Femtosecond Laser–Assisted Intraocular Lens Fragmentation: Low Energy Transection

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ABSTRACT

PURPOSE: To describe a case of femtosecond laser–assisted hy-drophobic intraocular lens transection.

METHODS: Case report.

RESULTS: Femtosecond laser–assisted transection of a one-piece acrylic hydrophobic intraocular lens for explantation via a small surgical incision was successfully performed with low energy parameters.

CONCLUSIONS: This case illustrates a novel and effective clinical application of the femtosecond laser.

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Intraocular lens (IOL) explantation following cata-ract surgery is relatively rare, but the need for the procedure has increased in recent years as a result of patient dissatisfaction following premium IOL im-plantation. Explantation is also performed in cases of IOL glistening, lens decentration/dislocation, optical zone opacification, and residual refractive error.[1] In-traoperative complications due to iatrogenic trauma to ocular structures while folding or cutting the IOL in the anterior chamber can occur.[1] We describe a novel technique for in vivo hydrophobic IOL transection with low energy parameters.

CASE REPORT

A patient presented approximately 2 months following cataract surgery and implantation of a one-piece acrylic IOL (AcrySof SN60AT; Alcon Laboratories, Inc., Fort Worth, TX). The patient had radial keratotomy 27 years previously to correct high myopia. Immediately after the recent cataract and implantation surgery, the patient had experienced diplopia due to high hyperopic error. After confirmation of the relatively stable refraction, the deci-sion was made to explant and exchange the IOL with a one-piece acrylic IOL with different parameters. Prior to explantation surgery, uncorrected distance visual acu-ity (UDVA) was 20/2000 and corrected distance visual acuity (CDVA) was 20/32 with a manifest refraction of +6.50 +0.25 @ 95°. Corneal topography (TMS-4; Tomey Corporation, Nagoya, Japan) showed no corneal astigma-tism (flat keratometry = 39.95 diopters @ 90°; steep kera-tometry = 40.15 diopters @ 0°). Axial length determined via optical biometry (IOLMaster 700; Carl Zeiss Meditec AG, Jena, Germany) was 27.50 mm, and central endothe-lial cell density determined via specular microscopy was 1,540 cells/mm^2. To identify the new IOL power, the Barrett Universal II formula was used.

Following preoperative topical anesthesia and di-lation, two side port incisions were made, the ante-rior chamber was filled with a homogeneous cohesive ophthalmic viscosurgical device (OVD) (sodium hyal-uronate 1.0%; Provisc; Alcon Laboratories, Inc.), and additional OVD was injected behind the IOL to avoid bubbles. The IOL was then dislocated anteriorly and the haptics positioned in the ciliary sulcus at the hori-zontal meridian. The corneal incisions were hydrated with balanced salt solution to ensure a watertight seal. The femtosecond laser patient interface was then ap-plied in a sterile fashion with suction and the eye vi-sualized under the laser.

The LenSx (Alcon Laboratories, Inc.) laser param-eters were adjusted to fragmentation only, length of 6 mm, energy of 6 µm, tangential spot separation of 7 µm, and layer separation of 7 µm. The pattern of the single laser cut was positioned centrally with online optical coherence tomography control (**Figure 1A**), and the fragmentation was performed. The interface was removed, the patient was moved back to the mi-croscope while maintaining sterility, and the anterior chamber was confirmed formed. The IOL was grasped with two 25-gauge end-gripping microforceps (Grie-shaber revolution DSP ILM forceps; Alcon Grieshaber AG, Schaffhausen, Switzerland) through the preexist-ing opposing paracenteses and divided into two parts. A new 2.5-mm temporal corneoscleral incision was made to avoid the radial keratotomy incisions, and the IOL parts were removed from the anterior chamber through the main corneoscleral incision. A one-piece acrylic IOL was then implanted in the capsular bag. After bimanual aspiration and irrigation of the anterior and posterior chambers, all corneal incisions were as-certained to be watertight.

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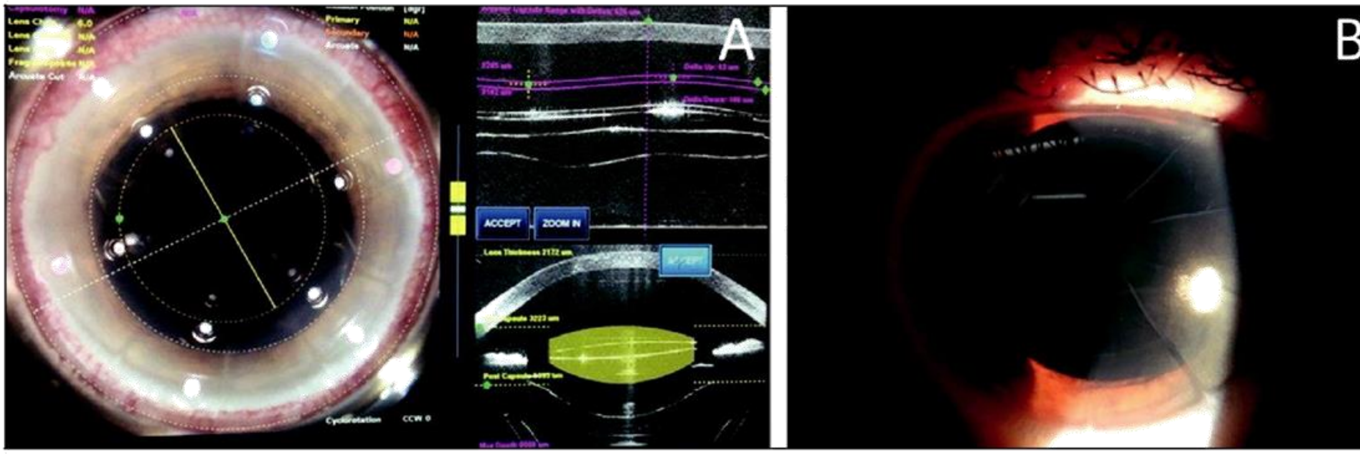

Figure 1. (A) Intraoperative view during intraocular lens (IOL) transection. Gas bubbles formed along the laser cut. Intraoperative optical coherence tomography image showing IOL profile (lower right image). (B) Slit-lamp photograph of the anterior segment 1 day postoperatively. The IOL is well centered in the capsular bag.

At the 1-month follow-up examination, the patient's UDVA and CDVA were 20/20 and no significant chang-es in endothelial cell density were apparent (1,498 cells/mm^2). The patient was highly satisfied with the outcome (**Figure 1B**).

DISCUSSION

Modern surgical techniques for IOL explantation in-clude criss-cross lensotomy,[2] bisection,[3] trisection,[4,5] intact optic removal,[6] the piggyback technique,[7] and the scaffold technique.[8] Although they are effective, there remains a risk of posterior capsular rupture, iris damage, and corneal endothelial cell loss.[6] Moreover, ongoing rapid advances in IOL technology and the de-velopment of accommodative lenses and lenses with complicated structures may increase the need for and complexity of IOL explantation.

The main concern that arises during manual IOL dissection or scaffold techniques is damage to corneal endothelium or the posterior capsule, which can occur with anterior chamber shallowing or where the IOL rotates or flips during manual dissection. The femto-second laser has become a reliable surgical tool. Al-though most commonly used to perform femtosecond laser–assisted cataract surgery, it proved to be useful for IOL fragmentation in an in vitro study reported by Bala et al.,[9] and in an in vivo study with hydrophilic IOLs with hydrophobic coating.[10] Femtosecond laser transection is a promising technology for IOL fragmen-tation, negating iatrogenic trauma to surrounding ocu-lar structures due to excessive intraocular manipula-tions, in contrast with manual dissection of an IOL by microsurgical scissors where rotation or slipping of the lens is a risk.

The aforementioned in vitro study by Bala et al.[9] showed that laser transection could be easily per-formed at the commercially available minimum en-ergy of 1 µJ. However, the cornea and aqueous humor can affect transmission, especially if corneal edema is present. No charring of the hydrophilic IOL with hydrophobic coating and significant pyrolitic prod-ucts were detected in the clinical study with laser settings of 8 µJ with a spot separation of 3 µm and layer separation of 6 µm.[10] The use of lower energy parameters is crucial to minimize the possible risk of toxic pyrolitic effects of hydrophobic IOLs in clinical application.

Furthermore, reduction of the tangential spot and layer separation parameters can result in an indirect increase in the energy delivered and consequent char-ring of the IOL material. Our case demonstrates that the fine structure of the laser cut can be achieved with-out IOL charring using the described parameters of the femtosecond laser (**Figure 2**).

Another concern is the need to stabilize the IOL during the femtosecond laser procedure. This can be achieved via cohesive OVDs, which also provide a deep stable space in the anterior or posterior cham-ber of the eye. Because the laser cut induces py-rolysis, no cavitation bubbles are formed inside the lens material. However, OVDs are a medium for gas bubble formation, which can appear at the back of the IOL where the laser beam is in contact with the OVD. Moreover, the limitations of the laser inter-face did not allow for the movement of the lens frag-mentation pattern in every axis, so the gas formed within OVD under the IOL optic can push the IOL out of the laser cut pattern, potentially resulting in incomplete IOL fragmentation. To improve the pre-cision of IOL fragmentation pattern positioning, a system that is more adjustable with regard to shape and size is required.

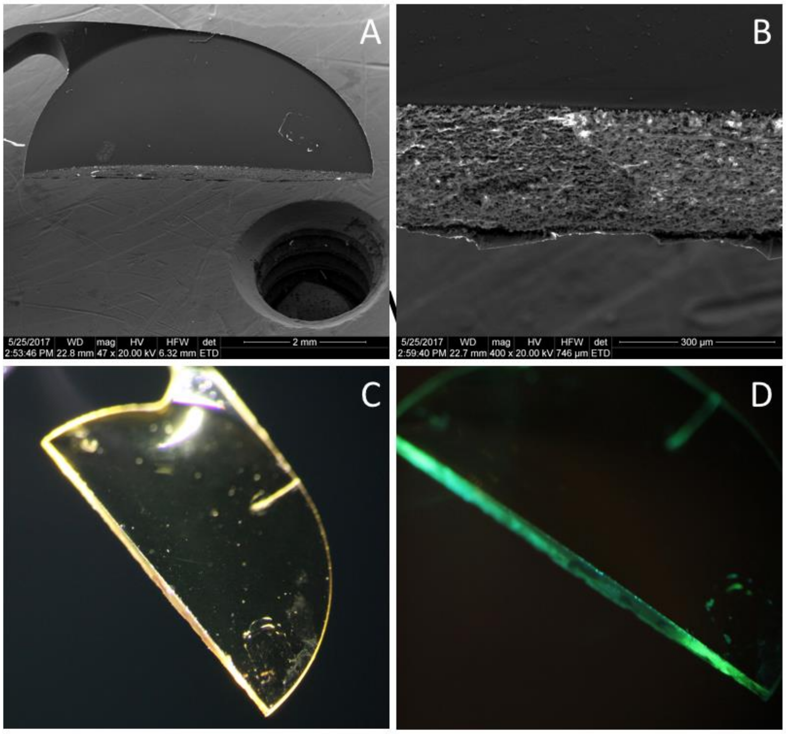

Figure 2. (A-B) Scanning elec-tron microscopy (original mag-nification ×47 and ×400) with the Quanta 200 microscope (FEI, Hillsboro, OR). The intraocular lens (IOL) margin in the area of femtosecond laser transec-tion. The finest structure of the cut surface. Little grooves and bumps can be seen, probably reflecting the application pattern of femtosecond laser pulses.

(C) Slit-lamp photograph of IOL, illumination without filter. (D) Slit-lamp photograph of IOL with standard green filter. No exces-sive IOL charring was apparent along the laser transection optic margin.

Further clinical studies are also required to confirm the safety of femtosecond laser–assisted IOL fragmenta-tion and optimize laser parameters for the various types of IOL materials and femtosecond laser platforms.

AUTHOR CONTRIBUTIONS

Study concept and design (NSA); data collection (NSA, RVK, NPS); analysis and interpretation of data (NSA, BEM, LBA, NPS, AAN, IAP); writing the manuscript (NSA); critical revision of the manuscript (NSA, BEM, LBA, NPS, RVK, AAN, IAP); administrative, technical, or material support (NPS, RVK

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