# Capsulorhexis Under Continuous Fluid Pressure in Intumescent Cataracts:  A New Technique

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**Research Article**

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# Abstract

**Purpose:** To evaluate the effectiveness of the anterior capsulorhexis technique under continuous fluid pressure with anterior chamber maintainer in intumescent cataracts.

**Methods:** Scheduled for phacoemulsification due to intumescent cataracts, 84 eyes of 84 patients were included in the study. An anterior chamber maintainer, which provided continuous fluid pressure in the anterior chamber, was placed in the patients of Group 1 (n = 42). Capsulorhexis without viscoelastic was then applied under continuous fluid pressure. In Group 2 (n = 42) patients, capsulorhexis was performed by utilizing an ophthalmic viscoelastic device (OVD) to the anterior chamber. The efficiency and reliability of our capsulorhexis method were evaluated by comparing the intraoperative and postoperative complications that occurred in such cases.

**Results:** Radial tear did not occur in any of the cases in the capsulorhexis stage in Group 1; however, 6 Group 2 patients were observed to have radial tears($p<0.05$). Progression of the anterior capsule, which did not turn into a radial tear, to the periphery was observed in 2 patients in Group 1, and 8 patients in Group 2($p<0.05$). When liquefied cortical material egress dynamics were evaluated; the controlled fluid output was observed in 41 patients (97.61%) in Group 1, and 29 patients (69.4%) in Group 2 ($p<0.001$). There was no statistically significant difference revealed between the two groups in the endothelial cell loss ($p> 0.05$).

**Conclusion:** The technique we used provides a controlled and safe capsulorhexis in intumescent cataracts, reduces surgical complications, and does not require any additional cost.

# Introduction

When the phacoemulsification method was used for cataract extraction the popularity of a continuous, circular capsulorhexis (CCC) rapidly grew [1]. The most challenging step in intumescent cataracts is to create a well-sized, central, continuous curvilinear capsulorhexis. In such mature cataracts the capsule tends to be thin and fragile, and the absence of red reflex makes it difficult to see the capsule rim along the capsulorhexis. In addition, when the pressurized and swollen lens capsule is punctured there is a tendency for the rupture in the anterior capsule to expand towards the equator with the exit of liquefied cortical material, which may cause a sudden decrease in capsule visibility [2–5]. The capsulorhexis tear tends to extend to the periphery because of the high intralenticular pressure [6, 7], which can cause a radial tear called the Argentinian flag sign. Thus, complications like zonular rupture or posterior capsule tears, nucleus drop, vitreous loss, and intraocular lens (IOL) decentralization may occur[6–8].

A clear view of the rims of the anterior capsule tear might reduce these complications. This can be achieved by using capsule dyes [9, 10] like trypan blue [11] and indocyanine green [8, 12], which create a contrast between the anterior capsule and the cortex, or by using devices such as a surgical slit illuminant[13] or an endoilluminator[3, 14].

So far, various methods have been described to minimize the risk profile of an uncontrolled opening of the anterior lens capsule and to improve surgical outcomes. Despite this, complications in intumescent cataracts persist. In this study, we intended to evaluate the effectiveness of the anterior chamber maintainer technique under continuous fluid pressure, which is an effective, safe, low-cost, and easily applicable method in intumescent cataracts with high intralenticular pressure.

## Materials And Methods

The study protocol was approved by the local ethics committee (Necmettin Erbakan University, Faculty of Medicine Ethics Committee, Konya).
A written informed consent form was obtained from each patient before the surgery.
The study was conducted according to the principles of the Declaration of Helsinki.

Eighty-four eyes of 84 patients, who were operated on for intumescent cataracts at Konyagozhospital between November 2018 and July 2020, were included in the study. The patients were divided into two groups. While capsulorhexis was performed under continuous fluid pressure in 42 patients in Group 1, it was performed with the help of viscoelastic material in 42 patients in Group 2. Exclusion criteria were patients with serious coexisting ocular disease (pseudoexfoliation syndrome, uncontrolled glaucoma, uveitis, ocular tumors), poorly dilating pupils (pupil < 6 mm), presence of subluxated lens, known zonular weakness, and history of ocular trauma. Preoperative Snellen visual acuity, slit-lamp biomicroscopic exam, tonometry, biometry, endothelial cell count, and dilated fundus exams were performed on all patients.

All surgeries were performed by the same single surgeon using the same surgical phacoemulsification technique. (F.U.) For mydriasis, 1% cyclopentolate and 2.5% phenylephrine were instilled 3 times, starting 1 hour before surgery. All surgeries were performed with topical anesthesia using 0.5% proparacaine HCl drops. Under aseptic conditions, a temporal main corneal incision with a width of 1.2 mm and two side port incisions of 1.2 mm were made, respectively. The anterior capsule was stained with trypan blue under air. The eye was fixed with a spatula inserted into the anterior chamber through the side port incision.

In Group 1 patients, after the anterior capsule was stained, the anterior chamber maintainer, which provides continuous fluid pressure, was placed in the anterior chamber by side port incision. The bottle height was adjusted to 75 cm. Under continuous fluid pressure - without viscoelastic material- the anterior capsule was punctured through the temporal incision with microcapsulorhexis forceps (Fig. 1). Since there was a continuous fluid inlet and outlet into the anterior chamber at continuous pressure, the liquefied cortex (milky substance), which is released when the capsule is opened, was easily removed away from the environment, and the visibility of the anterior chamber was constantly preserved. The capsule rim was gripped with microcapsulorhexis forceps, and capsulorhexis was performed in a spiral shape, like peeling an orange (Fig. 2–6). The capsular material, which was extended towards the incision site due to spiral capsulorhexis, was shortened with micro scissors when necessary. Following the completion of the capsulorhexis process, the temporal incision was enlarged with a 2.75 mm knife. Afterwards, the anterior chamber maintainer was removed. Viscoelastic material (hydroxypropyl methylcellulose, HPMC) was injected into the anterior chamber to protect the corneal endothelium. The implementation of the entire technique is shown in Video 1.

In Group 2 patients, the anterior chamber was filled with visco-adaptive viscoelastic material (3% Sodium Hyaluronate 5000, Healon) after the anterior capsule was stained, and a flattened anterior capsule was eventually obtained. Then, the anterior capsule was punctured with microcapsulorhexis forceps, and a spiral capsulorhexis was performed by grasping the leaf of the opened capsule.

In both groups, phacoemulsification was applied with the Whitestar Signature phacoemulsification system (Johnson & Johnson Vision) using the stop and chop technique, without hydrodissection and hydrodelination. The cortical material was cleaned with a coaxial irrigation/aspiration probe. Finally, the posterior capsule was polished.

In all cases, a one-piece hydrophilic acrylic IOL was implanted into the capsular bag using a viscoelastic material. After cleaning the viscoelastic material with a coaxial I/A probe, the incision sites were hydrated and checked for water tightness. Corneal endothelial cell count was realized in the patients in the postoperative 1st month by specular microscopy.

The main outcomes were the anterior chamber depth, the lens thickness, intraoperative complications, and the corneal endothelial cell loss. In addition, the surgical videos of the patients were examined and the liquefied cortical material egress dynamics were evaluated.

All descriptive statistical analyses were performed using SPSS software (SPSS, Inc., version 22). Continuous variables were identified as mean ± SD, and group comparisons between continuous variables were realized using independent t-tests. Categorical variables between groups were compared using the chi-square test and Fisher's exact test. A P value less than 0.05 was considered statistically significant.

# Results

The study included 84 eyes of 84 patients. The mean age was 61.25 ± 12.46 (42–83); it was 59.61 ± 12.20 (42–82) in Group 1 ($n = 42$) and 61.95 ± 12.58 (45–83) in Group 2 ($n = 42$). There were 21 males (50%) and 21 females (50%) in Group 1, whereas 23 males (54.76%) and 19 females (45.23%) were in Group 2.

The mean anterior chamber depth was 1.95 ± 0.04 mm in Group 1 and 1.97 ± 0.04 in Group 2 ($p > 0.05$). The lens thickness was measured as 5.22 ± 0.06 mm in Group 1 and 5.21 ± 0.07 in Group 2 ($p > 0.05$). When liquefied cortical material egress dynamics were evaluated; the controlled fluid output was observed in 41 patients (97.61%) in Group 1, and 29 patients (69.4%) in Group 2 ($p < 0.001$). Progression to periphery in the capsule, which did not turn into a radial tear, was observed in 2 eyes in Group 1, and 8 eyes in Group 2 ($p < 0.05$). Known as the Argentinian flag sign, the radial tear was not observed in Group 1, while it was observed in 6 eyes in Group 2 ($p < 0.05$). No patient in either group had conversions to extracapsular cataract extraction (ECCE), posterior capsule rupture, nucleus drop, or vitreous loss ($p > 0.05$) (Table 1).

Table 1
Comparison of preoperative and intraoperative data in Group 1 (CCC with continuous fluid pressure) and Group 2 (CCC with viscoelastic material).

| **PARAMETER** | **GROUP 1 (n = 42)** | **GROUP 2 (n = 42)** | **P VALUE** |
| --- | --- | --- | --- |
| Anterior chamber depth (mm) | 1.95 ± 0.04 | 1.97 ± 0.04 | **0.15** |
| The lens thickness(mm) | 5.22 ± 0.06 | 5.21 ± 0.07 | **0.78** |
| Controlled fluid output (n) | 41 (97.61%) | 29 (69.4%) | **0.00** |
| Progression to periphery in the capsule (n) | 2 | 8 | **0.04** |
| Radial Tear (Argentinian flag sign) (n) | 0 | 6 | **0.02** |
| Posterior capsule tear (n) | 0 | 0 | **1** |
| Vitreous loss (n) | 0 | 0 | **1** |
| Dropped nucleus (n) | 0 | 0 | **1** |
| ECCE (n) | 0 | 0 | **1** |
| (mm = millimeter, n = number of eyes, ECCE = extracapsular cataract extraction) | | | |

Endothelial cell loss was 186.95 ± 136.32 (cells/$mm^2$) in Group 1 and 178.19 ± 133.54 (cells/$mm^2$) in Group 2 (Fig. 7). There was no statistically significant difference revealed between the two groups in the endothelial cell loss ($p > 0.05$) (Table 2).

Table 2
Comparison of preoperative and postoperative corneal endothelial cell density and endothelial cell loss in Group 1 (CCL with continuous fluid pressure) and Group 2 (CCC with viscoelastic material).

| **PARAMETER** | **GROUP 1** (n = 42) | **GROUP 2** (n = 42) | **P VALUE** |
|---|---|---|---|
| Preoperative corneal endothelial cell density (cells/mm$^2$) | 2627.85 ± 340.63 | 2594.50 ± 352.29 | 0.66 |
| Postoperative corneal endothelial cell density (cells/mm$^2$) | 2440.90 ± 383.77 | 2416.30 ± 389.20 | 0.77 |
| Endothelial cell loss (cells/mm$^2$) | 186.95 ± 136.32 | 178.19 ± 133.54 | 0.76 |

# Discussion

Capsulorhexis in intumescent cataracts has always been a challenge for surgeons due to the absence of red reflex. Moreover, due to the high intralenticular pressure, there is a high risk of the capsule expanding into the periphery and radial tear [15]. Until now, the following methods have been described to achieve a controlled capsulorhexis in intumescent cataracts such as creating a closed anterior chamber [16, 17], using diathermy or high-frequency diathermy to create anterior capsulotomy [18–20], phacocapsulotomy [21], aspiration of liquefied cortex simultaneously with perforation of the anterior capsule and decompression of intralenticular pressure [22], and 2-stage capsulorhexis [5, 23–26]. Despite all these methods, capsulorhexis complications in intumescent cataracts continued and new methods were tried to be investigated.

In the previously described method of aspiration and decompression of intralenticular pressure while applying pressure to the lens with ophthalmic viscosurgical device (OVD), the anterior capsule is punctured with the help of a needle and the liquefied cortex is simultaneously aspirated [27]. Leakage may occur from the side ports in surgeries using viscoelastic material. This can result in sudden decompressions that cause a radial tear. In addition, time-consuming and costly viscoelastic reinjections may be required due to the shallowness of the anterior chamber and the curvature and curling of the anterior capsule rim [28, 29].

New methods have recently been introduced, such as Neodymium, YAG laser capsulotomy [30, 31], femtosecond laser capsulotomy [32], nanopulse capsulotomy [33] (Zepto, Mynosys Cellular Devices, Inc.), and Capsulaser [33] (Excel-Lens, Inc.), which is selectively absorbed by the laser by the anterior capsule stained with trypan blue. Although these new methods automate the capsulotomy and reduce their dependence on surgical skills, they add a high amount of cost to cataract surgery procedures. Furthermore, these methods have not yet been studied to perform a safe and complete capsulotomy for intumescent cataracts [33].

In contrast, our technique, which is mentioned above as capsulorhexis under continuous fluid pressure, is an effective and safe method to prevent uncontrolled expansion of capsulorhexis by providing a controlled reduction of intralenticular pressure. The main advantage of continuous fluid pressure is the tamponade effect, which resists the high intralenticular pressure in intumescent cataracts. Thus, the milky material is released slowly and then goes into the anterior chamber in a controlled manner. In addition, there is continuous fluid entry and exit to the anterior chamber at continuous pressure; the visibility of the anterior chamber is constantly preserved because the milky material that occurs when the capsule is opened is removed from the environment in an easy and controlled manner. This significantly reduces the occurrence of capsule complications.

No leakage occurs from the side ports since viscoelastic material is not used with this technique; moreover, an adequate anterior chamber depth is created and the anterior chamber remains more stable. The results of this study showed that our method significantly reduced all complications and at the same time provided a controlled fluid output and good visualization during surgery. Using the capsulotomy method under continuous fluid pressure facilitates the completion of capsulorhexis, and provides a more controlled surgery, while minimizing the risk of uncontrolled expansion of the capsule into the periphery.

To our knowledge, there is no other study other than our study in which capsulorhexis was performed with maintainer under continuous fluid pressure in intumescent cataracts. In a study by Sethi et al. [34], capsulorhexis was performed with a cystotome using an irrigation probe in immature cataracts. Öksüz et al. [29] performed vacuum-assisted capsulorhexis with an aspiration probe while providing anterior chamber stabilization with an irrigation probe in immature cataracts.

While this technique provides a safe and effective capsulorhexis, we did not experience any corneal edema due to endothelial failure. According to the endothelial cell count results, no statistically significant difference was observed between the two groups, and the capsulorhexis method under continuous fluid pressure was not revealed to be harmful to the corneal endothelium [29].

In conclusion, the technique we used provides a controlled and safe capsulorhexis in intumescent cataracts, reduces surgical complications, and does not require any additional cost. Additionally, it reduces the intense consumption of viscoelastic material as well as the operation costs in clinics where many cataract surgeries are performed. No special tools or instruments are required except those currently used in a classical phacoemulsification surgery. Moreover, viscoelastic injections and reinjections do not involve time-consuming steps such as liquefied cortical material aspiration.

# Declarations

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**Conflict of interest:** The authors have no financial or proprietary interest in a product, method, or material described herein.

**Authors' contribution:** All procedures of this article were carried out by Fikret Ucar.

**Data Availability:** All data will be available upon request.

**Ethical approval:** The study protocol was approved by the local ethics committee (Necmettin Erbakan University, Faculty of Medicine Ethics Committee, Konya). The study was conducted in accordance with the tenets of the Declaration of Helsinki. A written informed consent form was obtained from each patient before the surgery.

**Consent to Participate:** All participants gave written informed consent for participation in the study.

**Consent to Publish:** All participants gave written informed consent for their data to be published.

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# Figures

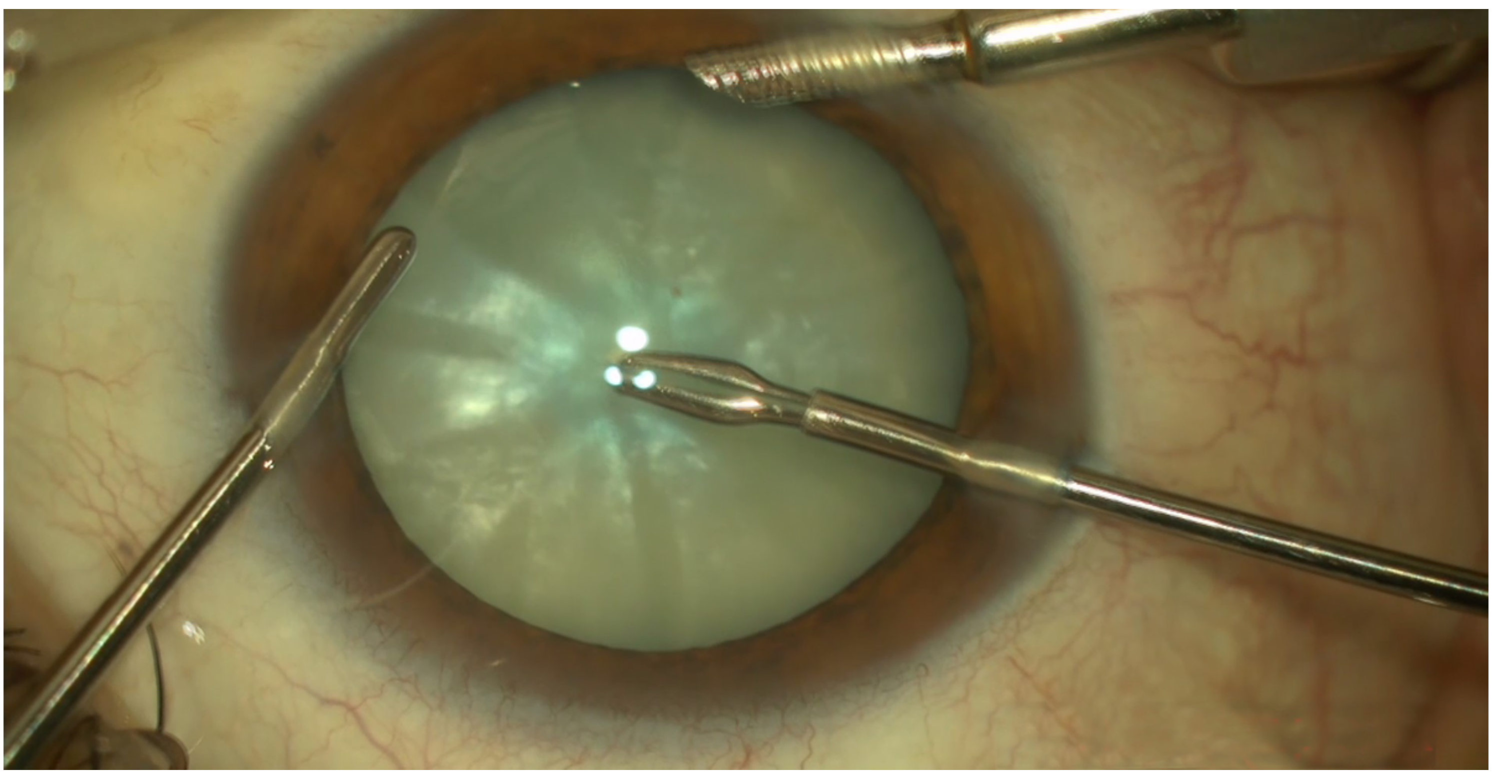


**Figure 1**

The anterior chamber maintainer was inserted and the eye was fixed with a spatula inserted from the side port. The capsule was punctured with microcapsulorhexis forceps, and due to the continuous fluid inlet and outlet into the anterior chamber, controlled milk material outlet started, which did not distort the view.

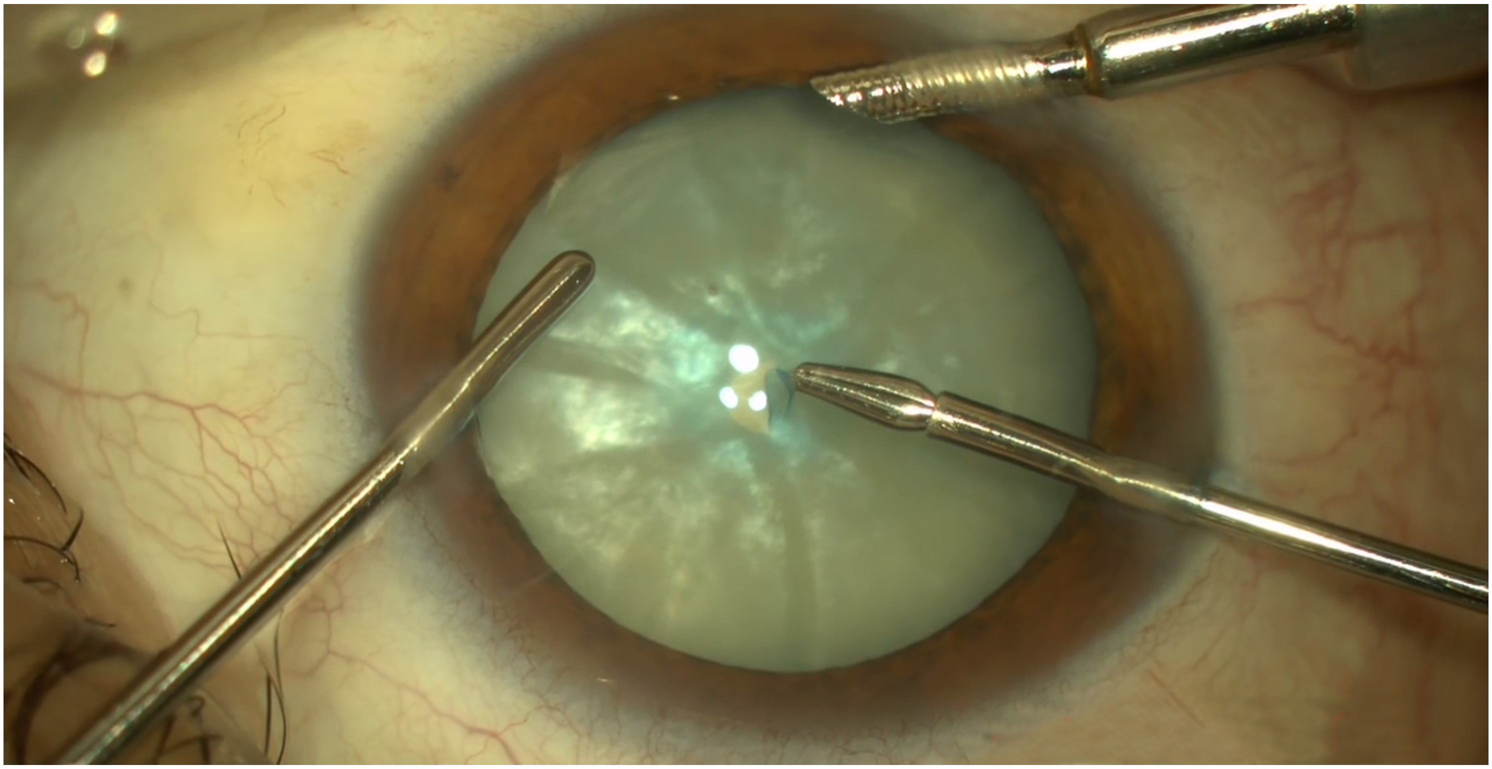
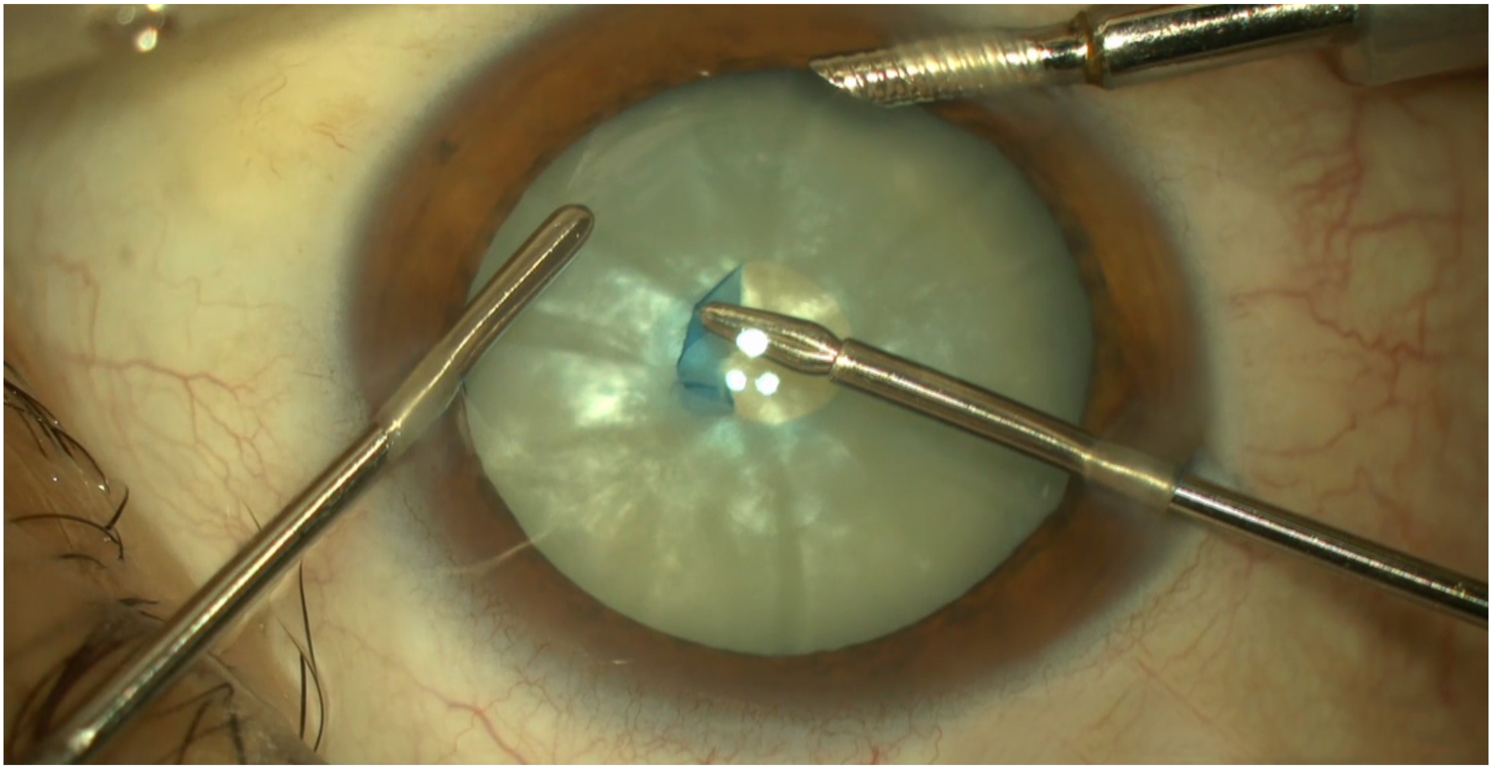


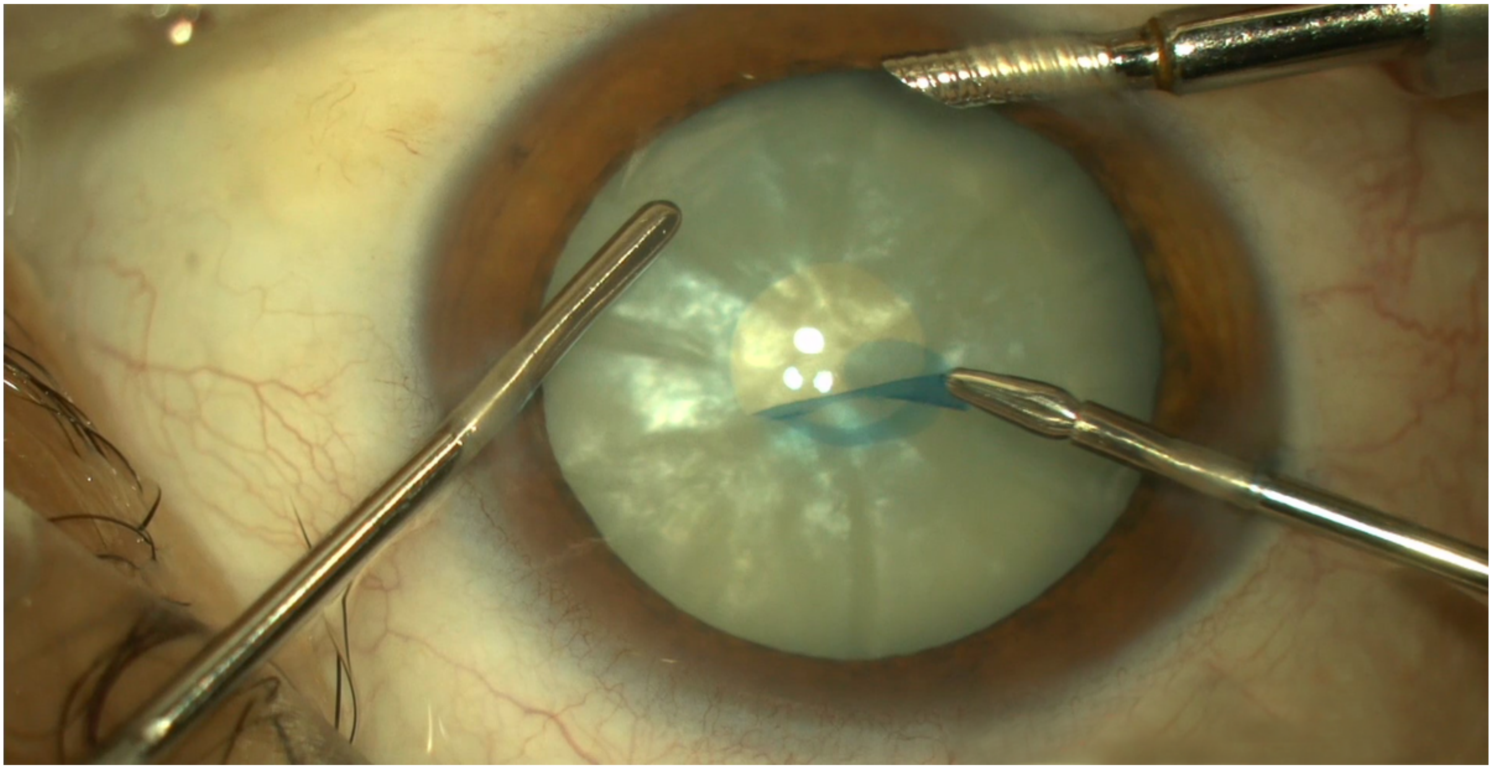
**Figure 2**

The capsular flap was gripped with microforceps, and the capsulorhexis process was started in a spiral shape, like peeling an orange. Controlled and slow milky material outflow continued.



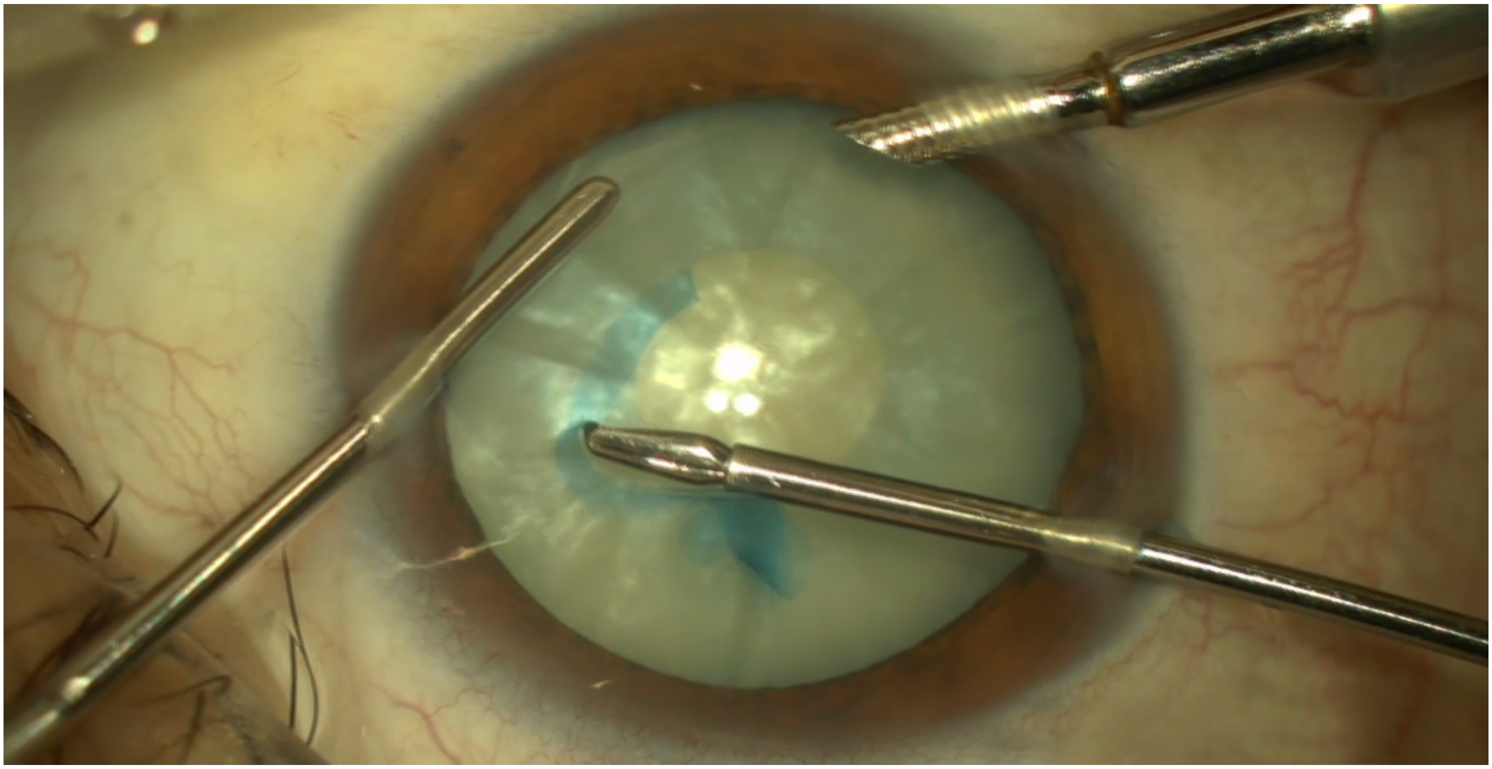
## Figure 3

Continuous curvilinear capsulorhexis was continued, like peeling an orange under continuous fluid pressure.



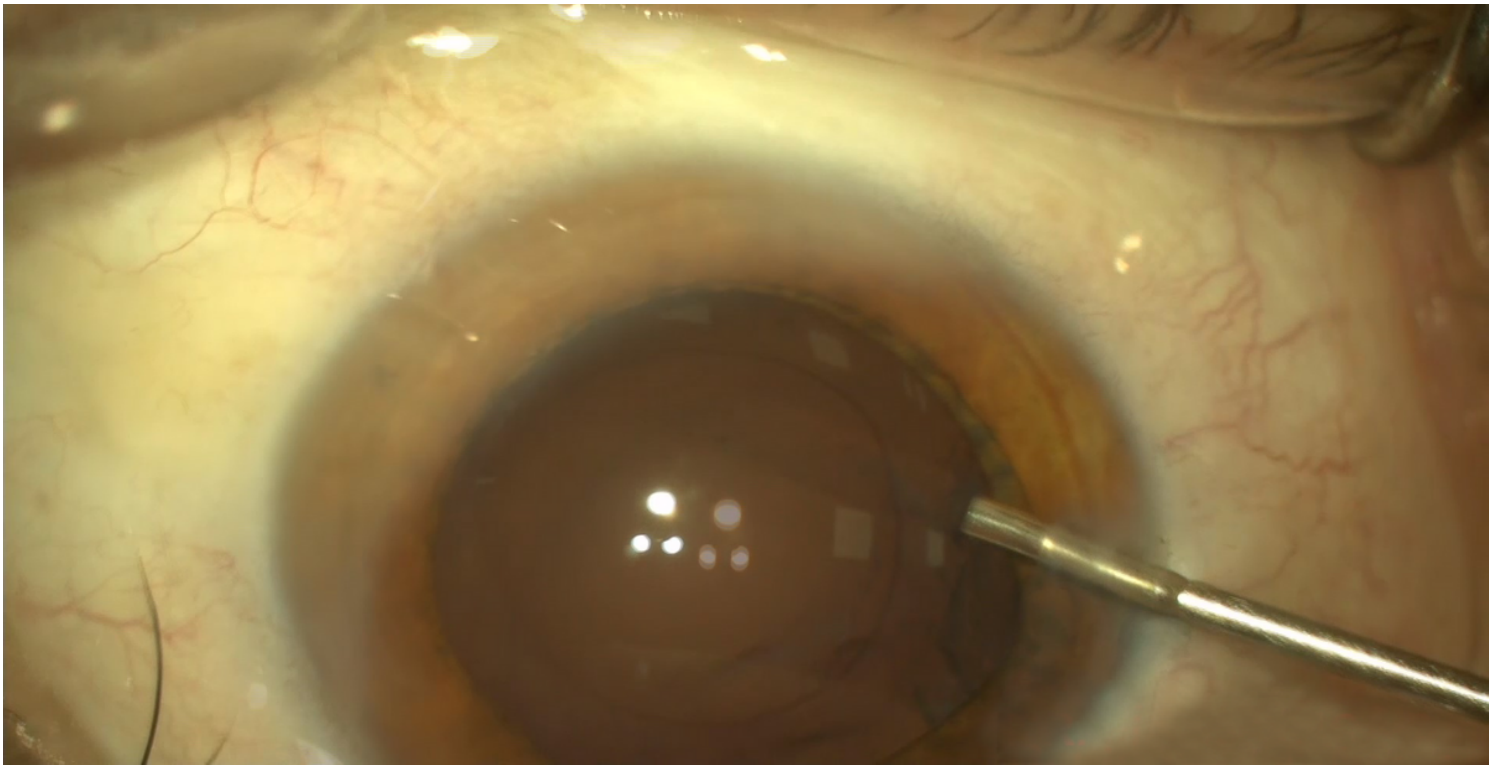
## Figure 4

Continuous curvilinear capsulorhexis was continued.



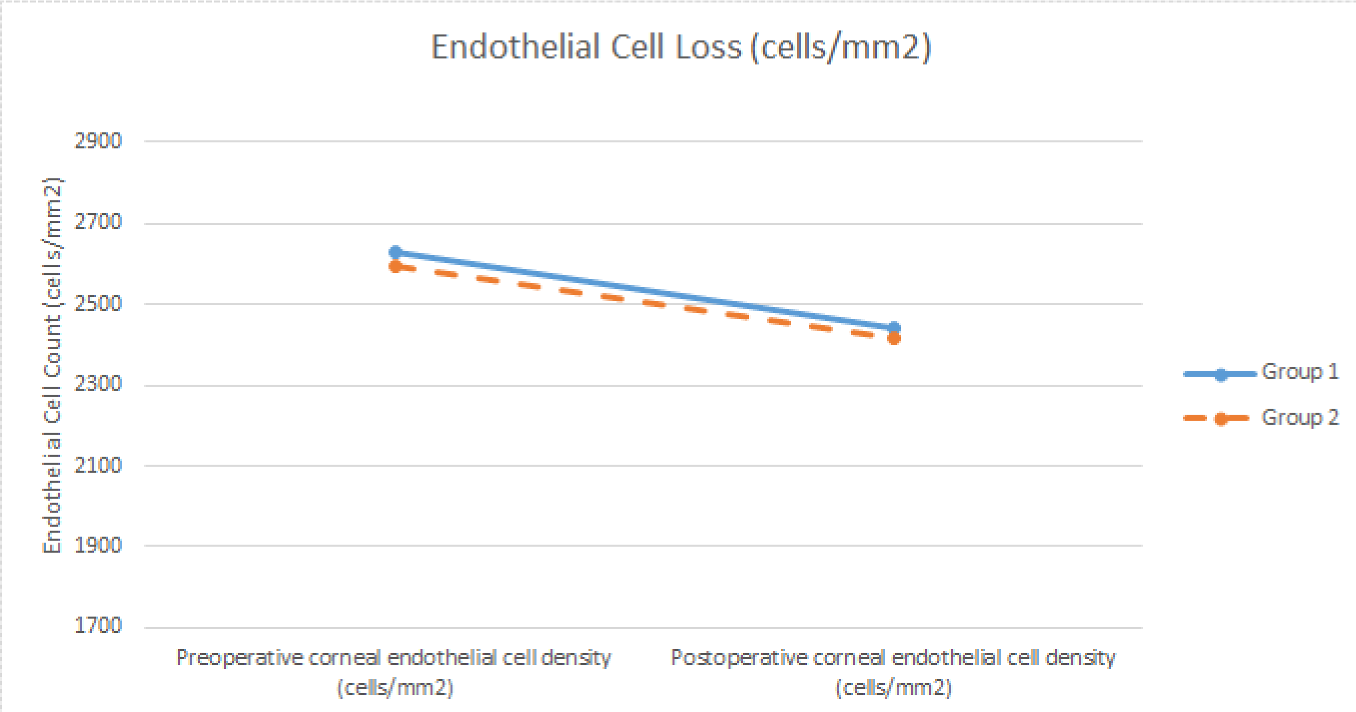
## Figure 5

Capsulorhexis about to be completed.



## Figure 6

A continuous, curvilinear capsulorhexis completed after phacoemulsification, before intraocular lens implantation.




### Figure 7

Comparison of preoperative and postoperative corneal endothelial cell density in Group 1 and Group 2.

# Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- Video1.mp4