal is currently ultrasound surgery - phacoemulsification. Over the last 60 years, the intelligence of doctors and engineers around the world has been invested in the phacoemulsification. The ultrasonic machines have reached a high degree of excellence. However, a serious drawback of this technology lies in the main physical property of ultrasound, which cannot be changed. The human lens is surrounded all around by cameral fluid and it is a good conductor of scattered ultrasound radiation. Therefore, when the lens is destroyed, all structures of the eye have ultrasonic radiation. Ultrasonic energy goes beyond the eye. Since the 90s of the last century, scientists have been trying, at least partially, to replace ultrasound with laser energy.

The first and the single, only laser technology in the world, which does not partially, but completely excludes ultrasound, was created under the leadership of academician. S.N. Fyodorov (1994 - 1997) surgeon V.G. Kopaeva and engineer-physicist A.V. Belikov [1,7]. Technology allows to destroy any cataract density without the involvement of ultrasound, without manual fragmentation of the lens nucleus. Today there is no other similar technology, where the introduced energy of the endodissector does not go beyond the lens and does not affect the surrounding tissues of the eye.

However, the introduction of the energy into a closed, low-volume eye cavity can raise concerns about the possible side effects, thermal effects, during the destruction of the lens occurs in close proximity to such sensitive areas of the eye as the iris, ciliary body and cornea.

Purpose and Method

To study in an experiment the degree of heating of the working tips, used in modern energetic cataract surgery (ultrasonic and laser) at various modes and power values of devices using a portable computer thermograph "IRTIS 2000", which is an optomechanical scanner with a highly sensitive infrared receiver with a measurement accuracy of 0.02°C.

Results

Studies have shown that the tip of the Stellaris Vision Enhancement System (Bausch + Lomb) operating in a continuous mode of 100% ultrasound without irrigation protection heats the needle up to a maximum of 44.21 ± 0.04°C, and when working in a pulsed mode, the needle heats up to the same temperature 1.5 times slower. In a pulsed mode of surgery and standard values of 40% of ultrasound, the phaco needle (tip) is heated even more slowly (by 1.7 times) and does not reach the limit values (Figure 1).

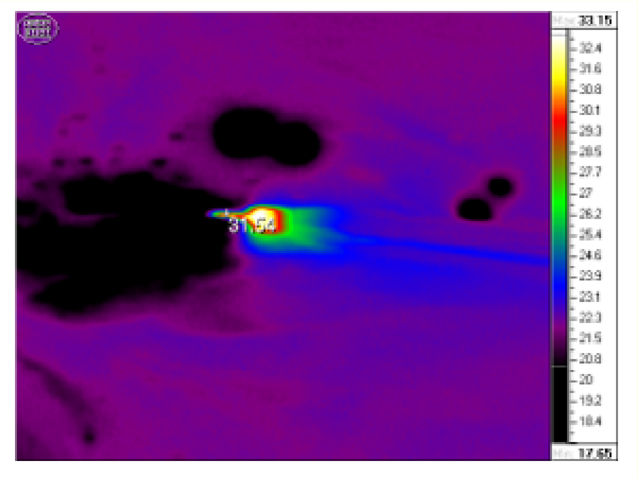

Figure 1: *The thermogram demonstrates the heating of the ultrasonic needle of the phacoemulsifier at 40% ultrasound power without cooling in a continuous mode.*

According to other authors, the maximum heating of the tip in air at the entrance to the cornea is recorded in the range from 39 to 55°C during the operation of ultrasonic tips of various phaco machines [10]. The place of direct contact of the phaco needle at the entrance to the cornea is the most problematic area if at some point there is insufficient or no coolant flow. However, with a short exposure to ultrasound, the maximum temperature recorded by us did not cause corneal burns. Deep stromal damage to the cornea occurs when exposed to temperatures above 50°C, if this exposure lasts more than 10s [6]. The use of irrigation solutions in the process of phacoemulsification under different operating modes of a needle with a coaxial irrigation sleeve effectively reduces the temperature to values that are safe for eye tissues.

In comparison with ultrasonic tips, the study of the laser tip of the "Rakot"VI device (Nela, Russia) showed that in air and in an aqueous medium at all operating modes at maximum (300 mJ) and average energy (150 mJ), the tip with a laser quartz-quartz fiber does not heat up (Figure 2).

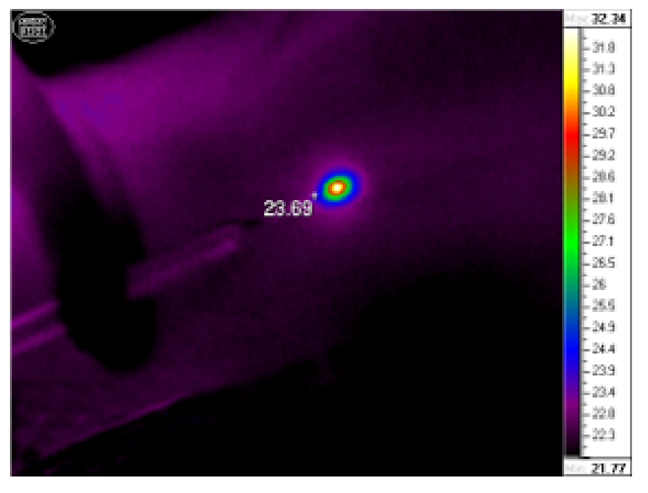

Figure 2: *The thermogram demonstrates instantaneous heating of only the air at the end of the laser fiberoptic tip with the laser beam Energy 300 mJ.*

Discussion

The spread of thermal energy from working handpieces in an aqueous medium has its own characteristic features. During the operation of the ultrasonic tip, the solution is uniformly mixed with a gradual slight increase in its temperature throughout the entire volume of the vessel (even within the entire Petri dish). When the laser tip is turned on, the temperature rises in a wider range, but locally, only in the area of the laser fiber tip in the center of the experimental vessel. At the same time, the laser light guide itself and the surface of the tip of the RakotVI laser cataract extractor (Nd-YAG 1.44 µm) does not heat up during operation and do not need cooling [3,4]. The cold mode of operation of the laser handpiece makes it possible to completely seal the incision during the operation. This is an important feature of laser cataract extraction. It plays an essential role in ensuring the efficiency and safety of the operation [8].

It is important to note that the short-term increase in the temperature of the intraocular fluid during the operation of the power tips (ultrasonic and laser), due to the effective mechanism of irrigation and aspiration, does not reach dangerous values. Similar data were presented by other authors [2] when conducting a thermographic study in a clinic.

It should also be taken into account that in a living organism the process of heat exchange and thermal protection is more perfect than in the experiment due to the function of the vascular bed of the eye.

Conclusion

In the process of ultrasonic and laser cataract surgery, with a balanced operation of the energy and irrigation-aspiration system, there are no significant temperature rises that can cause thermal damage to the tissues of the eye. A slight burn of the cornea is possible at the site where the ultrasonic tip enters the cornea only when the synchronization of the irrigation solution supply and discharge is disturbed.

Laser cataract extraction with the "Rakot" device for the removal of soft, medium and hard cataracts is thermally safe even under conditions of short-term occlusion of the aspiration system [4,5,9].

The generated heat only around the tip of the laser light guide in the Rakot installation is carried away by the flow of a balanced solution before the next pulse is generated with the release of heat. This is due to the fact that laser pulses follow with an interval that is significantly (hundreds of times) longer than the pulse duration.

Disclosure

The authors declare that they do not have any financial interest or conflict of interest.

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