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Femtosecond laser LenSx–assisted phacoemulsification of mature intumescent cataract

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Background: *Phacoemulsification (phaco) of mature intumescent cataract is one of the most difficult to perform anterior eye surgeries. In mature intumescent cataract phaco, the most difficult phase is performing a continuous capsulorhexis which should be as round as possible. The incidence of an anterior capsular tear during capsulorhexis has been reported to range from 0.8 to 5.0% and increases with an increase in cataract density. This is because in dense intumescent cataracts, capsulorhexis tends to extend to the periphery due to high intracapsular pressure. Femtosecond laser–assisted phaco of mature intumescent cataract enables a safe laser-assisted capsulotomy with a substantially reduced risk of intraoperative complications. Because this approach is as yet not widely used in ophthalmology, we aimed to share our experience in the use of femtosecond laser in phacoemulsification of mature and intumescent cataracts.*

Purpose: *To assess the efficacy of femtosecond laser–assisted treatment of mature intumescent cataract.*

Methods: *Sixty-five patients (68 eyes) with mature intumescent senile cataract underwent femtosecond laser-assisted cataract surgery (FLACS) with intraocular lens (IOL) implantation and were involved in this study.*

Results: *In 55 eyes (80.8%), laser capsulotomy of the desired diameter (5.0 mm) was performed completely. In 8 eyes (11.7%), capsular bridges (capsular tissue remnants at the site of laser-assisted cut of the anterior capsule) were seen. In addition, after the laser phase of surgery, 3 eyes (4.4%) showed an irregularly shaped anterior capsular disc due to the failure of the laser to cut through the capsule in several regions. In all study eyes, the IOL was well centered in the bag.*

Conclusion: *In eyes with mature intumescent cataract, it is reasonable to use the femtosecond laser for a safe and accurate anterior capsulorhexis to avoid the severe intraoperative complications (those associated with posterior capsular rapture and vitreous prolapse) that can be seen during manual capsulorhexis.*

Keywords:

ultrasound phacoemulsification, senile brunescent cataract, senile Morgagnian cataract, femtosecond laser

Introduction

Phacoemulsification of mature intumescent cataract is one of the most difficult to perform anterior eye surgeries. The disease can be seen in a hard brown-black nucleus which is difficult to break up by phaco chopping and can be accompanied by an increased intracapsular pressure due to lens cortex liquefaction. In mature intumescent cataract phacoemulsification, the most difficult phase is performing an anterior continuous capsulorhexis which should be as round as possible. Performing a capsulorhexis is a key stage in cataract surgery, because capsulorhexis size and shape have an impact on the safety of the subsequent stages of surgery, possibility to implant a particular intraocular lens (IOL), and postoperative refractive power. That is why capsulorhexis should be continuous, centered and as precise as possible in terms of size. Because eyes with a dense lens nucleus show poor or no fundus reflex, in all patients, the anterior capsule is stained with trypan blue to improve visualization of the capsular flap and ease visualization of the capsulorhexis edge. It has been found that the application of trypan blue resulted in a reduced elasticity and increased rigidity of the lens capsule. This has an impact on the technique of capsulorhexis.

It has been reported that the incidence of an anterior capsular tear during capsulorhexis was 0.8–5.0% [1-4]. The incidence of an anterior capsule tear during capsulorhexis increases with an increase in cataract density. This is because in dense intumescent cataracts, capsulorhexis tends to extend to the periphery due to high intracapsular pressure. When punctured during the surgeon's attempt to create the capsulorhexis, the capsule occasionally splits in what has been described as an Argentinean flag sign [5, 6].

In order to avoid the Argentinian flag sign, some high-density viscoelastic is injected into the anterior chamber to reduce bulging of the anterior capsule [7, 8]. Thereafter, the anterior capsule is punctured centrally to aspirate liquified lens material and reduce intracapsular pressure. A special squeeze-handle tool is introduced into the eye through an incision as small as 1.0 mm in order to maintain pressure in the anterior chamber and avoid viscoelastic leakage while performing capsulorhexis.

Capsulorhexis is performed slowly while trying to keep the edge of the cut in the anterior capsule as round as possible. If the capsulorhexis runs out to the equator, squeeze-handle scissors are used to make an additional incision centrally to the run-out area, and squeeze-handle forceps are used to complete the circumferential incision in the lens capsule.

In our clinical practice, we also use an approach involving the creation of an anterior capsulorhexis with a smaller diameter (about 4 mm) compared to the aforementioned one, and this capsulorhexis is easier to prevent from extending to the periphery. After an IOL is implanted in the capsular bag, Vannas scissors are used to make an incision in the proper direction in the capsule to enlarge the initial capsulorhexis to a more appropriate size of 5-6 mm. One should, however, bear in mind that a too small capsulorhexis can make it difficult to remove nuclear fragments and cataract masses from the capsular bag, while one that is too large can lead to a capsulorhexis running to the periphery. In the event of a runaway capsulorhexis, continuing with phacoemulsification carries the risk of extension of the capsular bag tear through the equator onto the posterior capsule. This can make surgery difficult, potentially leading to nucleus luxation to the vitreous and vitreous prolapse into the anterior chamber. In such an event, it is usually recommended to use low vacuum and aspiration parameters to remove the nucleus and lenticular masses at the capsular site contralateral to the site of runaway [9].

Femtosecond lasers have been Food and Drug Administration (FDA) approved for the following three steps in cataract surgery: corneal incision construction, anterior capsulotomy, and lens fragmentation. The use of femtosecond laser in phacoemulsification for mature and intumescent cataracts reduces the rate of intraoperative complications. Because this approach is as yet not widely used in ophthalmology, we aimed to share our experience in the use of femtosecond laser in phacoemulsification for mature and intumescent cataracts.

Material and Methods

We retrospectively reviewed medical records of 65 patients (68 eyes) with mature and intumescent senile cataracts who had undergone femtosecond laser-assisted cataract surgery (FLACS) with IOL implantation. Patient age ranged from 48 to 76 years (mean age, 64.6 years). Of the 65 patients, 29 (44.6%) were women and 36 (55.4%) were men. Patients with a pupil diameter < 5.0 mm, corneal endothelial cell density less than 2000 cell/mm2, or concomitant eye disease were excluded from the study.

The study was approved by the Bioethics Committee of the Filatov Institute and adhered to the Helsinki Declaration. Informed consent was obtained from all study subjects. Animals were not used in this study.

Preoperative visual acuity ranged from perception of light with accurate projection to 0.02. In all affected eyes, biomicroscopy found an intumescent white cataract, and the intraocular pressure was within the normal range (17.0-20.0 mmHg). A local unified protocol [10] consistent with ICD-10 was used to determine cataract stage and locations of lens opacities.

A comprehensive eye examination included autorefractometry (Huvitz MRK-3100 Huvitz Co. Ltd, GoonPoh-Si, South Korea), slit-lamp biomicroscopy (SL-200), Maklakov applanation tonometry, iCare IOP measurements. IOL power was calculated based on biometric measurements taken by the LENSTAR LS 600 Biometer (Haag-Streit, Koeniz Switzerland). In addition, ultrasound biometry (OcuScan RxP; Alcon Laboratories Inc, Irvine, CA) was performed in case of diffuse lens opacification. Posterior segment ultrasonography was conducted using Cinescan (Quantel Medical, Clermont-Ferrand, France). All measurements were performed by one examiner using the same instrument.

The following parameters were assessed intraoperatively: adhesion of the anterior capsular disc to the capsular bag after performing anterior capsulorhexis; anterior capsular tears; posterior capsular tears; absolute phaco time; and effective phaco time. Patients were given topical non-steroidal anti-inflammatory and antibacterial medications a day before and at a day of surgery. Atropine sulphate and cyclopentolate hydrochloride 1% were used to achieve maximal mydriasis.

Operative technique

All surgeries were performed by a single surgeon using a standardized methodology, with the parameters specified through the Centurion Vision System (Alcon Laboratories, Inc., Fort Worth, TX). In addition, the LenSx laser system (Alcon-LenSx Inc., Aliso Viejo, CA) and OPMI Lumera T microscope (Carl Zeiss Meditec AG, Jena, Germany) were used. Nuclear fragmentation was performed using the phaco-chop technique in all cases.

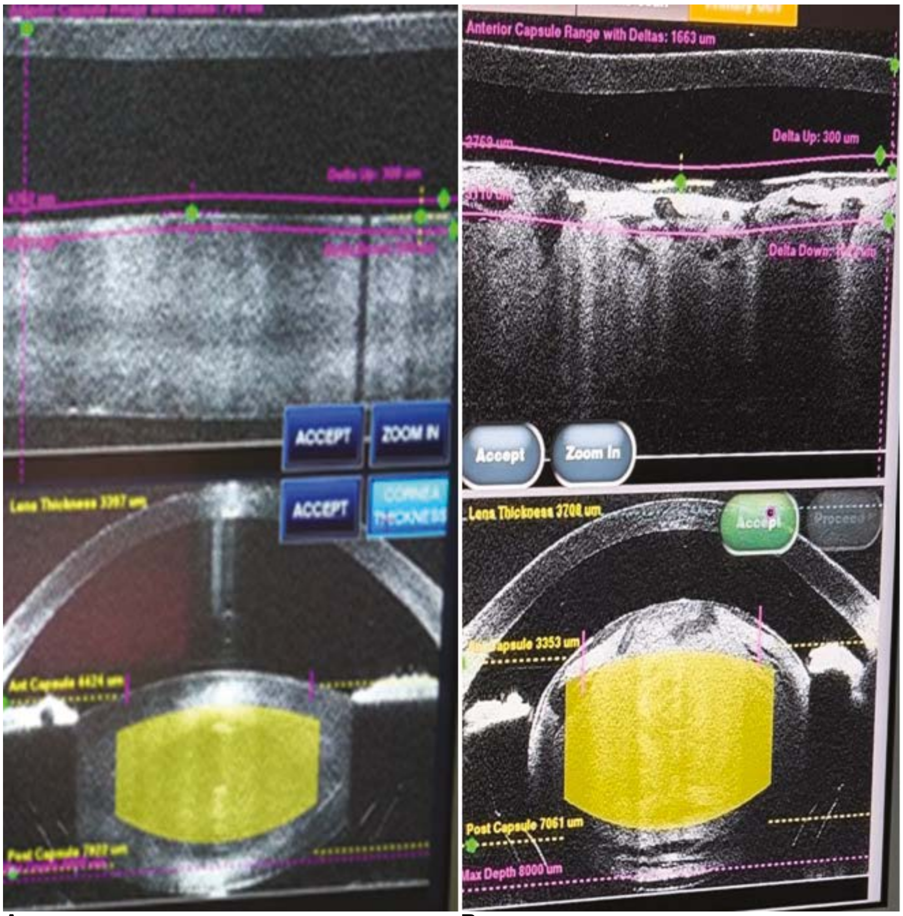
A routine femtosecond laser-assisted cataract extraction protocol was employed. The first phase included setting the patient interface (applying a low-vacuum suction ring to the surface of the globe); docking the patient interface to the cornea; and marking the boundaries of primary and secondary corneal incisions and the depth and diameter of laser-assisted lens incisions on the femtosecond-laser monitor. In all FLACS eyes, capsulotomy diameter ranged from 5.0 to 5.2 mm, and the level of laser pulse energy for capsulotomy, 6.0 to 6.6 mJ. The anterior (delta up) offset was set to 300-400 μm (Fig. 1). These values are significantly greater than standard manufacturer's settings, and, in most cases, allowed for a complete circular incision of the anterior capsule. The tang spot separation was set to 3 μm (Fig. 2). In addition, the layer separation was set to 4 μm, which somewhat increased the time required for performing laser-assisted cataract fragmentation, but facilitated making a complete continuous incision of the anterior capsule. A grid pattern was used for lens fragmentation with pulse energy at 6 mJ. In addition, the pulse length was 600-800 fs, and operating wavelength, 1030 nm. Lens fragmentation duration depended on the density of the lens.

After the laser phase of surgery was completed, the patient was transferred to the operating room for the next phase of surgery. Primary and secondary corneal incisions were reopened with forceps and spatula. Lidocaine and mesaton 1% were introduced into the anterior chamber for additional mydriasis, and tryphan blue was injected to stain the anterior capsule. Viscoat (a dispersive viscoelastic agent) was also introduced into the anterior chamber. A squeeze-handle tool was used to remove fragments of the anterior capsule. Hydrodissection and hydrodelineation were performed in a routine manner. Phaco tip and chopper were used for lens fragmentation and the removal of fragments. The bimanual irrigation and aspiration system was employed to remove residues of lens and viscoelastic. The IOL was implanted using a wound assist approach. The corneal incisions were sealed to complete the surgical procedure.

Results

In the current clinical study, we assessed the results of phacoemulsification in 65 patients (68 eyes) with cataract. Patient age ranged from 48 to 76 years (mean age, 64.6 years). Of the 65 patients, 29 (44.6%) were women and 36 (55.4%) were men.

In 55 eyes (80.8%), laser capsulotomy of the desired diameter (5.0 mm) was performed completely, and trypan blue staining showed an evenly round anterior capsular disc in the anterior chamber of the eye; the disc appeared peeled off from the anterior capsule.



A B

Fig. 1. (A) OCT image of the sagittal section of the lens in a patient with mild age-related cataract. Top panel: Marking the planned depth of laser delivery in the anterior lens capsule. Bottom panel: Planned depth of laser delivery in the lens matter. (B) OCT of the anterior segment, imaging the sagittal section of the lens in a patient with mature intumescent cataract. Top panel: Marking the planned depth of laser delivery in the anterior lens capsule. Bottom panel: Planned depth of laser delivery in the lens matter. Liquefied lens matter is seen, and the heterogeneous anterior capsule and subcapsular space appear heterogenous. Bottom panel: Planned depth of laser delivery in the lens matter. The lens is increased in size and displaced into the anterior chamber due to lens swelling

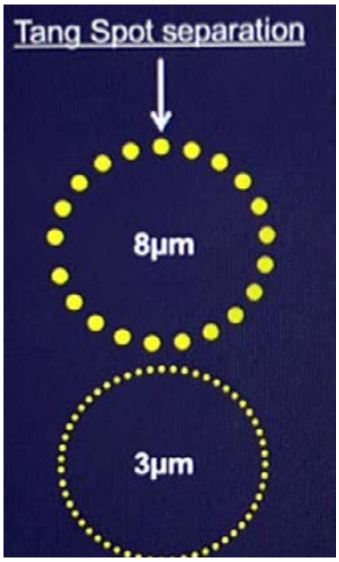


Fig. 2. Spot size during femtosecond-laser assisted capsulotomy. With a reduced spot size, the quality of laser-assisted cuts of the anterior capsule is improved due to increased number of laser pulses. This allows for a continuous and uniform cut but somewhat increases capsulotomy time

In addition, in 8 eyes (11.7%), capsular bridges (capsular tissue remnants at the site of laser-assisted cut of the anterior capsule) were seen. Before disc removal, trypan blue staining showed small capsular adhesions between the capsulorhexis area and the capsule. The presence of capsular bridges did not affect the desired shape and diameter of capsulorhexis and required a little effort to peel off the capsulotomy disc from the anterior capsule.

Moreover, after the laser phase of surgery, 3 eyes (4.4%) showed an irregularly shaped anterior capsular disc due to the failure of the laser to cut through the capsule in several regions (≤ 90°). After the capsular bag was stained with trypan blue and viscoelastic injected into the anterior chamber, squeeze-handle forceps and scissors were used to cut through the anterior chamber and get a round capsulorhexis. This allowed getting a round capsulorhexis and implanting the IOL in the bag in all study cases.

A radial tear of the anterior capsule with no posterior capsular tear or vitreous prolapse occurred during phacoemulsification in 2 eyes (2.9%). This complication was seen in the phase of ultrasound fragmentation of the lens nucleus and was not associated with the performance of the laser phase of the cataract operation.

In some cases, the final capsulorhexis diameter was somewhat larger than the target capsulotomy diameter of 5.0 mm due to pupil constriction and the requirement for cutting the lens capsule at a small distance from the iris.

In all study eyes, the IOL was well centered in the bag.

Discussion

Performing a successful manual continuous capsulorhexis in mature intumescent cataract is a challenge because no fundus reflex is visible and capsulorhexis tears can extend to periphery because of high intralenticular pressure with sudden capsulorhexis radialization. A high intralenticular pressure during the performance of capsulorhexis can cause an irregular capsular tear due to an increased lens volume and reduced density of the lens matter. An anterior capsular tear can make cataract extraction surgery extremely difficult due to poor construction of capsulorhexis and possible rupture of the posterior capsule [11]. The anterior capsular tear rate in mature intumescent cataracts ranges from 3.85 to 28.3% [12, 13]. Viscoelastic injections, capsular dyes, diathermy-assisted capsulotomy and two-stage capsulorhexis techniques are recommended for obtaining a capsulorhexis of the desired size and shape in eyes with mature intumescent cataracts.

Even after capsule staining with trypan blue increases visualization and increases the stiffness of the anterior capsule [14], capsule puncture can result in uncontrollable extension of the opening of the anterior lens capsule. Hawlina and colleagues [15] analyzed the anterior lens capsule thickness and ultrastructure changes of intumescent white cataracts in comparison with nuclear cataracts. Capsule thickness was not significantly different in intumescent white compared to nuclear cataracts. The main morphological features of capsules were extrusions of capsule at the basement membrane-epithelial border embedding cellular material which were significantly more frequent in intumescent cataracts.

Femtosecond laser cataract surgery applications have expanded to include not only ordinary cases but also challenging ones [16, 17]. Opinions vary regarding the role of femtosecond laser technology in the management of mature intumescent cataracts. Conrad-Hengerer and colleagues [3] were the first to evaluate in 2014 the feasibility and safety of femtosecond laser–assisted capsulotomy in eyes with intumescent white cataract. They concluded that the use of the femtosecond laser–assisted system for capsulotomy in surgery for intumescent white cataract appeared to be safe and technically feasible. Others [18, 19] later discussed the use of femtosecond laser-assisted cataract surgery in eyes with mature intumescent cataract, but did not compare femtosecond laser-assisted phacoemulsification with conventional phacoemulsification for efficacy. A prospective study by Titiyal and colleagues [20] included 80 patients to compare femtosecond laser-assisted capsulotomy with conventional manual capsulorhexis in cases of white cataract. They, however, found no difference in terms of visual outcomes and intraoperative complications.

In the current study, we assessed the quality and safety of femtosecond laser-assisted capsulorhexis in eyes with mature intumescent cataract.

Of the 68 eyes, 8 (11.7%) showed residual capsular bridges and 3 showed incomplete circular cuts. However, in all the 68 eyes, femtosecond laser-assisted capsulorhexis resulted in obtaining a round aperture after the removal of the anterior capsular disc. A radial tear of the anterior capsule with no posterior capsular tear or vitreous prolapse occurred during phacoemulsification in 2 eyes (2.9%). The IOL maintained its correct and well-centered position in all study eyes over the six-week follow-up.

It is of note that, when performing femtosecond laser-assisted capsulorhexis in eyes with mature intumescent cataract, one should take into account a release of liquified lens matter into the anterior chamber immediately after capsulotomy.

In eyes with mature intumescent cataract, it is reasonable to use the femtosecond laser for a safe and accurate anterior capsulorhexis to avoid the severe intraoperative complications (those associated with posterior capsular rapture and vitreous prolapse) that can be seen during manual capsulorhexis.

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Disclosures

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