Intraocular pressure measurements during flap preparation using 2 femtosecond lasers and 1 microkeratome in human donor eyes

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PURPOSE: To evaluate and compare intraocular pressures (IOPs) during flap preparations performed using 2 femtosecond lasers and a mechanical microkeratome in human donor globes.

SETTING: University Medical Center Mainz, Mainz, and Euroeyes Clinic Stuttgart, Stuttgart, Germany.

DESIGN: Experimental study.

METHODS: A cannula was inserted through the optic nerve in human globes. The IOP was obtained continuously during flap preparation using the 60 kHz Intralase femtosecond laser, the 200 kHz Visumax femtosecond laser, or the Amadeus II microkeratome. For each experiment, a normal lamellar flap preparation (regular procedure) and a worst-case procedure (femtosecond laser interface was pressed against globe until docking maneuver was aborted) were performed.

RESULTS: During the regular procedure, the mean maximum IOP measured was 181.3 mm Hg (range 159.1 to 194.8 mm Hg) with the 60 kHz femtosecond laser, 77.6 mm Hg (range 58.1 to 100.3 mm Hg) with the 200 kHz femtosecond laser, and 198.1 mm Hg (range 162.8 to 299.6 mm Hg) with the microkeratome. During the worst-case procedure, the maximum measured IOP was 319.7 mm Hg (range 299.1 to 341.2 mm Hg) with the 60 kHz laser and 120.4 mm Hg (range 118.1 to 134.7 mm Hg) with the 200 kHz laser.

CONCLUSION: Maximum IOPs during corneal flap preparations in human enucleated eyes were lower during performance of a regular procedure and a worst-case procedure with the 200 kHz femtosecond laser than with the 60 kHz femtosecond laser and the mechanical microkeratome.

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Laser in situ keratomileusis (LASIK) is an effective surgical treatment for refractive errors such as myopia, hyperopia, and low astigmatism.[1] The LASIK procedure consists of 3 steps: preparation of a corneal flap with a microkeratome or a femtosecond laser, ablation of stromal tissue using an excimer laser, and repositioning the flap.[1]

Femtosecond lasers emit laser pulses of very short duration in the femtosecond range (one-quadrillionth of a second; 10^{-15} s) using the principle of mode locking. Femtosecond lasers use infrared light to produce precise, nonmechanical intrastromal cutting. Each laser pulse causes a small intrastromal dissection with a diameter of several micrometers using photodisruption. The damage to the neighboring tissue is minimal.[2] Femtosecond laser–assisted LASIK seems to result in better uncorrected visual acuity than conventional LASIK.[3,4]

Laser in situ keratomileusis procedures performed using mechanical microkeratomes can lead to complications in the anterior and posterior segments.[5] Posterior segment–related complications, such as posterior vitreous detachment, rhegmatogenous retinal detachment, choroidal neovascularization, macular hemorrhage, macular holes, and cystoid macular edema, have been reported.[6–8] Most complications are related to intraoperative intraocular pressure (IOP) elevation.[9,10]

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Posterior segment complications after femtosecond laser-assisted LASIK procedures have also been reported. For example, Principe et al.[11] describe a case of postoperative macular hemorrhage, and Hori et al.[12] report a case of rhegmatogenous retinal detachment.

Recently, we published results obtained from continuous IOP measurements recorded during LASIK flap preparations performed using 4 models of femtosecond lasers.[13] However, intraocular measurements were performed in porcine globes, which differ from human eyes anatomically and biomechanically.

Thus, the aim of the present study was to obtain and evaluate the IOP during femtosecond laser–assisted and microkeratome-assisted LASIK flap preparation in human donor globes.

MATERIALS AND METHODS

Enucleated globes from human donors that had been excluded from transplantation use because of positive serology results for hepatitis B or C or for human immunodeficiency virus were used in the experiments. Consent for experimental use of the donor tissue was obtained from the donors' relatives. The study was approved by the local ethics committee.

The time between death and IOP measurements did not exceed 24 hours. None of the globes had visible corneal clouding or anatomic abnormalities. The IOPs were measured during performance of LASIK flap preparations using the following 3 devices: the 60 kHz Intralase femtosecond laser (Abbott Medical Optics, Inc.), the 200 kHz Visumax femtosecond laser (Carl Zeiss Meditec AG), and the Amadeus microkeratome (Ziemer Ophthalmic Systems AG).

The experimental setup was assembled as described by Bradley et al. (Figure 1).[14] A pressure transducer (33X, Keller AG) was used; the transducer was previously calibrated by the manufacturer using a dead-weight tester (accuracy ±0.042%). The transducer was connected to a pneumotonometer, and calibration was confirmed before each experimental session by comparing the display on the transducer with pneumotonometer values at 20 mm Hg and 200 mm Hg. The transducer was then connected to a transparent chamber with a 20-gauge cannulation needle on top and to an infusion set via a 3-way stopcock. The system was filled with sodium chloride 0.9%, and the remaining air was washed out through the cannula.

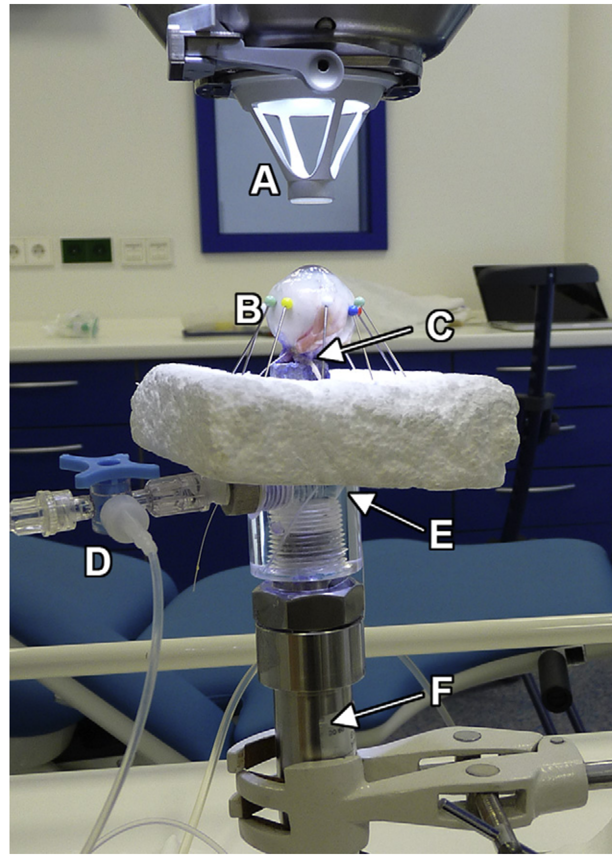

Figure 1. The experimental setup. The 20-gauge needle on top of the transparent chamber (C) is inserted into the vitreous cavity of a human globe (B). Pressure values were obtained every 0.1 second from a pressure transducer (F) connected to the transparent chamber (E). Femtosecond laser contact glass (A); 3-way stopcock (D).

Measurement Technique

The cannula was introduced into the vitreous cavity of each globe via the optic nerve. During the maneuver, minimal outflow of saline prevented insertion of air. The IOP was then adjusted to between 15 mm Hg and 20 mm Hg. The stopcock was closed, and the cannula was examined for vitreous blockage by discrete indentation of the globe, which should lead to a steep increase in the IOP curve. In case of blockage, the cannula was flushed again outside the eye and repositioned. The site of needle insertion was sealed using n-butyl-2-cyanoacrylate glue (Histoacryl, B. Braun Melsungen AG). The IOPs were measured every 100 milliseconds during the performance of each experiment, resulting in a pressure curve; Figure 2 shows examples of the curves.

In the 2 femtosecond laser groups, 2 types of procedures were performed in each globe. First was a worst-case procedure in which the highest IOP tolerated by the devices was measured. Both femtosecond lasers have a sensor that measures the force with which the eye is pressing against the patient interface (Table 1). They are also equipped with

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Christina Butsch, MD, B. Sprang, I. Vachtel, and T. Meyer procured the donor globes.

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