Original Article

Modified capsulorhexis for fluid-filled mature cataracts

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ABSTRACT

Background: The aim of this study was to develop a modified capsulorhexis technique featuring a new maneuver for the removal of subcortical fluid in fluid-filled mature cataracts to avoid high intralenticular pressure.

Methods: This prospective interventional study included 33 eyes with mature cataracts and evidence of subcapsular fluid spaces by slit lamp examination. For each patient, 20% mannitol was administered intravenously according to the bodyweight 1 h preoperatively. Under peribulbar anesthesia, a 2.2-mm main incision was made, and the anterior chamber was filled with a dispersive ophthalmic viscosurgical device. Using a bent-tip cystotome, a 2-mm curved incision was made in the center of the anterior capsule, which released subcortical fluid and was drained through compression of the posterior lip of the main incision using a spatula. Then, fine gentle milking in all quadrants around the puncture on the anterior lens capsule from the periphery toward the site of puncture using the blunt-edged spatula further assists drainage of subcortical fluid and breaks fine septa inside the lens to remove fluid from intralenticular fluid pocket collections.

Results: The study included 15 (45.5%) men and 18 (54.5%) women with a mean ± standard deviation (SD) of age of 63.2 ± 5.33 and 64.4 ± 6.21 years, respectively. The modified capsulorhexis technique was performed for 33 intumescent cataracts. Capsulorhexis was completed in all cases; capsulorhexis was easy in 31 (94%) eyes and difficult in 2 (6%) eyes. In the two difficult cases, radial extension occurred in one eye, and it was retrieved using the Little technique; the other case with radial tear was completed successfully using a retinal micro scissor from the other edge of the capsulorhexis until reaching an oval, continuous capsulorhexis.

Conclusions: This modified capsulorhexis technique with compression on the posterior lip of the main incision and capsule milking allowed for a safe, continuous curvilinear capsulorhexis. Further comparative studies are necessary to confirm our preliminary results.

KEY WORDS

capsulorhexis, cataract, intumescent cataract, phacoemulsification

INTRODUCTION

Despite technical advances such as laser capsulotomy, performing safe, continuous curvilinear capsulorhexis (CCC) still poses a challenge in mature fluid-filled cataracts. It is a constant struggle for ophthalmic surgeons to achieve CCC without any inadvertent capsular complications in such cases, in spite of developments in phacoemulsification [1, 2]. The most challenging step in handling an intumescent cataract is the creation of an adequately round, centered CCC. In these mature cataracts, the capsule tends to be thin, and the absence of red reflex results in difficult visualization of the capsule edge during capsulorhexis. There is also a tendency

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for the anterior capsule tear to extend toward the periphery after the swollen lens is punctured, with spillage of liquefied cortical material and sudden loss of capsule visibility [3-5]. Due to the high intralenticular pressure (ILP) [6, 7], capsulorhexis tears tend to extend to the periphery, forming a radial tear that produces the so-called Argentinian flag sign [2], which can be observed when the capsule is stained with trypan blue. This may progress to complications, such as zonular or posterior capsule tears, vitreous loss, dropped nucleus parts, and intraocular lens (IOL) decentration [2].

Many techniques for performing capsulorhexis in intumescent cataracts have been described, including a sealed anterior chamber (AC) [8, 9], phacocapsulotomy [10], decompression of the ILP through simultaneous capsule puncture and aspiration of the liquid cortex [11], and two-stage capsulorhexis [4, 12-16]. The previously described aspiration and decompression of the ILP involve penetrating the center of the anterior capsule with a needle and simultaneously aspirating the liquid material, while maintaining downward pressure on the lens with an ophthalmic viscosurgical device (OVD) [11]. The success rates vary with the skill of the surgeon and technique used. Currently, modern methods, such as femtosecond laser capsulotomy, CAPSULaser (Excel-Lens, Inc.), and nanopulse capsulotomy (Zepto, Mynosys Cellular Devices, Inc.), in which the laser is selectively absorbed by the capsules stained with trypan blue, have been developed [1, 17]. Although these technologies automate capsulotomy and reduce the dependence on surgical skills, they add to the cost of the cataract procedure, are not totally free of complications, as incomplete capsulotomy was recorded in 8% of eyes, and are not available in all ophthalmic theaters, especially in developing countries [1, 18].

The Argentinian flag sign must have new aspects. The collection of intralenticular pockets of fluid is multiloculated and differs from one lens to another. These pockets are well established by anterior optical coherence tomography (OCT) studies [19, 20]. Thus, the main issue in intumescent cataracts is to reduce the ILP in a controlled manner to decrease the risk of the Argentinian flag sign. The modified capsulorhexis technique used in the present study was performed to evaluate its feasibility in obtaining easy capsulorhexis in intumescent cataracts.

METHODS

This prospective interventional study included patients with fluid-filled mature white cataracts who underwent elective unilateral standard phacoemulsification in a private ophthalmic center (El Gaohara eye Center) in Ismailia, Egypt. The study was conducted between January 2018 and October 2020. After providing an explanation of the risks, possible complications, and visual prognosis, written informed consent for surgery was obtained from all patients. The study was approved by the ethical committee of the Faculty of Medicine, Port Said University, and adhered to the tenets of the Declaration of Helsinki.

Patients included in the study had mature cataracts and preoperative evidence of subcapsular fluid pockets along with increased anterior capsule convexity toward the AC by slit lamp examination (Nidek, Tokyo, Japan) with high-magnification. Preoperative values of biometric parameters, including axial length (AL), anterior chamber depth (ACD), and lens thickness (LT) were recorded using an optical biometer, Lenstar LS 900 (Haag-Streit, USA).

Patients were prepared as usual for cataract surgery in these eyes. Intravenous mannitol (20%) was administered according to the bodyweight of the patient, 1 h before the operation. Peribulbar anesthesia using a single-injection technique was performed to inject a mixture of 5 mL (1:1 solution) of 0.5% bupivacaine (BupiWell; Wellona Pharma, India) and 2% lidocaine (Debocaine; Sigma-Tec pharmaceutical Indus, Egypt), which provides rapid onset of akinesia combined with a longer duration of analgesia. Globe compression was performed to lower the intraocular pressure if the eye was firm after injection.

Intraoperatively, the lid speculum retracted the eyelids gently and did not exert excessive pressure on the globe. If corneal clarity was inadequate, coating the outer surface of the cornea with dispersive OVD was performed to enhance visualization during capsulorhexis. A 2.2-mm main temporal clear corneal incision was made using a keratome with initially no side-port incisions, with the aim of controlling the escape of subcortical fluid through the main incision. The capsule was stained with 0.06% trypan blue under air in the AC, irrigation with fluid was performed to remove excess trypan blue, and then the AC was filled with a dispersive viscoelastic solution of low molecular weight, highly purified grade of hydroxypropyl methylcellulose (HPMC) 2% (Supreme; Rumex International Co. USA).

The force inside the mature cataract with these fluid-filled pockets was exerted in all directions, and if the AC was filled with dispersive OVD, the intralenticular forces were directed toward the AC, and the moderate pressure inside the AC exerted by dispersive OVD could support AC formation with relatively less pressure than ILP (Figure 1A).

The anterior lens capsule can be flattened by cohesive OVDs; then, with two forces acting against each other, the intralenticular pocket force causes bulging of the anterior capsule, and the OVDs cause flattening of the anterior capsule. This high pressure in the AC will encounter a higher ILP to resist flattening of the anterior lens capsule, and vitreous pressure force also assists in increased ILP in the closed eye system (Figure 1B). Thus, when anterior capsule puncture occurs, the two forces act on each other, and if the ILP is greater, then the Argentinian flag sign easily occurs. These radial tears can occur in any direction according to the direction of the force in fluid-filled pockets.

Capsule elasticity can withstand ILP; once punctured, the ILP and capsular elasticity aid in the occurrence of radial tear. Thus, the policy of use of OVDs in AC was directed to maintain space in the AC and not overfill and pressurize the AC.

Fluid-filled cataracts may have minimal fluid due to fluid-filled pockets. These pockets can induce radial tear when capsulotomy is performed over these areas with sudden release of fluid from these pockets with induced radial tear. Therefore, after central capsular puncture, milking the anterior capsule from the periphery of the lens toward the central puncture was performed. This step induced rupture of intralenticular lens fiber septa with release of fluid toward the central capsule puncture and decreased the risk of radial tears with hidden pockets (Figure 1C).

Generally, dispersive OVDs are good for coating intraocular structures but are not as effective as cohesive materials for maintaining surgical space [19]. As the aim in the described procedure here is to aid in escaping intralenticular fluid from a higher ILP gradient to less pressure in the AC and to minimize pressure through the main incision, dispersive OVDs were used (Figure 1D).

A 27-gauge needle, bevel up, mounted on an insulin syringe was used to puncture the center of the anterior capsule, and the liquefied cortical material immediately came like a storm in the center of the lens. Then, using a fine blunt edged spatula, the lower lip of the main temporal incision was compressed, and the cortical fluid was removed through the main incision associated with dispersive OVD; milking of the intact capsule temporal and nasal to central puncture was performed using the same spatula. When the AC became shallow, repeated injection of dispersive OVD was performed again with pressure on the posterior lip of the main incision to facilitate more fluid escape through the main incision. Milking was repeated gently again with movement from the periphery toward the center to assess the release of subcapsular fluid through the puncture site. The endpoint of milking was feeling the capsule floppy under gentle pressure away from the central puncture. The procedure of milking is important to drain fluids in pockets, as, with previous experience with capsulorhexis in white cataracts, the pressure inside the lens was multiloculated, which explains why the Argentinian flag sign can occur in any direction of the lens depending on where the fluid-filled pocket is present, which is confirmed by evidence of a recent anterior segment OCT study on the lens [19].

The drainage of the subcapsular fluid takes approximately 2 min. When the midperipheral anterior capsule had been adequately flattened, more OVDs were injected. Capsulorhexis of the desired size was created in the usual manner using capsulorhexis microforces or cystotomes. The surgical steps are shown in Figure 2. The rest of the phacoemulsification procedure and IOL implantation were completed using standard techniques [19]. At the 1-month postoperative visit, best corrected visual acuity (BCVA) of all participants was measured using the logarithm of the minimum angle of resolution (logMAR) chart.

Collected data were computerized and analyzed using IBM SPSS Statistics for Windows (version 21.0; IBM Corp., Armonk, Chicago, USA). Descriptive statistics were used to describe the variables. For quantitative data, the mean and standard deviation (SD) were calculated. For qualitative data, the number and percentage distribution were calculated. Comparisons between subgroups were performed. The chi-square test was used to evaluate differences in proportions. The Student's t-test was used to evaluate differences in the mean values between the two groups. Statistical significance was considered at a 95% confidence level (i.e., significant if $P < 0.05$).

RESULTS

The modified capsulorhexis technique was successfully performed in 33 patients with intumescent cataracts. The study included 15 (45.5%) men (8 right eyes and 7 left eyes) with a mean ± SD of age of 63.2 ± 5.33 years and 18 (54.5%) women (10 right eyes and 8 left eyes) with a mean ± SD of age of 64.4 ± 6.21 years. All preoperative parametric values and logMAR BCVA at 1-month postoperatively were comparable between the two sexes. Table 1 shows the demographic characteristics, preoperative biometric parameters, and postoperative logMAR BCVA of participants at 1 month ($P > 0.05$ for all comparisons). There was no statistically significant difference between men and women regarding the affected eye and capsulorhexis difficulty ($P > 0.05$ for all comparisons).

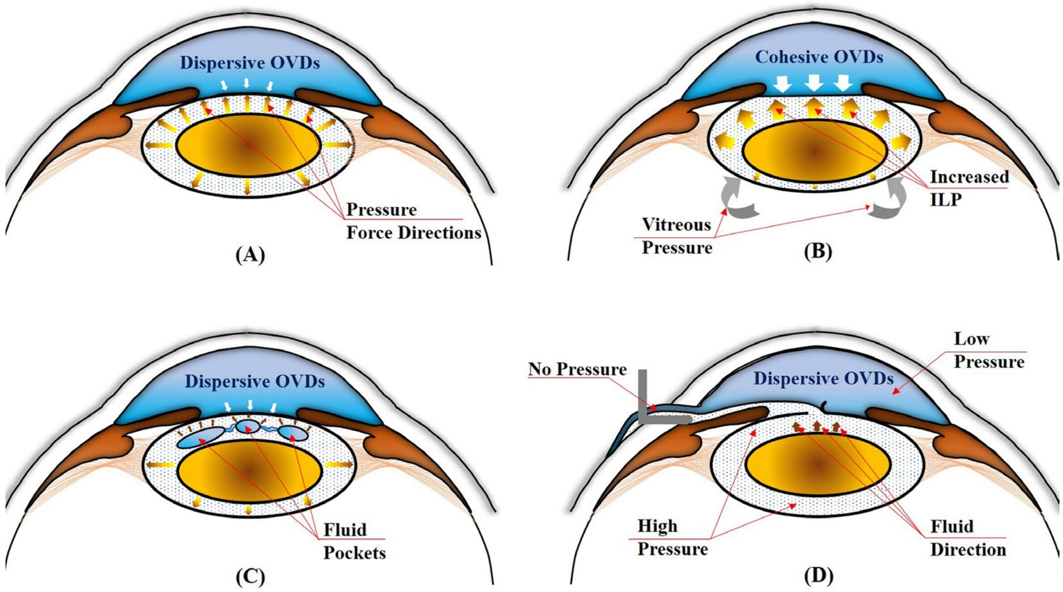

Figure 1. Behavior of different ophthalmic viscosurgical devices (OVDs) in the anterior chamber (AC) before capsulorhexis and after puncture of the anterior capsule in mature fluid-filled cataracts. (A) Dispersive OVDs are good for coating intraocular structures, as they exert minimal pressure on the lens [21] (white arrows), while intralenticular pressure (ILP) is relatively high as indicated by the yellow arrows. (B) Cohesive OVDs maintain the surgical space in the AC and induce a high force pressure that flattens the anterior lens capsule [20] as indicated by the white arrows. This induces higher ILP (yellow arrows) and increases back pressure from the vitreous (gray arrows), which increases the possibility of radial tear. (C) Fluid-filled pockets under the anterior capsule are the first step in the conversion of a mature cataract to a hypermature cataract. They exert localized pressure in certain directions according to fluid collection [19] (brown arrows). Milking through the anterior lens capsule destructs fluid pocket septa (curved blue lines), facilitates egress of fluid from the anterior capsule puncture, and prevents radial tear from localized fluid collections. (D) Opening anterior capsule together with compression on the posterior lip of the main incision induces a pressure gradient with high pressure inside the lens (brown arrows), through less pressure in the AC due to dispersive OVDs, to no pressure through the main incision. This pressure gradient facilitates escape of intralenticular fluid through the main incision together with OVDs.

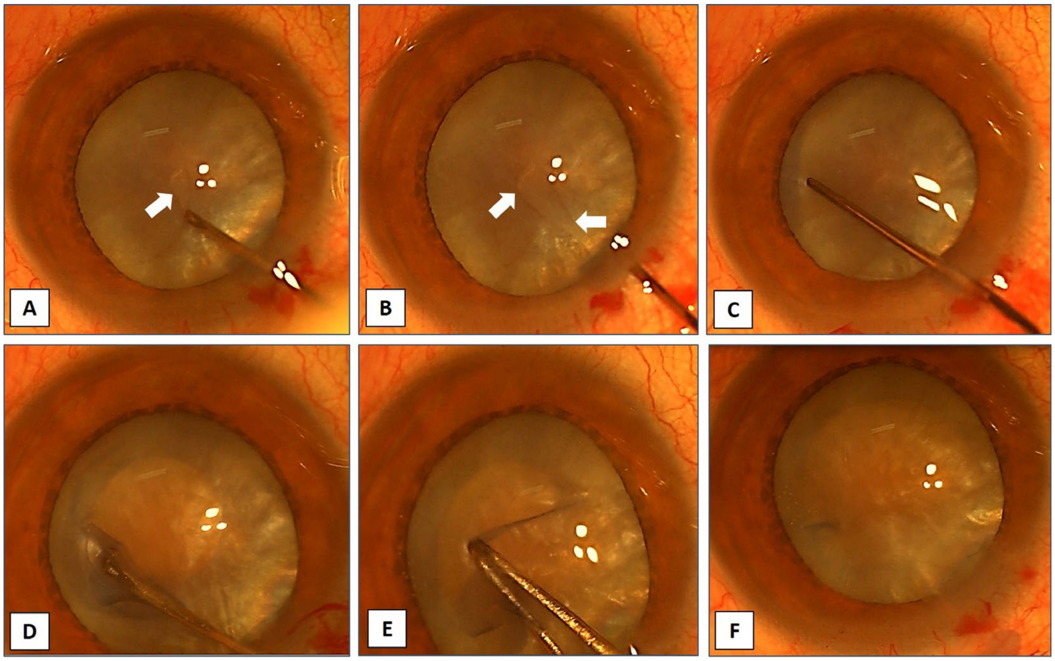

Figure 2. Surgical steps for modified capsulorhexis in mature fluid-filled cataracts. (A) Capsule puncture with the tip of a bent insulin syringe. (B) Compression of posterior lip of the main incision with a fine spatula with egress of lenticular fluid through the main incision. (C) Milking anterior lens capsule from periphery toward the site of central capsule puncture using the blunt edged spatula, to facilitate fluid escape and break intralenticular fluid pockets to enhance drainage through the central puncture. (D) Continuation of circular capsulorhexis with the aid of bent cystotome. (E) Completion of capsulorhexis with a capsulorhexis forceps. (F) Obtention of a continuous curvilinear capsulorhexis.

Table 1. Characteristics of the study participants

Variable	All subjects	Men	Women	*P*-value
Participants, n (%)	33 (100)	15 (45.5)	18 (54.5)	
Right eye operated, n (%)	18 (54.6)	8 (24.3)	10 (30.3)	0.898*
Left eye operated, n (%)	15 (45.4)	7 (21.2)	8 (24.2)	
Age, Mean ± SD	63.8 ± 5.77	63.2 ± 5.33	64.4 ± 6.21	0.555**
Preoperatively				
AL (mm), Mean ± SD	23.45 ± 1.95	23.7 ± 1.97	23.2 ± 1.93	0.469**
ACD (mm), Mean ± SD	3.08 ± 0.58	3.1 ± 0.52	3.06 ± 0.63	0.843**
LT (mm), Mean ± SD	4.55 ± 0.79	4.76 ± 0.82	4.34 ± 0.75	0.138**
Intraoperatively				
Easy rhexis, n (%)	31 (94)	14 (42.5)	17 (51.5)	0.894*
Difficult rhexis, n (%)	2 (6)	1 (3)	1 (3)	
1-month postoperatively				
BCVA (logMAR), Mean ± SD	0.26 ± 0.22	0.25 ± 0.22	0.27 ± 0.21	0.792**

Abbreviations: n, number; %, percentage; mm, millimeters; SD, standard deviation; AL, axial length; ACD, anterior chamber depth; LT, lens thickness; rhexis, continuous curvilinear capsulorhexis; BCVA, best corrected visual acuity; logMAR, logarithm of the minimum angle of resolution. *Chi-square test, **Student's t-test.

All included eyes had intralenticular fluid. In all eyes, capsulorhexis was completed; capsulorhexis was easy in 31 (94%) eyes and difficult in 2 (6%) eyes (Table 1). In the two difficult cases, radial extension occurred in one eye, and it was retrieved well by the Little technique [22]. The other case with radial tear was completed successfully by a retinal micro scissor from the other edge of the capsulorhexis. Finally, a complete oval continuous capsulorhexis was obtained.

Phacoemulsification was performed in all eyes. Only one eye had a posterior capsule tear during removal of the last nuclear quadrant; anterior vitrectomy was performed and a three-piece intraocular lens was implanted in the sulcus. Otherwise, all eyes were implanted with a single acrylic hydrophobic lens (Aktis SP; NIDEK, Gamagori, Aichi, Japan) in the capsular bag. No postoperative complications were noted at the 2-month follow-up.

DISCUSSION

This study introduced a modified capsulorhexis technique with compression on the posterior lip of the main incision and capsule milking. The technique was found to be successful for achieving a safe, CCC. Capsulorhexis is a very important step in cataract surgery, especially in mature cataracts. Failure to achieve an intact anterior capsule opening may result in posterior extension beyond the equator, resulting in complications such as zonule rupture, vitreous loss, a dropped nucleus, and posterior displacement of the IOL [7, 23, 24]. We used capsule dye to improve visualization [7]. In addition, in all cases, intravenous mannitol was administered to shrink the vitreous, which lowered intravitreal pressure and reduced counter pressure on the lens from the vitreous [9]. Complete filling of the AC with OVD, preferably a dispersive material, is particularly important as this further tamponade the anterior lens capsule and facilitates escape of subcortical fluid through the main incision [14].

The use of dispersive OVDs to maintain AC creates a pressure gradient between the lens and the AC with a higher pressure inside the lens [3]. This pressure gradient is created with the aid of gentle pressure on the lower lip of the main incision with a fine spatula. These maneuvers assist in easy drainage of the intralenticular fluid outside of the eye with dispersive OVDs.

Generally, dispersive OVDs are good for coating intraocular structures but are not as effective as cohesive materials for maintaining surgical space [21]. The aim here is to coat the intraocular structure and facilitate the escape of dispersive OVDs with lenticular fluid through the main incision.

Gentle milking of the anterior lens capsule from the periphery toward the site of puncture using the blunt-edged spatula further assists the escape of fluid from the lens and breaks fine septa inside the lens to remove fluid from intralenticular fluid pocket collections, repeated injection of AC with a dispersive OVD is needed again with pressure on the posterior lip of the main incision and milking of the anterior capsule. The entire drainage took an average of 2 min. Thus, with an overly busy surgeon, it is better to delay mature cataract to the end of the list so that the surgeon will be relaxed as the technique requires more time and patience to obtain more safety to the patient and procedure of cataract.

In previous studies [23, 25, 26], simultaneous puncture of the anterior capsule and decompression was performed by actively aspirating the cortical material from within the bag to prevent an uncontrolled radial extension of the tear. However, this initial central decompression may still be inadequate and carries the risk of more unsafe maneuvers in unsteady pressure forces between the AC and ILP. The downward pressure exerted by cohesive OVDs described by many may be dangerous [3, 8]. The force in the AC and intralenticular force are two opposing high forces once the elastic capsule is punctured by the cystotome, and because the nature of the capsule is elastic, the capsule will obey the law of power, so if the ILP is higher, the Argentinian flag radial tear will occur [14].

The Argentinian flag sign can occur in any direction according to the vector of force under the anterior capsule or in fluid-filled pockets [23]. If fluid moves freely under the anterior lens capsule, the management steps using preoperative mannitol induce vitreous shrinkage, which minimizes back pressure on the lens [9]. The use of dispersive OVDs in AC creates a pressure gradient from the lens to the AC, which assists in fluid drainage through the main incision. If the pressure gradient is the same in the AC and inside the lens, then the risk of radial tear is high on slight capsular maneuvers during capsulorhexis because the capsule is extremely elastic [14].

On the other hand, when a fluid pocket was present, milking the anterior capsule from the periphery toward the site of puncture was preferred as this maneuver assisted in gentle destruction of septa (lens fibers between fluid-filled pockets), assisted in the escape of fluid through the site of puncture, and protected against sudden bulging of cortical fibers to the AC with cystotome manuvers [19].

By reviewing the occurrence of the Argentinian flag sign in many cases, it can occur initially within seconds once the anterior capsule is punctured, and this is explained by continuous fluid collection under the anterior capsule or around the lens nucleus [2, 8-11]. These fluid collections have been studied recently by real-time anterior OCT with mature cataract surgery [20]. Conversely, from our experience, delayed radial tears can occur during the creation of capsulorhexis that passes suddenly over a pocket of fluid with sudden release of fluid pressure and sudden occurrence of radial tear. This type of radial tear can be minimized by milking the anterior capsule, as described. We created side-port incisions after capsulorhexis was complete; this assists in drainage of fluid through the main incision, when minimal fluid escapes from the capsular puncture and the capsule becomes floppy under the pressure of the spatula. Then, the capsulorhexis procedure was continued without fear of radial tear. Our modification of the technique not only ensures initial decompression, but also prevents a catastrophic Argentinian flag sign. It also facilitates the controlled creation of a capsulorhexis of the desired size.

However, the anterior capsule may be thin and fragile in these cases [5]. Milking was performed gently using a smooth blunt spatula. Furthermore, dispersive OVD coats the entire surface of the capsule, which also buffers it against damage. The main risk arising from this action, if the movement is too aggressive, is the sudden excessive displacement of cortical material through the initial tear, causing a radial extension, as described previously [4, 12, 13, 15]. Although laser technology [13] provides effective tools that help create a perfect capsulotomy, the technology adds to the cost of cataract surgery and is not perfect, as incomplete capsulorhexis has been recorded [1, 18].

Eyes with intumescent cataracts are more commonly encountered in developing countries, which are less able to afford new femtosecond laser technologies [5]. Moreover, when the planned femtosecond laser capsulotomy rapidly decompresses the swollen lens, the high intracapsular pressure can lead to collapse of the anterior lens surface and a consequent movement of the anterior capsule, resulting in failed capsulorhexis [18, 21].

Some authors claim high success rates, creating the CCC when the anterior capsule is kept pressurized, aided by water-tight incisions through which the CCC is performed [8, 15]. However, this technique may be very dangerous as the ILP is increased because of pressure in the AC. In addition, the counter pressure from the vitreous, with such a struggle of forces in different directions, can induce radial tear once anterior capsule puncture is formed [3, 23].

The results of the current study on human subjects provide preliminary evidence for the feasibility of the modified capsulorhexis technique in fluid-filled mature cataracts. However, the major limitations of the present study are the small sample size and the lack of a control group. The complication of capsulorhexis in mature cataracts is well known [2, 4, 23]. The difficulties in different surgical techniques have been reported; therefore, a single surgical maneuver was chosen here to minimize the burden on the patients. Although the presence of a fluid-filled pocket was confirmed by evidence of a recent anterior segment OCT study of the lens [19], we did not conduct anterior segment OCT imaging in our subjects. Further studies are needed to compare different OVDs used to maintain AC in the management of fluid-filled mature cataracts, with baseline data concerning anterior segment OCT images of intumescent cataracts.

CONCLUSIONS

In this study, a modified capsulorhexis technique with compression on the posterior lip of the main incision and capsule milking was found to be successful for achieving a safe CCC in intumescent cataracts. The modification addresses the source of the problem by eliminating the intralenticular forces on the anterior capsule encountered when performing CCC in intumescent cataracts.

ETHICAL DECLARATIONS

Ethical approval: The study was approved by the ethical committee of the Faculty of Medicine, Port Said University, and adhered to the tenets of the Declaration of Helsinki. After providing an explanation of the risks, possible complications, and visual prognosis, written informed consent for surgery was obtained from all patients.
Conflict of interests: None.

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REFERENCES

1. Chee SP, Chan NS, Yang Y, Ti SE. Femtosecond laser-assisted cataract surgery for the white cataract. Br J Ophthalmol. 2019;103(4):544-550. doi: 10.1136/bjophthalmol-2018-312289 pmid:29907631
2. Figueiredo CG, Figueiredo J, Figueiredo GB. Brazilian technique for prevention of the Argentinean flag sign in white cataract. J Cataract Refract Surg. 2012;38(9):1531-6. doi: 10.1016/j.jcrs.2012.07.002 pmid:22906440
3. Fabrikantov OL, Nikolashin SI, Shutova SV, Pirogova ES. [Determination of intralenticular pressure in patients with intumescent cataract]. Vestn Oftalmol. 2018;134(3):42-47. doi: 10.17116/oftalma2018134342 pmid:29953081
4. Aslan L, Aksoy A, Aslankurt M, Ozdemir M. Lens capsule-related problems in patients undergoing phacoemulsification surgery. Clin Ophthalmol. 2013;7:511-4. doi: 10.2147/OPTH.S42758 pmid:23507672
5. Sharma B, Abell RG, Arora T, Antony T, Vajpayee RB. Techniques of anterior capsulotomy in cataract surgery. Indian J Ophthalmol. 2019;67(4):450-460. doi: 10.4103/ijo.IJO_1728_18 pmid:30900573
6. Wygledowska-Promienska D, Jaworski M, Koziel K, Packard R. The evolution of the anterior capsulotomy. Wideochir Inne Tech Maloinwazyjne. 2019;14(1):12-18. doi: 10.5114/wiitm.2019.81313 pmid:30766624
7. Om Parkash R, Mahajan S, Om Parkash T. Modified 30 G needle trypan blue staining technique under air for a uniform and consistent anterior capsule staining. Clin Ophthalmol. 2017;11:1651-1656. doi: 10.2147/OPTH.S147510 pmid:29075093
8. Chan DD, Ng AC, Leung CK, Tse RK. Continuous curvilinear capsulorhexis in intumescent or hypermature cataract with liquefied cortex. J Cataract Refract Surg. 2003 Mar;29(3):431-4. doi: 10.1016/s0886-3350(02)01449-9 pmid:12663001
9. Robinson MS, Olson RJ. Simple approach to prevent capsule tear-out during capsulorhexis creation in hypermature cataracts. J Cataract Refract Surg. 2015;41(7):1353-5. doi: 10.1016/j.jcrs.2015.06.002 pmid:26287875
10. Genc S, Guler E, Cakir H, Ozerturk Y. Intraoperative complications in intumescent cataract surgery using a phaco capsulotomy technique. J Cataract Refract Surg. 2016;42(8):1141-5. doi: 10.1016/j.jcrs.2016.06.025 pmid:27531289
11. Teng CC. Phaco capsulotomy: a technique to prevent the Argentinean Flag Sign. Clin Ophthalmol. 2017;11:1937-1940. doi: 10.2147/OPTH.S138676 pmid:29184382
12. Nabil KM. Lens decompression technique for prevention of intraoperative complications during phacoemulsification of intumescent cataract. Indian J Ophthalmol. 2017;65(12):1436-1439. doi: 10.4103/ijo.IJO_352_17 pmid:29208830
13. Kara-Junior N, de Santhiago MR, Kawakami A, Carricondo P, Hida WT. Mini-rhexis for white intumescent cataracts. Clinics (Sao Paulo). 2009;64(4):309-12. doi: 10.1590/s1807-59322009000400007 pmid:19488587
14. Gavris M, Mateescu R, Belicioiu R, Olteanu I. Is Laser Assisted Capsulotomy better than standard CCC? Rom J Ophthalmol. 2017;61(1):18-22. doi: 10.22336/rjo.2017.4 pmid:29450366
15. Dhingra D, Balyan M, Malhotra C, Rohilla V, Jakhar V, Jain AK. A multipronged approach to prevent Argentinian flag sign in intumescent cataracts. Indian J Ophthalmol. 2018;66(9):1304-1306. doi: 10.4103/ijo.IJO_51_18 pmid:30127146
16. Chen Y-J, Wu P-C. Automated Irrigation/Aspiration Before Phacoemulsification in Eyes With White Cataracts. Ophthalmic Surge Lasers Imaging. 2005;36(2):118-21. doi: 10.3928/1542-8877-20050301-07 pmid:15792312
17. Chee SP, Chan NS. Capsule milking: Modification of capsulorhexis technique for intumescent cataract. J Cataract Refract Surg. 2017;43(5):585-589. doi: 10.1016/j.jcrs.2017.04.023 pmid:28602316
18. Conrad-Hengerer I, Hengerer FH, Joachim SC, Schultz T, Dick HB. Femtosecond laser-assisted cataract surgery in intumescent white cataracts. J Cataract Refract Surg. 2014;40(1):44-50. doi: 10.1016/j.jcrs.2013.08.044 pmid:24269086
19. Dhami A, Dhami AS, Singh H, Dhami GS. Role of anterior segment optical coherence tomography for safer management of mature white cataracts. J Cataract Refract Surg. 2019;45(4):480-484. doi: 10.1016/j.jcrs.2018.11.009 pmid:30733105
20. Titiyal JS, Kaur M, Shaikh F, Goel S, Bageshwar LMS. Real-time intraoperative dynamics of white cataract-intraoperative optical coherence tomography-guided classification and management. J Cataract Refract Surg. 2020;46(4):598-605. doi: 10.1097/j.jcrs.0000000000000086 pmid:32271296
21. Yildirim TM, Auffarth GU, Son HS, Khoramnia R, Munro DJ, Merz PR. Dispersive viscosurgical devices demonstrate greater efficacy

in protecting corneal endothelium in vitro. BMJ Open Ophthalmol. 2019;4(1):e000227. doi: 10.1136/bmjophth-2018-000227 pmid:30997401
22. Little BC, Smith JH, Packer M. Little capsulorhexis tear-out rescue. J Cataract Refract Surg. 2006;32(9):1420-2. doi: 10.1016/j.jcrs.2006.03.038 pmid:16931249
23. Adams ML, Diakonis VF, Weinstock RJ. Argentinian Flag Sign and Its Management during Femtosecond Laser-Assisted Cataract Surgery in a Case with Intumescent Cataracts. Case Rep Ophthalmol. 2021;12(1):129-133. doi: 10.1159/000513483 pmid:33976669
24. Pandey SK, Werner L, Escobar-Gomez M, Roig-Melo EA, Apple DJ. Dye-enhanced cataract surgery Part 1: anterior capsule staining for capsulorhexis in advanced/white cataract. J Cataract Refract Surg. 2000;26(7):1052-9. doi: 10.1016/s0886-3350(00)00296-0 pmid:10946199
25. Figueiredo CG. Reply: Prevention of the Argentinean flag sign. J Cataract Refract Surg. 2013;39(2):307-8. doi: 10.1016/j.jcrs.2012.12.023 pmid:23332275
26. 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):564-9. doi: 10.3928/1081597X-20110607-01 pmid:21688765