Real-time Measurement of Intraocular Pressure During Femtosecond Laser Enabled Keratoplasty

To the Editor:

The use of the femtosecond laser in refractive (LASIK) and corneal (IntraLase-enabled keratoplasty) procedures has steadily increased in the past several years with the commercial availability of four different types of femtosecond laser systems.1-9

The most commonly used femtosecond laser, the IntraLase FS (Abbott Medical Optics, Santa Ana, California), relies on a low-pressure (35 mmHg) suction ring to align and stabilize the globe. A flat lens attached to the laser delivery system is used to applanate the cornea within the suction ring. To create the ideal cut to penetrate the corneal tissue, sufficiently high intraocular pressure (IOP) is needed to treat the eye.

Several reports have proposed a casual relationship between suction of the globe and retinal detachments in myopic eyes, macular hemorrhages, macular holes, lacquer cracks, and choroidal neovascularization. However, there have been no well-controlled clinical studies that demonstrate a relationship between high IOP and these complications with the femtosecond laser. Different hypotheses have been used to explain the potential for posterior segment complications, with the first theory being that mechanical stress is triggered by the IOP elevation induced by the pneumatic suction ring. The theory is that this increase in pressure may induce tangential stress on the posterior segment.

The challenge with identifying elevated IOP during flap creation or penetrating keratoplasty (PK) is the real-time measurement of IOP. Currently, there are two ways to measure IOP during corneal refractive surgery: applanation tonometry and direct cannulation of the anterior chamber or vitreous cavity.

Because it is not possible to use applanation tonometry under these circumstances, we conducted a study to investigate whether direct cannulation of the anterior chamber could provide accurate, real-time IOP measurements via the posteroocorneal limbus. The main potential drawback of this approach is reduced perilimbal space while applying the suction ring.

In this experimental model, we prospectively evaluated the changes in IOP from the application of the suction ring to cone application with the patient interface in place through to removal of the suction ring. A 60-year-old man was scheduled to undergoenucleation due to an iris tumor secondary to metastatic bronchial cancer. Before undergoing enucleation, the patient was informed about the measurement and potential complications. He provided written agreement following informed consent. The study was approved by the ethical committee of the Ruhr University Eye Clinic, Bochum, Germany.

To obtain the measurements, we used an intraocular needle tonometer (Düsseldorf, G-19235; Geuder, Heidelberg, Germany). A special 26-gauge needle was inserted through a limbal paracentesis through the soft part of the suction ring into the anterior chamber. This needle was connected to an electrolyte solution–filled infusion system that transmitted the IOP to a piezoelectric element. The IOP could be read on a monitor connected to the system. Before starting the procedure, the system was calibrated to verify that the pressure would be registered correctly.

The IOP was measured at five stages: 1) at placement of the suction ring; 2) when the suction was turned on; 3) upon cone application; 4) when cone application was stopped; and 5) when the suction was turned off. Each series of measurements was performed four times. As a final step, a PK cut (full thickness) was created in the cornea with the femtosecond laser. During this procedure, the IOP was recorded continuously. In customary surgery, suction is turned off at the end of the procedure and the whole patient interface is removed. In the final step of this experiment, the needle was removed carefully by lowering the suction slowly. At the same time, the cone pressure was decreased slowly to reduce the risk of expulsion of ocular contents including tumor tissue. This procedure is different compared to customary surgery but was necessary because of the position of the special needle within the cone and anterior chamber. This final step was possible only once because the needle had to be removed in a controlled and careful manner, preventing damage to the intraocular structures.

At the first stage of measurement (no suction), the IOP ranged from 17 to 20 mmHg, while at the third stage (cone applanation on), the IOP ranged from 95 to 97 mmHg. Upon removal of all suction, the IOP level immediately returned to within a normal range (18 to 20 mmHg). The mean time to complete suction was 21 seconds; the total time to create the PK was 185 seconds.

These measurements confirmed an immediate increase in IOP after the placement of the suction ring that was maintained during the entire procedure. At each measurement, the IOP remained below 100 mmHg. After suction was stopped, IOP levels returned to preoperative values.

To date, the only other study to evaluate intraoperative IOP during flap creation with a femtosecond laser was an animal eye study in which researchers compared the IOP between pig eyes that underwent suction.
and pressure increase and LASIK flap creation using two different devices: a femtosecond laser (IntraLase FS Laser) and the M2 microkeratome (Moria, Antony, France). Intraocular pressure increased in both groups: in the femtosecond laser group, the mean IOP during suction was 89.24 ± 24.57 mmHg and 119.00 ± 17.01 mmHg during flap creation. In the microkeratome group, the mean IOP was 122.53 ± 30.40 mmHg during suction and 160.52 ± 22.73 mmHg during flap creation. The authors noted that the femtosecond laser group had overall lower IOP increases, although the amount of time required for flap creation was longer compared to the mechanical microkeratome.

A number of other published studies have examined IOP increases in animal and donor eyes during flap creation. Bissen-Miyajima et al11 measured IOP increases in animal and donor eyes during the mechanical microkeratome. The time required for flap creation was longer compared to the overall lower IOP increases, although the amount of time required for flap creation was longer compared to the mechanical microkeratome.

The lower IOP level found in our study compared to the rate reported in the study by Hernández-Verdejo et al10 may reflect the fact that the velocity at which the pressure is transmitted in a fluid-filled tube depends on the fluid velocity. The measurements registered in the anterior chamber are thought to be more precise than those obtained in the vitreous cavity, which is why we used this method of measurement. Furthermore, based on statistical analysis (data not presented), this method also enduces reproducible results.

Sudden increases in IOP, although well tolerated, may induce retinal changes.13,14 As a result, it is important to obtain an accurate measurement of the IOP during refractive and corneal procedures where the globe is placed under increased pressure. Although the IOP increase triggered in this study was lower than that seen with traditional, mechanical trephine keratoplasties, suction was applied for a longer period of time. The clinical implication of such a rise in IOP and its association with increased duration of raised IOP with femtosecond laser needs to be elaborated further. Moreover, comparative studies are needed to determine whether there is a long-term impact due to this difference in the procedures.

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REFERENCES