Anterior Segment OCT Imaging After Femtosecond Laser Cataract Surgery

Zoltan Z. Nagy, MD, PhD, DSc; Tamás Filkorn, MD; Ágnes I. Takács, MD; Kinga Kránitz, MD; Tibor Juhasz, PhD, DSc; Eric Donnenfeld, MD; Michael C. Knorz, MD; Jorge L. Alio, MD, PhD

ABSTRACT

PURPOSE: To report the anterior segment imaging characteristics after femtosecond laser assisted cataract surgery.

METHODS: Cataract surgery was performed with the LenSx femtosecond laser (Alcon-LenSx Inc., Aliso Viejo, CA) in 40 eyes of 40 patients. The laser was programmed to perform a 4.5-mm capsulorhexis, a cross-pattern fragmentation of the nucleus, a 2.8-mm main incision, and a 1.0-mm side-port incision. The anterior segment was then analyzed using the Visante OCT anterior segment program (Zeiss-Meditec AG, Jena, Germany).

RESULTS: The preoperatively set treatment parameters correlated well with the achieved results. For the capsulorhexis, the femtosecond laser cut was programmed to start 350 μm behind the anterior lens capsule and OCT measured 377 ± 55.3 μm. Nucleus fragmentation was programmed to start 750 μm in front of the posterior capsule and end 550 μm behind the anterior capsule, and OCT measured 794 ± 111 and 568 ± 147 μm, respectively. The diameter of the capsulorhexis measured by OCT was 4.54 ± 0.2 mm, compared to the 4.5 mm programmed.

CONCLUSIONS: Anterior segment OCT imaging was able to detect the tissue changes within the lens after femtosecond laser capsulorhexis and nucleus fragmentation. The measured values correlated well with the planned treatment parameters.

[J Refract Surg 2013;29:110-112.]

Femtosecond laser technology has been widely used in recent years, especially in corneal surgery. The first use in corneal flap creation in LASIK was reported in 2003.[1] The technique was first described by Kurtz et al.[2], and later Vogel[3] and Juhasz[4] contributed.

In recent years, femtosecond laser technology has been introduced for cataract surgery.[5-11] We report the results of anterior segment imaging immediately after femtosecond laser treatment of the lens and the cornea during cataract surgery, with special regard to morphological changes observed within the crystalline lens and in the cornea.

PATIENTS AND METHODS

Forty eyes of 40 patients with cataract were included in this study. Cataract grade was assessed by the Lens Opacities Classification System III (LOCS III) grading system. All eyes were between LOCS 2.0 and 4.0. Exclusion criteria were dilated pupil size less than 6 mm, corneal scars, lens subluxation, previous eye surgery, and very hard (more than LOCS 4.0) or mature cataract.

Patients gave their informed consent to the femtosecond laser procedure and the study was approved by the Ethical Committee of the University (Semmelweis University, Budapest) and the Regional Ethical Committee. Surgery was performed as detailed elsewhere.[7] In brief, all operations were performed under topical anesthesia (proparacaine hydrochloride 0.5%) by the same surgeon (ZZN). The LenSx femtosecond laser system (Alcon LenSx Lasers Inc., Aliso Viejo, CA)

From the Department of Ophthalmology, Semmelweis University, Budapest, Hungary (ZZN, TF, AIT, KK, TJ); the Department of Ophthalmology, University of California–Irvine, Irvine, California (TJ); Ophthalmic Consultants of Long Island, Rockville Centre, New York (ED); Medical Faculty Mannheim of Heidelberg University, Mannheim, Germany (MCK); and the Department of Ophthalmology, Universidad Miguel Hernandez, Alicante, Spain (JLA).

Submitted: July 20, 2012; Accepted: November 30, 2012

Drs. Nagy, Juhasz, Knorz, Donnenfeld, and Alio are consultants to Alcon-LenSx Inc. The remaining authors have no financial or proprietary interest in the materials presented herein.

Correspondence: Zoltan Z. Nagy, MD, PhD, DSc, Department of Ophthalmology, Semmelweis University, Mária u. 39, H-1085 Budapest, Hungary. E-mail: nz@szem1.sote.hu

doi:10.3928/1081597X-20130117-05

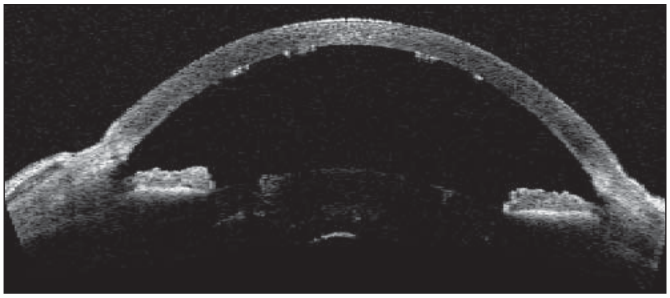

Figure 1. Carbon dioxide bubbles attached to the corneal endothelium (Visante OCT; Zeiss Meditec AG, Jena, Germany).

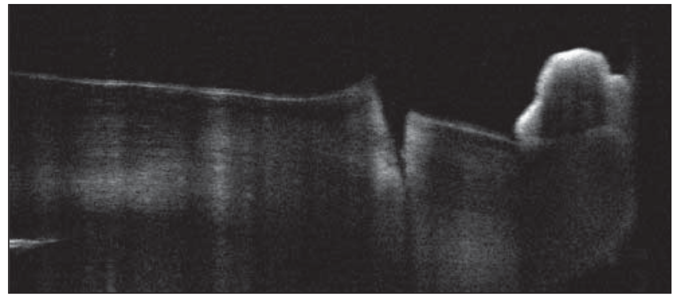

Figure 2. Laser-created continuous curvilinear capsulotomy. In the lower part, the complete capsulorhexis can be seen (Visante OCT; Zeiss Meditec AG, Jena, Germany).

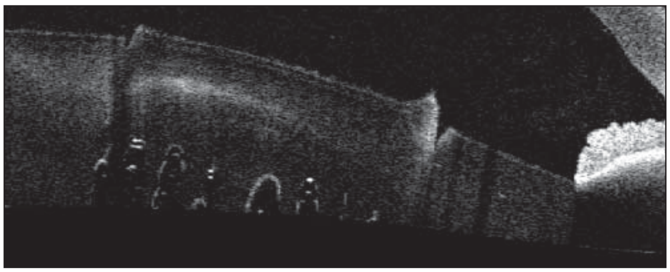

Figure 3. Laser capsulotomy within the anterior capsule (Visante OCT; Zeiss Meditec AG, Jena, Germany).

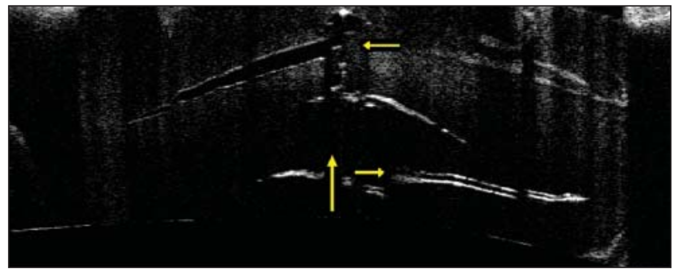

Figure 4. Dissection plane of the femtosecond laser within the lens nucleus (Visante OCT; Zeiss Meditec AG, Jena, Germany).

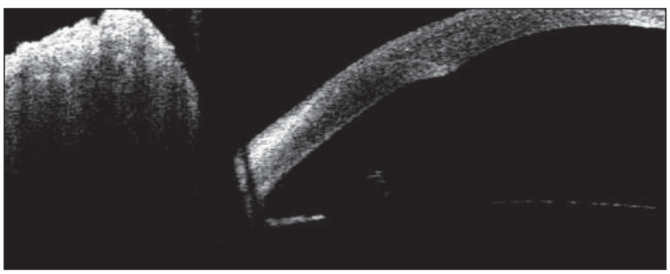

Figure 5. Self-sealing corneal wound created with the femtosecond laser (Visante OCT; Zeiss Meditec AG, Jena, Germany).

was used to generate a 4.5-mm capsulotomy, nucleus fragmentation in a cross-pattern with a diameter of 4.5 mm, and two corneal incisions (a 2.8-mm two-plane main incision and a 1.0-mm single-plane side port incision). The capsulotomy laser-cut was programmed to start 350 µm below the anterior lens capsule and end 100 µm above the anterior capsule. The nucleus fragmentation was programmed to start 750 µm in front of the posterior capsule and to end 550 µm behind the anterior capsule.

In all treated eyes, anterior segment imaging was performed using optical coherence tomography (OCT) (Visante OCT; Zeiss Meditec AG, Jena, Germany) immediately after the femtosecond laser procedure. Anterior segment single and high-resolution corneal programs were used for imaging the anterior segment, including the anterior capsule, lens material, and cornea. The Visante software was used to measure the dimensions of the laser-treated area behind the anterior capsule for the capsulorhexis creations, and the distances of the nucleus fragmentation from the anterior and posterior capsule during nucleus fragmentation. The shape and position of the corneal laser incisions were also analyzed.

RESULTS

An intact, round, and complete capsulorhexis was achieved in all eyes. During capsulorhexis creation, carbon dioxide bubbles appeared in the anterior chamber (**Figure 1**).[12] The laser pulses started at a distance of 377 ± 55 µm behind the anterior capsule, as measured with the Visante OCT (**Figure 2**). The diameter of capsulorhexis was 4.54 ± 0.2 mm after femtosecond laser treatment (**Figure 3**).

In all eyes, the cross-pattern fragmentation lines within the lens nucleus were visible in the OCT image. The laser pulses created two vertical planes within the lens, which were perpendicular to each other. In 22 eyes (45%), an additional horizontal plane was formed within the lens (**Figure 4**). This horizontal layer was most likely caused by the carbon dioxide bubbles[12] formed within the nucleus during the laser treatment. The femtosecond laser fragmentation planes extended between 568 ± 147 µm behind the anterior capsule and 794 ± 111 µm from the posterior capsule.

The two corneal incisions (2.8-mm main incision and 1.0-mm side port) were both programmed to be 1.8 mm in length. The measured values (OCT) were similar at 1.84 ± 0.12 mm (**Figure 5**). The planned width of the incisions was 2.8 mm, whereas the postoperative value was 2.71 ± 0.11 mm.

DISCUSSION

To our knowledge, this is the first report on anterior segment imaging immediately after femtosecond laser application for cataract surgery. Femtosecond lasers were first used to produce anterior circular capsulorhexis and phacofragmentation procedures in porcine eyes by Nagy et al.[5]

Initial results demonstrated a higher precision of the laser capsulotomy than a manual capsulorhexis both in porcine eyes[5] and clinically.[6,7]

The femtosecond laser system used in our study uses a built-in OCT to measure the dimensions of the anterior segment, namely the cornea, the anterior and posterior lens capsule, and the nucleus. The laser treatment is planned and performed based on these measurements. In this study, we evaluated the actual treatment location using another anterior segment OCT system immediately after laser treatment and compared the measured values to the planned values. We found that the preoperatively set laser treatment parameters correlated well with the achieved results. This indicates that the built-in OCT system is reliable in measuring the anterior segment and in guiding the laser treatment in laser refractive cataract surgery.

AUTHOR CONTRIBUTIONS

Study concept and design (JLA, ED, TJ, KK, ZZN); data collection (JLA, TF, ZZN, AIT); analysis and interpretation of data (JLA, TF, MCK, ZZN); drafting of the manuscript (JLA, ZZN); critical revision of the manuscript (JLA, ED, TF, KK, MCK, AIT); statistical expertise (JLA); administrative, technical, or material support (TF, AIT); supervision (JLA, KK)

REFERENCES

1. Ratkay-Traub I, Ferincz I, Juhasz T, Kurtz RM, Krueger RR. First clinical results with the femtosecond neodymium-glass laser in refractive surgery. *J Refract Surg.* 2003;19(2):94-103.
2. Kurtz RM, Liu X, Elner VM, et al. Plasma mediated ablation in human cornea as a function of laser pulse width. *J Refract Surg.* 1977;13:653-658.
3. Vogel A, Capon MRC, Vogel A, Birngruber R. Intraocular photodisruption with picosecond and nanosecond laser pulses: tissue effects in cornea, lens and retina. *Invest Ophthalmol Vis Sci.* 1994;35(7):3032-3044.
4. Juhasz T, Kastis GA, Suarez G, Bor Z, Bron EW. Time-resolved observations of shock waves and cavitation bubbles generated by femtosecond laser pulses in corneal tissue and water. *Lasers Surg Med.* 1996;19(1):23-31.
5. Nagy ZZ, Takacs A, Filkorn T, Sarayba M. Initial clinical evaluation of an intraocular femtosecond laser in cataract surgery. *J Refract Surg.* 2009;25(12):1053-1060.
6. Nagy ZZ, Kranitz K, Takacs AI, Mihaltz K, Kovacs I, Knorz MC. Comparison of intraocular lens decentration parameters after femtosecond and manual capsulotomies. *J Refract Surg.* 2011;27(8):564-569.
7. Kranitz K, Takacs A, Mihaltz K, Kovacs I, Knorz MC, Nagy ZZ. Femtosecond laser capsulotomy and manual continuous curvilinear capsulorhexis parameters and their effects on intraocular lens centration. *J Refract Surg.* 2011;27(8):558-563
8. Miháltz K, Knorz MC, Alio JL, et al. Internal aberrations and optical quality after femtosecond laser anterior capsulotomy in cataract surgery. *J Refract Surg.* 2011;27(10):711-716.
9. Kránitz K, Takacs A, Miháltz K, Kovács I, Knorz MC, Nagy ZZ. Intraocular femtosecond laser use in traumatic cataracts following penetrating and blunt trauma. *J Refract Surg.* 2012;28(2):151-153.
10. Filkorn T, Kovacs I, Takacs A, Horvath E, Knorz MC, Nagy ZZ. Comparison of IOL power calculation and refractive outcome after laser refractive cataract surgery with a femtosecond laser versus conventional phacoemulsification. *J Refract Surg.* 2012;28(8):540-544.
11. Ecsedy M, Miháltz K, Kovács I, Takacs A, Filkorn T, Nagy ZZ. Effect of femtosecond laser cataract surgery on the macula. *J Refract Surg.* 2011;27(10):717-722.
12. Habib MS, Speaker MG, Schnatter WF. Mass spectrometry analysis of the by-products of intrastromal photorefractive keratectomy. *Ophthalmic Surg Lasers.* 1995;26(5):481-483.