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Safety and efficiency of lens cortex removal assisted by fluid jet

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ABSTRACT

Background: This retrospective study investigated the safety and efficiency of lens cortex removal assisted by a fluid-based capsular polishing technique called a fluid jet.
Methods: This was a retrospective case study. A total of 300 patients were included in this study. All patients underwent phacoemulsification using two different surgical sequences: a fluid jet before irrigation/aspiration (I/A) and an I/A before the fluid jet. They were divided into two groups: the fluid jet before I/A group (group 1, 150 eyes) and the I/A before the fluid jet group (group 2, 150 eyes). The frequencies of posterior capsule rupture (PCR) and posterior capsule being sucked into the I/A tip were recorded. The times of the fluid jet, I/A cortex, and entire procedure were noted.
Results: PCR occurred only in group 2. Compared with group 1, the posterior capsule being sucked into the I/A tip was more frequent in group 2 ($P = 0.003$). The fluid jet time was longer in group 1 than that in group 2 ($P < 0.001$). The I/A cortex time was shorter in group 1, and total time for fluid jet and I/A cortex together was shorter in group 2 ($P = 0.014$ and $P = 0.007$, respectively). However, the time of the entire procedure was shorter in group 1 ($P < 0.001$).
Conclusions: Fluid jet-assisted lens cortex removal is safe, time-saving, and simple to perform.

1. Background

Posterior capsule rupture (PCR) is a common complication of phacoemulsified cataract surgery [1]. The incidence rate of PCR in phacoemulsification surgery has been reported as 0.9–5.2 % [2–9]. Most capsule tears (61 %) occur during the phacoemulsification phase, and 27–47 % occur during the irrigation/aspiration (I/A) phase [10,11]. Therefore, avoiding PCR during the I/A phase is essential during surgery.

A fluid jet is a technique that aims to remove the residual cortex from the posterior capsule following I/A by manually injecting a balanced salt solution (BSS) towards the posterior capsule and bag fornices via the hydrodissection cannula, also called hydropolish [12]. In clinical applications, we found that fluid jets can be applied before I/A instead of after I/A. There are many advantages to using a fluid jet before I/A. After the fluid jet, the cortex can be removed safely and easily. Simultaneously, owing to the change in the sequence of surgical steps, the surgical process was optimized and improved surgical efficiency.

In this study, we compared the safety and efficiency of fluid jet-assisted lens cortex removal with those of routine cortex removal.

Abbreviations: PCR, posterior capsule rupture; I/A, irrigation/aspiration; OVD, ophthalmic viscoelastic device; IOL, intraocular lens.

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2. Methods

This study was approved by the Ethics Committee of the Affiliated Hospital of Qingdao University (approval ID: QYFYWZLL 26576). The protocol was registered at Chictr. org.cn (ChiCTR2100050240). This was a retrospective study of 300 eyes with cataracts recruited between April 2022 and October 2022. All patients underwent phacoemulsification cataract surgery with different sequences of surgical steps: fluid jet before I/A (Group 1, 150 eyes) or I/A before fluid jet (Group 2, 150 eyes) (Fig. 1). Which approach would be used according to the date of the surgery. Eyes eligible for this study where surgery was performed by Bai H since July 2022 used the new approach (fluid jet before I/A), which were selected for Group 1. Patients who underwent surgery before July 2022 were selected as the Group 2. The inclusion criteria for these patients were: 60–80 years of age, 22.0–25.0 mm axial lengths, more than 2000 endothelial cells/mm^2, anterior chamber depth beyond 2.5 mm, dilated pupil diameter beyond 6 mm, cataract nucleus grade 2 to 4 (according to Emery-Little classification [13]), without any intraoperative complications before cortex removal, and no other oculopathy. Only one eye per patient was included in this study.

One day before surgery, the preoperative visual acuity was measured by using a logarithmic visual acuity chart. The distance between the chat and the person was 5 m. All surgeries were performed by the same surgeon (Bai H), who is experienced in phacoemulsification, using the WHITESTAR Signature Phaocemulsification System (Johnson & Johnson Surgical Vision, Inc.). The fluid jet was injected using a 5 mL syringe with a bent and blunt-tip needle from the main incision. This technique is the same as that described in the previous studies [12,14].

The authors had access to information that could identify individual participants during data collection. For each case, the following clinical data were collected: PCR, posterior capsule sucked into the I/A tip, fluid jet time, I/A cortex time, and duration of the entire procedure (from the end of nucleus removal to the beginning of close incisions). When PCR occurred, the time for each procedure was no longer recorded.

The independent-samples *t*-test was used to compare continuous variables between two groups. The assumption of equal variance was used. The Chi-square and Fisher's exact tests were used to evaluate differences in categorical variables. The Mann–Whitney *U* test was used to ranked data. Data were analyzed using Statistical Package for Social Sciences software (version 27, International Business Machines Corp.). The level of significance was set to a *P*-value of 0.05.

3. Results

One hundred and fifty patients were evaluated in each group. The characteristics of the patients in the two groups are shown in Table 1. There were no statistically significant differences in any characteristics between the two groups. No eye had the extremely low

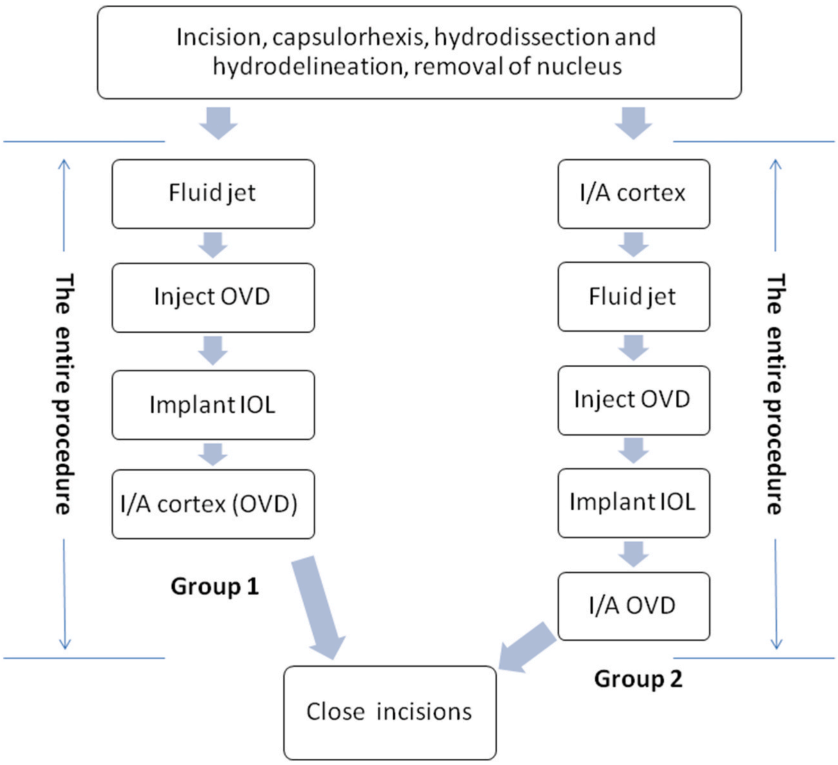

Fig. 1. The different sequence of surgical steps in both groups.

vision levels of count fingers, hand movements, perception of light or no perception of light.

The occurrence of PCR and the posterior capsule being sucked into the I/A tip is shown in Table 2. In group 2, the posterior capsule was sucked into the I/A tip nine times, which was more frequent than that in group 1. In all 300 cases, PCR occurred twice only in group 2. There was no statistically significant difference in the occurrence of PCR between the two groups ($P = 0.498$).

The duration of each procedure in both groups is shown in Table 3. The fluid jet time was longer in Group 1 than that in Group 2 ($P < 0.001$). The I/A cortex time was shorter in group 1, and the total time for the fluid jet and I/A cortex together was shorter in group 2 ($P = 0.014$ and $P = 0.007$). However, the duration of the entire procedure was shorter in Group 1 ($P < 0.001$).

4. Discussion

Phacoemulsification is the most common surgical technique used to treat cataracts worldwide. PCR is a common complication of this procedure. In the I/A cortex, the incidence of PCR has been reported to be 0.13–0.69 % [10,15]. According to our own experience, at a certain stage, PCR is more likely to occur in the I/A phase than in the phaco phase in surgical trainees [16]. Therefore, preventing PCR during the entire I/A phase is important.

We attempted to apply a fluid jet before the I/A cortex, which is called lens cortex removal assisted by a fluid jet. The aim was to improve the safety of the I/A cortex and avoid PCR. In this method, an ophthalmic viscoelastic device (OVD) is injected after the fluid jet, and an intraocular lens (IOL) is implanted before I/A. The I/A cortex and OVD were performed together.

Fluid jets are typically used to remove the residual cortex after the I/A cortex by rinsing with BSS, also called hydropolishing [11]. In a previous study, we found that fluid jets could be administered before the I/A phase, and after the fluid jet, the cortex could be easily removed [15]. The removal of the cortex from the subincisional space is challenging [17,18]. Dewey demonstrated a cortex removal technique using a J-shaped cannula for subincisional cortical removal [19]. However, because of the shape of the J-cannula, intraocular tissues may be hooked at the tip. In our technique, the I/A cortex was performed after fluid jet, OVD injection, and IOL implantation. And the cortex in the sub-incisional space could be easily removed. In our surgery, the fluid jet was applied just from the main incision; therefore, the cortex in the sub-incisional space could not be rinsed directly. However, after injection of the OVD and implantation of the IOL, the cortex could be pushed from the center to the capsular fornix and easily removed by I/A. The IOL protects the posterior capsule and prevents PCR. Our study suggests the protective effects of this technology on the posterior capsule. In group 1, no posterior capsule was sucked into the I/A tip, and PCR occurred in the I/A phase. In Group 2, the posterior capsule was sucked into the I/A tip nine times during the I/A phase. And during these 9 times, PCR occurred twice. For further confirming the protective effects of this technology, a study over a longer time period, with surgery by multiple surgeons in different hospitals and ideally randomised would be needed.

Our study found that the fluid jet time was different in both groups. Before the I/A cortex, the fluid jet required more time. As with the existence of much cortex, the fluid jet needs to rinse the central cortex, and then the residual cortex on the posterior capsule. However, if the fluid jet follows the I/A cortex, only the residual cortex on the posterior capsule should be rinsed. The duration of the entire procedure was significantly shorter in group 1($P < 0.001$). The main reason was that the I/A cortex and I/A OVD were performed in a single step in group 1 (Fig. 1). After fluid jet and IOL implantation, the I/A cortex was easily removed in group 1 ($P = 0.014$).

Occasionally, the IOL loop may suppress the cortex and cause difficulties in cortex removal. Rotation of the IOL can overcome this limitation. In addition, we attempted to rinse the cortex in the sub-incisional space using a side port. We did not observe any differences in cortical removal after IOL implantation. In our study, the IOL was one-piece hydrophilic. In our clinical experience, all types of IOL are suitable for this method.

However, this technique has some limitations. First, some patients were not suitable for this method, such as patients after

Table 1
Patient characteristics.

Characteristic	Group 1 (n = 150)	Group 2 (n = 150)	*P* Value
Age (y)			
Median (range)	72 (60, 80)	71 (60, 80)	0.436[a]
Sex, n (%)			
Male	70 (46.7 %)	74 (49.3 %)	0.644[†]
Female	80 (53.3 %)	76 (50.7 %)	
Right eye, n (%)	75 (50 %)	78 (52 %)	0.729[†]
Left eye, n (%)	75 (50 %)	72 (48 %)	
First treated eye, n (%)	129 (86.0 %)	135 (90.0 %)	0.286[†]
Second treated eye, n (%)	21 (14.0 %)	15 (10.0 %)	
Preoperative visual acuity (LogMar) Median (range)	0.5 (0.3, 1.0)	0.5 (0.3, 1.0)	0.454[a]
Axial length	23.47 ± 1.97	23.41 ± 1.87	0.802[a]
Anterior chamber depth	3.04 ± 0.29	3.02 ± 0.29	0.543[a]
Cataract nucleus grade, n (%)			
II	52 (34.7 %)	57 (38 %)	0.613[#]
III	69 (46 %)	65 (43.3 %)	
IV	29 (19.3 %)	28 (18.7 %)	

Mean ± SD.
[a] Independent-samples *t*-test; †Chi-square test; #Mann-Whitney *U* test.

Table 2
The occurrence of PCR and posterior capsule being sucked.

Complications	Group 1 (n = 150)	Group 2 (n = 150)	*P* Value
PCR	0 (0 %)	2 (1.3 %)	0.498
Posterior capsule being sucked	0 (0 %)	9 (6.0 %)	0.003

Table 3
Time for each step in the two groups.

Time (second)	Group 1 (n = 150) Median (range)	Group 2 (n = 148) Median (range)	*P* Value
Fuid jet	13 (6, 23)	7 (4, 17)	<0.001
I/A cortex	20 (10, 36)	23 (12, 49)	0.014
Fluid jet + I/A cortex	37 (19, 56)	34 (17, 55)	0.007
The entire procedure	94 (70, 115)	102 (80, 147)	<0.001

vitrectomy or patients with high myopia. These patients did not have sufficient vitreous support, and after removing the nucleus, the anterior chamber did not collapse in most cases. Therefore, rinsing the posterior capsule is difficult. Second, the fluid jet is not suitable for polishing the anterior capsule.

This study also has some limitations. First, the eligibility criteria excluded high-risk eyes. Secondly, the sample size was relatively small. These samples account for approximately 30 % of the total cataract surgeries performed in our hospital within the study time period. Third, these were single center study, single surgeon study, study in China and thus results may not be representative for other ethnic groups.

Conclusion

Fluid jet-assisted lens cortex removal is safe, time-saving, and simple to perform.

Accordance statement

We confirm that all methods were performed in accordance with the relevant guidelines and regulations.

Ethics statement

This study had obtained human research ethics approval by Ethics Committee of the Affiliated Hospital of Qingdao University, China (approval ID: QYFYWZLL 26576).

Consent for publication

Not applicable.

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Data availability statement

The data of this study can be obtained by contacting the corresponding author.

CRediT authorship contribution statement

Lin Yao: Writing – review & editing, Writing – original draft, Project administration, Methodology, Investigation, Funding acquisition, Data curation. **Haiqing Bai:** Writing – review & editing, Writing – original draft, Supervision, Resources, Methodology, Investigation, Data curation.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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References

[1] F.H. Zaidi, M.C. Corbett, B.J. Burton, P.A. Bloom, Raising the benchmark for the 21st century–the 1000 cataract operations audit and survey: outcomes, consultant-supervised training and sourcing NHS choice, Br. J. Ophthalmol. 91 (6) (2007) 731–736.
[2] R.L. Johnston, H. Taylor, R. Smith, J.M. Sparrow, The Cataract National Dataset electronic multi-centre audit of 55,567 operations: variation in posterior capsule rupture rates between surgeons, Eye 24 (5) (2010) 888–893.
[3] N. Narendran, P. Jaycock, R.L. Johnston, et al., The Cataract National Dataset electronic multicentre audit of 55,567 operations: risk stratification for posterior capsule rupture and vitreous loss, Eye 23 (1) (2009) 31–37.
[4] R. Pokroy, E. Du, A. Alzaga, et al., Impact of simulator training on resident cataract surgery, Graefes Arch. Clin. Exp. Ophthalmol. 251 (3) (2013) 777–781.
[5] L. Zhang, W. Xu, K. Yao, The risk factors of posterior capsule rupture in phacoemulsification of cataract, Zhonghua. Yan. Ke. Za. Zhi. 51 (4) (2015) 282–287.
[6] A. Gupta, J.R.C. Miller, G.C.L. Yam, A. Ionides, Patient age and posterior capsule rupture risk in phacoemulsification cataract surgery, Published, Acta Ophthalmol. (2023 May 3).
[7] M.H.M. Segers, A. Behndig, F.J.H.M. van den Biggelaar, et al., Outcomes of cataract surgery complicated by posterior capsule rupture in the European registry of quality outcomes for cataract and refractive surgery, J. Cataract Refract. Surg. 48 (8) (2022) 942–946.
[8] H. Hashemi, M. Khabazkhoob, F. Rezvan, et al., Complications of cataract surgery in Iran: trend from 2006 to 2010, ophthalmic, Epidemiology 23 (1) (2016) 46–52.
[9] H. Hashemi, F. Rezvan, K. Etemad, et al., Intraoperative complications of cataract surgery in tehran province, Iran, Optom. Vis. Sci. 93 (3) (2016) 266–271.
[10] M.F. Pingree, A.S. Crandall, R.J. Olson, Cataract surgery complications in 1 year at an academic institution, J. Cataract Refract. Surg. 25 (5) (1999) 705–708.
[11] H.V. Gimbel, Hydrodissection and hydrodelineation, Int. Ophthalmol. Clin. 34 (2) (1994) 73–90.
[12] S.B. Wang, X.M. Quah, S. Amjadi, J. Tong, I.C. Francis, Hydropolish: a controlled trial on a technique to eradicate residual cortical lens fibers in phacoemulsification cataract surgery, Eur. J. Ophthalmol. 25 (6) (2015) 571–574.
[13] J.M. Emery, J.H. Little, Patient selection, in: J.M. Emery, J.H. Little (Eds.), Phacoemulsification and Aspiration of Cataracts; Surgical Techniques, Complications, and Results, CV Mosby, St. Louis, MO, 1979, pp. 45–48.
[14] K.E. Han, S.H. Han, D. Lim, et al., A modified-simple technique of removing the lens cortex during cataract surgery, Indian J. Ophthalmol. 65 (1) (2017) 59–61.
[15] H.V. Gimbel, R. Sun, M. Ferensowicz, et al., Intraoperative management of posterior capsule tears in phacoemulsification and intraocular lens implantation, Ophthalmology 108 (12) (2001) 2186–2192.
[16] H. Bai, L. Yao, H. Wang, Clinical investigation into posterior capsule rupture in phacoemulsification operations performed by surgery trainees, J. Ophthalmol. (2020 Feb 12), 1317249.
[17] D.J. Apple, Q. Peng, N. Visessook, et al., Surgical prevention of posterior capsule opacification. Part 1: progress in eliminating this complication of cataract surgery, J. Cataract Refract. Surg. 26 (2) (2000) 180–187.
[18] Q. Peng, D.J. Apple, N. Visessook, et al., Surgical prevention of posterior capsule opacification. Part 2: enhancement of cortical cleanup by focusing on hydrodissection, J. Cataract Refract. Surg. 26 (2) (2000) 188–197.
[19] V. Rengaraj, V. Kannusamy, T. Krishnan, et al., Cortical removal simplified by J-cannula irrigation, J. Cataract Refract. Surg. 31 (6) (2005) 1085–1086.