



Vitreous-lens interface changes after cataract surgery using active fluidics and active sentry with high and low infusion pressure settings

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Purpose: To determine whether the infusion pressure used during phacoemulsification may have a detrimental effect on the anterior hyaloid membrane barrier (AHMB) in a pressure fluctuation-free environment using diagnostic spectral-domain optical coherence tomography (SD-OCT) postoperatively.

Setting: Tandil Eye Clinic, Tandil, Buenos Aires, Argentina, and Centro Oftalmológico Dr. Charles, CABA, Buenos Aires, Argentina.

Design: Prospective, randomized, multicenter, experimental, and double-masked study.

Methods: Phacoemulsification with intraocular lens implantation was performed in all patients with the Centurion Vision System equipment with active fluidics and active sentry. Patients were randomly assigned to configuration 1 or 2. Configuration 1 had intraocular pressure (IOP) 30 mm Hg and configuration 2 IOP 80 mm Hg. Inclusion criteria were axial length >22 mm and <25 mm, age older than 50 and younger than 70 years, and complete adhesion of AHMB.

Results: 80 eyes of 80 patients were included. Berger space was identified in 17 cases (42.5%) of group 2 and 3 cases (7.5%) of group 1 postoperatively using SD-OCT. A statistically significant relationship was established using Fisher exact test ($P = .0003$). Postoperatively, we observed posterior vitreous detachment changes in only 1 patient (1.25%) during the 3 months of follow-up ($P = .5$). According to the Wong-Baker FACES Scale, the patient's subjective perception was better for the low infusion pressure group ($P = .0001$, Fisher exact test).

Conclusions: Phacoemulsification with high infusion pressure can change the vitreous-lens interface. Positive Berger space after phacoemulsification is a biomarker of this change and can occur in eyes without risk factors. Incidence is directly related to the infusion pressure used.

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Cataract extraction is the most general surgical procedure with an estimated 20 million cases per year worldwide, with phacoemulsification being the surgical method of choice.^{1,2} This number will increase in the coming years, mainly for 2 reasons: the increase in life expectancy of the global population and the increasing trend to perform phacoemulsification in younger people. The effect of phacoemulsification on psychosocial well-being and quality of life is increasingly relevant, and therefore, the importance of performing a minimally invasive surgery that does not cause any damage to the ocular tissues, modify their natural history, or increase the risk of any vision-threatening condition is critical.

The vitreous base anchors the vitreous body and is the only zone where collagen fibers course perpendicular to the

retina and directly interdigitate with the nonpigmented epithelium of the ciliary body and neuroglia of the peripheral retina. This strong mechanical adhesion is responsible for persistent attachment along the vitreous base despite posterior vitreous detachment (PVD). Unlike at the vitreous base, the collagen fibrils in the posterior vitreous cortex run parallel to the plane of the retina. This orientation does not allow direct insertion into the retina and accounts for the weaker adhesion along this zone. The anterior vitreous and anterior hyaloid membrane (AHM) run from the pars plana and firmly adhere to the posterior lens caps through the ligament of Wieger that delimits the Berger space. In most adults, this is a potential (rather than real) space, with the posterior capsule and anterior hyaloid face directly attached in normal eyes.³

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Table 1. Demographics and biometrics distribution by groups

Variable	Low infusion pressure (30 mm Hg; n = 40 eyes)						
	Female	Age	LA	ACD	LT	Avg K	Corneal map
Mean	23 (57.5%)	66.82	23.17	3.14	4.47	43.31	525
SD		3.78	0.72	4.61	0.55	1.96	33.47
Median		68	23.4	3.09	4.72	43.5	525
P value (Mann-Whitney U test)		.85	.50	.41	.73	.15	.43

ACD = anterior chamber depth; Avg K = average keratometry; LA = long axial; LT = lens thickness

Based on these anatomical characteristics, we consider that over time with the normal aging process, the posterior vitreous cortex always detaches; the vitreous base never detaches because of its histology; and the AHM could detach in certain situations such as trauma, vitreous hemorrhage, and aging and as demonstrated in many studies after phacoemulsification. The extent to which the vitreous is altered because of the leakage of debris from cortical lens fibers into the anterior vitreous during phacoemulsification is not well-established.⁴

The mechanical resistance of normal ocular tissues is not boundless, so not considering the influence of high infusion pressure and the type of fluidics system used in the incidence of AHM barrier disruption and other potential complications could be a mistake.

The purpose of this study was to determine whether the infusion pressure used during phacoemulsification may have a detrimental effect on the AHM barrier by spectral-domain optical coherence tomography (SD-OCT) postoperatively.

To our knowledge, this is the first time that a study is performed using active fluidics and active sentry comparing their efficiency and safety with high and low infusion pressure in a clinical setting.

METHODS

This was a randomized, multicenter, prospective, experimental, and double-masked study. The study was performed at Tandil Eye Clinic, Tandil, Buenos Aires, Argentina, and Centro Oftalmológico Dr. Charles, CABA, Argentina, following the tenets of the Declaration of Helsinki. Patients gave their informed consent after receiving an explanation of the investigative nature and intent of the study. This study was approved by the Research Ethics Committee of the Argentine Society of Ophthalmology. The data were analyzed using Stats Direct statistical software v. 2, 7, 2.

Fisher exact test was used to compare proportions while the Mann-Whitney test was used to compare numerical variables. A P value less than 0.05 was considered statistically significant. The sample size was 80 patients (40 per group) undergoing cataract phacoemulsification surgery with intraocular lens implantation. The primary outcome to be evaluated was the involvement of the vitreous-lens interface, taking Berger space detection as the event. To test the null hypothesis, the sample size decision (40 eyes per group) was made considering a significance level of 5% and power of 80%, to compare samples from independent groups, which had different levels of intraoperative IOP (30 mm Hg group 1 vs 80 mm Hg group 2). All surgeries were performed by the same surgeon (H.A.S.) in both clinics. The Centurion Vision System equipment with active fluidics and active sentry (Alcon Laboratories, Inc.) was used in all patients. The procedure was performed under topical anesthesia, through a 2.2-mm incision (intrepid balanced tip) stop-and-chop technique with the following fluidic parameters: configuration 1 IOP 30 mm Hg, flow rate 45 mL/min, and vacuum 450 mm Hg and configuration 2 IOP 80 mm Hg, flow rate 45 mL/min, and vacuum 450 mm Hg. In both configurations, IOP ramp in 3 seconds, automatic patient eye level, and irrigation factor in position 2 were used. Special attention was paid when injecting an ophthalmic viscosurgical device and performing hydrodissection, to avoid an increase in the intraocular pressure (IOP) during these steps of the surgery. Patients were randomly assigned to configuration 1 or 2. The evaluation of the anterior vitreous and its interface with the crystalline lens was carried through a cross-section (in the axis 0 to 180) that passed through the corneal apex with Optovue Solix FullRange (Optovue, Inc.) SD OCT-A (scanning field 18 mm wide and 6.25 mm deep). When the AHM was observed separately from the posterior capsular lens, it was considered a positive Berger space. Posterior vitreous was evaluated by Optovue Solix FullRange SD-OCT (FullRange Retina) preoperatively and postoperatively with dilated pupils. Staging of the posterior vitreous was performed according to the classification described by Johnson (stages 0 to 4).⁵

Central macular thickness and ganglion cell complex (GCC) were evaluated with Optovue Solix FullRange SD-OCT and Retina Cube QuickVue, respectively. Endothelial count was evaluated with a Tomey EM 4000 specular microscope and corneal thickness

Table 2. Surgical efficiency: fluidics metrics by groups

Variable	Total CDE		TUT (sec)		TEFA (mL)		TAT (sec)		ASM actuation	
	Low IPG	High IPG	Low IPG	High IPG	Low IPG	High IPG	Low IPG	High IPG	Low IPG	High IPG
Mean	7.31	8.02	75.7	68.33	51.92	51.04	211.47	191.18	1.29	7.59
SD	3.19	3.3	25.89	21.07	9.83	10.21	40.66	41.4	2.06	8.65
Median	6.70	7.17	70.5	62.5	52	48.5	207	179	1	4
P value (Mann-Whitney U test)	.87		.08		.93		.01		.0004*	

ASM = active sentry module; CDE = cumulative dissipated energy; IPG = low infusion pressure group; TEFA = total estimated fluid aspirated; TAT = total aspiration time; TUT = total ultrasound time

*Statistically significant

Table 1. Continued

High infusion pressure (80 mm Hg; n = 40 eyes)						
Female	Age	LA	ACD	LT	Avg K	Corneal map
17 (42.5%)	66.09	23.69	3.20	4.61	43.10	528
	4.57	0.75	4.29	0.42	1.53	34,10
	67	23.49	3.25	4.59	43.2	521

with Optovue Solix FullRange SD OCT-A. Preoperative data were analyzed, in addition to those obtained in the postoperative period at days 1, 7, 30, and 90.

Fluid metrics, the patient's subjective perception (Wong-Baker FACES Pain Rating Scale), and postoperative inflammation (Standardization of Uveitis Nomenclature) were also evaluated.^{6,7}

Inclusion criteria were both sexes, age older than 50 and younger than 70 years, healthy eyes, axial length >22 mm and <25 mm, no risk factors for anterior vitreous detachment (AHD), and complete adhesion of the AHM evidenced by SD-OCT.

Exclusion criteria were previous surgeries and any type of previous ocular pathology (glaucoma, uveitis, retinopathy, trauma, pseudoexfoliation syndrome [PEX], etc.), except cataracts.

RESULTS

The study included 80 eyes of 80 patients who underwent uneventful phacoemulsification with IOL implantation during the study period (June 2022 through December 2022). Table 1 summarizes the demographics and biometrics distribution by groups.

In 3 eyes of group 1 (7.5%) and 17 eyes of group 2 (42.5%), Berger space was visualized using an SD-OCT device in the postoperative period. The difference between groups was statistically significant with $P = .0003$ (Fisher exact test).

As indicators of the efficacy and safety of the procedure, cumulative dissipated energy, total ultrasound time, total aspiration time (TAT) and active sentinel module (ASM) actuation were evaluated in both groups. Table 2 summarizes the fluidics metric. There were no statistically significant differences between the 2 groups for the first 3 parameters. There was a statistically significant difference

for TAT ($P = .007$, Mann-Whitney U test) and ASM actuation ($P = .0004$, Mann-Whitney U test).

The preoperative PVD stages in our population study are summarized in Table 3. Postoperatively, we observed PVD changes in only 1 patient (1.25%) during the 3 months of follow-up ($P = .5$, not statistically significant).

There was an increase in macular thickness postoperatively (full thickness, outer thickness, and GCC) at days 30 and 90 in both groups. The increase of GCC thickness was higher in group 2 and statistically significant ($P = .02$, Mann-Whitney U test) (Table 4).

The patient's subjective perception was better for the low infusion pressure group according to the Wong-Baker FACES Scale (statistically significant $P = .0001$, Fisher exact test) (Table 5).

We found no statistically significant difference in endothelial cell count on day 90 ($P = .74$), corneal map on day 1 ($P = .41$), and postoperative inflammation ($P = .56$) between the groups (Table 6).

DISCUSSION

Interest in the changes generated in the vitreous-lens interface during and after phacoemulsification has increased in recent years. Much has been researched and speculated about the risk factors and potential consequences, but little thought has been given to how to avoid or reduce these possible damages. One apparent reason not taken into account is the mechanical resistance of normal ocular tissues and how it is challenged daily by cataract surgeons around the world.⁸ This already falls into the category of ethical considerations.

It is well known that there are risk factors of AHM barrier disruption, some related to the eye itself that are readily identifiable (trauma, myopia, vitreous hemorrhage, aging, or PEX) and others related to the hydrodynamics of phacoemulsification. In this area, there are 2 main problems: first, the IOP fluctuations that in our study with the active fluidics system (AFS) and active sentry were eliminated. The second problem is the IOP beyond the physiological range, a necessary condition in a gravity fluidics system (GFS) to get a stable anterior chamber (AC). It is important to mention that GFS is an old fluidics system in which it is impossible to use higher settings unless the IOP set is very high, affecting the physiological conditions of the ocular tissues. AFS and active sentry contain integrated pressure sensors monitoring IOP changes in real time. By using the AFS, it is possible to operate with IOP values close to physiological values, with higher flow and vacuum settings, considering that IOP is independent of changes in these parameters (flow and vacuum).^{9,10}

Table 3. Evolution of the early stages of posterior vitreous detachment

Preop PVD stages (according to Johnson)	Low infusion pressure (30 mm Hg; n = 40 eyes), n (%)	High infusion pressure (80 mm Hg; n = 40 eyes), n (%)
0	13 (32.5)	12 (30)
1	10 (25)	6 (15)
2	6 (15)	4 (10)
3	1 (2.5)	2 (5)
4	10 (25)	16 (40)
Postop changes in the PVD stages		
Yes	1 (2.5)	0 (0)
No	39 (97.5)	40 (100)
P value (Fisher exact test)	.5	

PVD = posterior vitreous detachment

Table 4. Distribution by groups of macular spectra according to the days of the postoperative period

Parameter	Full TH		Outer TH		GCC	
	Low IPG	High IPG	Low IPG	High IPG	Low IPG	High IPG
1 d	−0.26	0.34	−0.38	0.78	−1.50	5.74
7 d	−0.47	1.32	0.40	0.76	−3.01	6.42
30 d	1.64	2.32	1.18	1.55	2.67	6.09
90 d	1.62	2.09	1.44	3.04	−1.25	8.00
<i>P</i> value (Mann-Whitney <i>U</i> test)	.34		.34		.02*	

GCC = ganglion cell complex; IPG = infusion pressure group; TH = thickness

*Statistically significant

Already in 2009 from the analysis of contrast-enhanced magnetic resonance imaging findings, Kawasaki et al. demonstrated that the posterior chamber AHM barrier was disrupted because of the abnormal elevation or fluctuation of IOP during the surgery and suggested that continuous elevation or an abrupt change of IOP may place stress on the Wieger ligament and induce a total detachment.¹¹ The detachment of the AHM can be artificially created by increasing the IOP with intracameral injections of irrigating fluid as first reported by Ikeda et al. who applied this technique in removing vitreous hemorrhage attached to the posterior lens capsule.¹²

Vasavada et al. reported that using high-fluidics parameters during phacoemulsification caused partial AHD with an intact posterior lens capsule. Higher irrigation pressure per se may cause damage to zonular fibers, which facilitates the entry of irrigation fluid into Berger space.¹³

Zhang et al. visualized Berger space with SS-OCT postoperatively in 19.7% of patients who underwent uneventful phacoemulsification with no risk factors of AHD.¹⁴ They used ultrasound power up to 40%, vacuum 500 mm Hg, and GFS to provide passive infusion at 95 to 110 cm above the eye level. The authors associated Berger space development with a higher irrigation pressure ($P < .001$) and shorter surgery duration ($P = .021$).

Vael et al. reported a 63% incidence of AHD with intraoperative OCT but did not report which fluidics parameters and the type of fluidics system they used. They

also found that age is a directly related risk factor of AHD since the natural aging of ocular tissues reduces their mechanical resistance.¹⁵ Li et al. described prolonged suction time and accumulated dissipated energy as risk factors for presenting DSA (with intraoperative DSA value of 56.1%).¹⁶ Still, we could not compare our results with them because the authors did not clarify which fluidics parameters they use (they only mentioned a flow rate of 35 mL/min). We hypothesize that both studies used a high infusion pressure because the incidence of AVD was similar to our group 2.^{15,16}

Yu et al. demonstrated that cataract surgery with AFS is more efficient.¹⁷ It is important to note that with active fluidics, we can operate efficiently and, at the same time, more safely using an infusion pressure close to the physiological ranges. As presented in Table 2, ASM actuation was statistically significantly lower in group 1, which implies that with AFS and active sentry, when the IOP set is lower, fewer IOP fluctuations occur.

In our study, the difference in TAT in the 2 groups was statistically significant and higher for the low infusion pressure group. However, it is important to consider wound leakage. Although this magnitude was not quantified in our study, scientific evidence shows that wound leakage is greater when the infusion pressure is higher for the same incision size.¹ The higher the infusion pressure, the greater the leakage and, therefore, the lower the fluid aspirated through the aspiration line for the same flow setting. In turn, this will result in greater compensation with a greater flow to keep the chamber stable, hence the explanation for the statistically significant increase in the number of active sentry actuation produced in group 2.

Using intraoperative OCT, Anisimova et al. reported the presence of Berger space and penetration of lens fragments into the hyaloid–capsular interspace.¹⁸ The incidence of AHD reported was 75%. It is important to remark that there are no specified fluidics parameters used and an important number of the patients were at high risk of AHD (most of the eyes with PEX).

AHD is associated with increased instability of the posterior lens capsule (due to loss of Wieger ligament fixation and support of anterior vitreous) and is a latent risk factor of posterior capsule rupture. AHD may also partly contribute to the pathogenesis of acute fluid misdirection syndrome (AFMS). However, in our and previous studies, despite its high incidence, no case of positive Berger space

Table 5. Distribution by groups of Wong-Baker FACES Pain Rating Scale

FACE	Wong-Baker FACES Pain Rating Scale	Low IPG (n = 40 eyes), n (%)	High IPG (n = 40 eyes), n (%)
FACE 0	No hurt	40 (100)	8 (20)
FACE 2	Hurt little bit		24 (60)
FACE 4	Hurts little more		7 (17.5)
FACE 6	Hurts even more		
FACE 8	Hurts whole lot		1 (2.5)
FACE 10	Hurts worst		
<i>P</i> value (Fisher exact test) = .0001			

IPG = infusion pressure group

Table 6. Distribution by groups of endothelial cell count, corneal map, and postoperative inflammation

Parameter	% of ECL at 90 d		CT increase % at 1 d		SUN	Low IPG	High IPG
	Low IPG	High IPG	Low IPG	High IPG	0	55%	50%
Mean	6.12	7.06	4.37	4.52	1	35%	35%
SD	8.64	10.95	4.16	3.19	2	10%	7.5%
Median	3.45	3.2	3.41	3.8	3	0%	7.5%
P value (Mann-Whitney U test)	.74		.41			.56	

CT = corneal thickness; ECL = endothelial cell loss; IPG = infusion pressure group; SUN = Standardization of Uveitis Nomenclature

or AHD presented with AFMS, which probably means that AHD is not a sufficient condition for AFMS to occur.^{14–16,19}

Santos-Bueso evaluated the presence of the Berger space using AS-OCT in 90 patients, and he found it in 3 patients.²⁰ Mori et al. evaluated the visibility of AHM in the retrolental space of normal human eyes, and AHM was seen in 6.9% of eyes examined with the deep-range AS-OCT.²¹ In this study, postoperatively, eyes with Berger space had higher irrigation pressure and suggest that a comprehensive consideration of irrigation pressure and surgical time may better reflect the effects of cataract surgery on the vitreolenticular interface.

Several studies have found that phacoemulsification may cause or accelerate previous PVD. Our results revealed that only 1.5% of the eyes developed or progressed PVD at 3 months postoperatively, and this result does not agree with the results obtained in previous studies.^{22–26} We assume that this reduction in the beginning or progression of the PVD in the immediate postoperative period up to 3 months is because active fluidics provides a fluctuation-free environment and, therefore, avoids sudden movements in the vitreous body and minimizes posteroanterior traction.

Based on our findings, we hypothesize that IOP fluctuations are related to posteroanterior traction and the increased incidence of PVD while high infusion pressure is related to anteroposterior traction and the increased incidence of anterior vitreous detachment. It is important to mention that in the case of GFS, the traction is in both directions (because of fluctuations and high IOP simultaneously).

In our opinion, the detachment of the anterior vitreous during phacoemulsification generates traction on the anterior edge of the vitreous base that could account for the multiple small tears near the ora serrata that characteristically can be seen in pseudophakic retinal detachments. It is important to consider the solid mechanical adhesion along the vitreous base. Regarding the incidence of pseudophakic retinal detachment, according to our results we observed that Active Fluidics and Active Sentry providing an environment without pressure fluctuations may have an active role in reducing the incidence of postoperative PVD and could limit the incidence of rhegmatogenous retinal detachment (0.36% to 2.9% of cases 10 years after phacoemulsification).^{27,28} The limitations of our study are that the results probably cannot be comparable with eyes with risk factors or with axial lengths in the borderlines (too short, too long). It is our thought that this study can

be an initial starting point for future studies with more prolonged follow-up to observe the changes in anterior vitreous interface and PVD in the long term. Nevertheless, further studies are needed to confirm and explain this hypothesis.

The effect of phacoemulsification on retinal structure and function has also been the focus of recent research. Increases in retinal thickness after cataract surgery have been observed, and such changes are closely related to surgical injuries, IOP changes, and inflammatory reactions.^{29–33} Our results agree with those reported in previous studies, with the increase in GCC thickness statistically significantly greater in group 2 ($P = .02$).

Endothelial cell loss associated with phacoemulsification injuries can range from 4% to 25% according to previous studies.^{34,35} Higher surgical efficiency and more stable AC reduce the possibility and extent of corneal endothelial cell damages when the AFS is applied to phacoemulsification.^{16,34}

High IOP causes discomfort such as eye distension and eye pain, even increasing patient anxiety and worsening surgical outcomes. The maintenance of the AC by AFS improves surgical safety and efficiency and allows for a low target IOP (up to 20 mm Hg). If the target IOP is closer to the physiologic state, patients' discomfort can be greatly reduced and surgery can be more safely performed.

We demonstrated that phacoemulsification with high infusion pressure can change the vitreous-lens interface. Positive Berger space after phacoemulsification is a biomarker of this change and can occur in healthy eyes with no risk factors.

The data of this work allow us to question the use of high IOP phacoemulsification settings, not only in patients with preexisting pathologies and cataracts but also in completely healthy and young patients, in whom phacorefractive surgeries are performed. Hopefully, our findings can help provide insight into changing the current high IOP phacoemulsification setup to a more moderate one. In addition, it is important to understand that to achieve this it is necessary to incorporate new technologies available today and make a critical change in mindset.

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WHAT WAS KNOWN

- Hydrodynamics and pressure fluctuations during cataract surgery can alter the normal attachment of the vitreous lens interface in eyes with risk factors.

WHAT THIS PAPER ADDS

- High infusion pressure affects the anterior hyaloid membrane in a pressure fluctuation-free environment in healthy eyes.
- Active fluidics system (AFS) and active sentry are more efficient at low infusion pressure even at high flow and vacuum settings
- AFS and active sentry at low infusion pressure do not modify the state of the posterior vitreous in the immediate post-operative period after uneventful phacoemulsification.

REFERENCES

- Lundstrom M, Barry P, Henry Y, Rosen P, Stenevi U. Evidence-based guidelines for cataract surgery: guidelines based on data in the European Registry of Quality Outcomes for Cataract and Refractive Surgery. *J Cataract Refract Surg* 2012;38:1086–1093
- Solomon KD, Lorente R, Fanney D, Cionni RJ. A clinical study using a new phacoemulsification system with surgical intraocular pressure control. *J Cataract Refract Surg* 2016 42:542–549
- Sakamoto T. *Vitreous: In Health and Disease*. New York: Springer-Verlag, 2014. pp. 847–848.
- Neal RE, Bettelheim FA, Lin C, Winn KC, Garland DL, Zigler JS Jr. Alterations in human vitreous humor following cataract extraction. *Exp Eye Res* 2005;80:337–347
- Johnson MW. Posterior vitreous detachment: evolution and complications of its early stages. *Am J Ophthalmol* 2010;149:371–382
- Wong DL, Baker CM. Pain in children: comparison of assessment scales. *Pediatr Nurs* 1988;14:9–17
- Jabs DA, Nussenblatt RB, Rosenbaum JT; Standardization of Uveitis Nomenclature (SUN) Working Group. Standardization of uveitis nomenclature for reporting clinical data. Results of the First International Workshop. *Am J Ophthalmol* 2005;140:509–516
- Campbell IC, Coudrillier B, Ross Ethier C. Biomechanics of the posterior eye: a critical role in health and disease. *J Biomech Eng* 2014;136:021005
- Nicoli CM, Dimalanta R, Miller KM. Experimental anterior chamber maintenance in active versus passive phacoemulsification fluidics systems. *J Cataract Refract Surg* 2016;42:157–162
- Thorne A, Dyk DW, Fanney D, Miller KM. Phacoemulsifier occlusion breaks surge volume reduction. *J Cataract Refract Surg* 2018;44:1491–1496
- Kawasaki S, Suzuki T, Yamaguchi M, Tasaka Y, Shiraiishi A, Uno T, Sadamoto M, Minami N, Naganobu K, Ohashi Y. Disruption of the posterior chamber-anterior hyaloid membrane barrier during phacoemulsification and aspiration as revealed by contrast-enhanced magnetic resonance imaging. *Arch Ophthalmol* 2009;127:465–470
- Ikeda T, Sato K, Katano T, Hayashi Y. Surgically induced detachment of the anterior hyaloid membrane from the posterior lens capsule. *Arch Ophthalmol* 1999;117:408–409
- Vasavada V, Srivastava S, Vasavada V, Vasavada S, Vasavada AR, Sudhakar A, Bilgic A. Impact of fluidic parameters during phacoemulsification on the anterior vitreous face behavior: experimental study. *Indian J Ophthalmol* 2019;67:1634–1637
- Zhang Z, Yao J, Chang S, Kancierz P, Khoramnia R, Deng M, Wang X. Incidence and risk factors for Berger's space development after uneventful cataract surgery: evidence from swept-source optical coherence tomography. *J Clin Med* 2022;11:3580
- Vael A, Van Os L, Melis K, Tassignon MJ. Evaluation of the vitreolenticular interface with intraoperative OCT. *J Cataract Refract Surg* 2022;48:826–830
- Lin W, Luo J, Li P, Ji M, Guan H. Anterior vitreous detachment and retrolental material during cataract surgery: incidence and risk factors, with pathological evidence. *J Cataract Refract Surg* 2023;49:578–583
- Luo Y, Xu G, Li H, Ma T, Ye Z, Li Z. Application of the active-fluidics system in phacoemulsification: a review. *J Clin Med* 2023;12:611
- Anisimova NS, Arbisser LB, Shilova NF, Melnik MA, Belodedova AV, Knyazev B, Malyugin BE. Anterior vitreous detachment: risk factor for

intraoperative complications during phacoemulsification. *J Cataract Refract Surg* 2020;46:55–62

- Grzybowski A, Kancierz P. Acute and chronic fluid misdirection syndrome: pathophysiology and treatment. *Graefes Arch Clin Exp Ophthalmol* 2018; 256:135–154
- Santos-Bueso E. Berger's space. *Arch Soc Esp Oftalmol* 2019;94:471–477
- Mori H, Ueno Y, Fukuda S, Oshika T. Detection of anterior hyaloid membrane detachment using deep-range anterior segment optical coherence tomography. *J Clin Med* 2022;11:3057
- Degirmenci C, Afrashi F, Montes J, Oztas Z, Nalcaci S, Akkin C. Evaluation of posterior vitreous detachment after uneventful phacoemulsification surgery by optical coherence tomography and ultrasonography. *Clin Exp Optom* 2017;100:49–53
- Ivatinovic D, Schwab C, Borkenstein A, Lackner EM, Wedrich A, Velikay-Parel M. Evolution of early changes at the vitreoretinal interface after cataract surgery determined by optical coherence tomography and ultrasonography. *Am J Ophthalmol* 2012;153:705–709
- Hikichi T. Time course of development of posterior vitreous detachments after phacoemulsification surgery. *Ophthalmology* 2012;119: 2102–2107
- Geng W, Lin W, Song P, Zhang M, Wu J, Su S, Yuan Y, Ji M, Guan H. Effect of anterior chamber instability during phacoemulsification combined with intraocular lens implantation. *J Ophthalmol* 2022;2022: 2848565
- Park JH, Yang H, Kwon H, Jeon S. Risk factors for onset or progression of posterior vitreous detachment at the vitreomacular interface after cataract surgery. *Ophthalmol Retina* 2021;5:270–278
- Qureshi MH, Steel DHW. Retinal detachment following cataract phacoemulsification—a review of the literature. *Eye (Lond)* 2020;34:616–631
- Srinivasan S. Pseudophakic retinal detachment: a ticking time bomb. *J Cataract Refract Surg* 2023;49:225–226
- Liu J, Liu Q, Yu H, Xia Y, Zhang H, Geng C, Dong L. Microvascular changes in macular area after phacoemulsification and its influencing factors assessed by optical coherence tomography angiography. *Ther Clin Risk Manag* 2021;17:405–414
- Liu X, Fang Y, Zhou Y, Wang M, Luo Y. Dynamic changes in retinal vessel density observed by optical coherence tomography angiography after phacoemulsification: active vs gravity fluidics system. *Arq Bras Oftalmol* 2022;85:205–207
- Zhou Y, Zhou M, Wang Y, Ben S, Gao M, Zhang S, Liu H, Sun X. Short-term changes in retinal vasculature and layer thickness after phacoemulsification surgery. *Curr Eye Res* 2020;45:31–37
- Luo Y, Li H, Chen W, Gao Y, Ma T, Ye Z, Li Z. A prospective randomized clinical trial of active-fluidics versus gravity-fluidics system in phacoemulsification for age-related cataract (AGSPC). *Ann Med* 2022;54:1977–1987
- Zhao Z, Yu X, Yang X, Zhang J, Zhang D, Sun N, Fan Z. Elevated intraocular pressure causes cellular and molecular retinal injuries, advocating a more moderate intraocular pressure setting during phacoemulsification surgery. *Int Ophthalmol* 2020;40:3323–3336
- Mencucci R, Ponchiotti C, Virgili G, Giansanti F, Menchini U. Corneal endothelial damage after cataract surgery: microincision versus standard technique. *J Cataract Refract Surg* 2006;32:1351–1354
- McDonnell PJ, Taban M, Sarayba M, Rao B, Zhang J, Schiffman R, Chen Z. Dynamic morphology of clear corneal cataract incisions. *Ophthalmology* 2003;110:2342–2348

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