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Research Article

Changes in the Postoperative Anterior Chamber Depth in Eyes Following Phacovitrectomy in Several Vitreoretinal Diseases

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ABSTRACT

Aim: To investigate the difference in postoperative Anterior Chamber Depth (ACD) following phacovitrectomy depending on the type of the vitreoretinal diseases, measured using optical biometry.

Methods: We investigated 14 eyes of 14 patients (11 males, 3 females; mean age 59.4 ± 8.4 years) with Rhegmatogenous Retinal Detachment (RRD) without macular involvement who underwent phacovitrectomy (RRD group), 14 eyes of 14 patients (10 males, 4 females; mean age 68.4 ± 4.7 years) with a macular hole (MH) who underwent phacovitrectomy (MH group), 24 eyes of 24 patients (14 males, 10 females; mean age 66.5 ± 7.6 years) with Epi Retinal Membrane (ERM) who underwent phacovitrectomy (ERM group), and 42 eyes of 29 patients (15 males, 14 females; mean age 71.4 ± 11.8 years) without macular disease who underwent cataract surgery (cataract group). ACD was measured prior to surgery and one month after surgery using optical biometry and was compared between groups. Results: The mean difference in ACD (postoperative ACD minus preoperative ACD) was 0.68 ± 0.38 mm in the RRD group, 1.12 ± 0.32 mm in the MH group, 1.04 ± 0.56 mm in the ERM group, and 1.00 ± 0.47 mm in the cataract group. Postoperative ACD in the RRD group was shallower compared to the other groups.

Conclusion: Postoperative ACD in patients with RRD is shallower compared to other groups, including patients with MH, making it one of the suspected causes of myopic shift in patients with RRD.

Keywords: Myopic shift; Anterior chamber depth; Phacovitrectomy

LIST OF ABBREVIATIONS

RRD: Rhegmatogenous Retinal Detachment; MH: Macular Hole; ERM: Epi Retinal Membrane; IOP: Intra Ocular Pressure; IOL: Intra Ocular Lens; ACD: Anterior Chamber Depth; AL: Axial Length; CI: Confidence Interval.

INTRODUCTION

Phacovitrectomy is a commonly performed procedure to prevent the treatment of post-vitrectomy cataract, in addition to facilitating the resection of the peripheral and anterior vitreous body [1-5]. Several studies associated with biometry and Intra Ocular Lens (IOL) power calculations have demonstrated improvement in refractive outcomes following cataract surgery [6-8].

However, several studies reported a myopic shift following phacovitrectomy in patients with vitreoretinal diseases, such as Epi Retinal Membrane (ERM), Macular Hole (MH), and Rhegmatogenous Retinal Detachment (RRD) [9-14].

The cause of the myopic shift following phacovitrectomy has been attributed to the inaccuracy in the IOL power calculation in cases of combined surgery, increased retinal thickness in ERM cases, and anterior IOL replacement due to gas tamponade in eyes with MH [12,15,16].

However, we speculated that the postoperative ACD with intraoperative gas tamponade might be affected by resection of the intraoperative peripheral and anterior vitreous body.

In general, resection of the intraoperative peripheral vitreous body in patients with MH is not performed as thoroughly compared to operations for RRD. Therefore, in the current study, we compared

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the ACD following phacovitrectomy in several vitreoretinal diseases including ERM, MH, and RRD.

MATERIALS AND METHODS

Ethical approval

The study protocol was approved by the ethics committee at Toho University Sakura Medical Center (approval number S19035) and adhered to the tenets of the Declaration of Helsinki. Risks and benefits of participation were explained via the Toho University Sakura Medical Center website in accordance with the guidelines for clinical research set out by the Japanese Ministry of Health, Labor and Welfare.

Subjects

This retrospective, observational comparative study included 14 eyes of 14 patients (11 males, 3 females; mean age 59.4 ± 8.4 years) with RRD who underwent phacovitrectomy (RRD group), 14 eyes of 14 patients (10 males, 4 females; mean age 68.4 ± 4.7 years) with MH who underwent phacovitrectomy (MH group), 24 eyes of 24 patients (12 males, 12 females; mean age 66.6 ± 7.6 years) with ERM who underwent phacovitrectomy (ERM group), and 42 eyes of 29 patients (15 males, 14 females; mean age 71.4 ± 11.8 years) without macular disease who underwent cataract surgery (cataract group) at Toho University Sakura Medical Center between November 2018 and March 2020.

As previously described [14], patients who underwent phacovitrectomy with segmental scleral buckling and encircling and those whose IOL was fixed on the anterior capsule because of rupture of the posterior capsule were excluded. Patients in whom measurements could not be obtained by optic biometry and whose Axial Length (AL) was >26 mm or <23.5 mm were also excluded, as were those who had undergone intraocular surgery or had a history of trauma. Patients with postoperative posterior synechia formation apparent on slit-lamp examination were also excluded. AL, autokeratometry, and ACD were measured using optical biometry (IOLMaster500; Carl Zeiss, Oberkochen, Germany) pre- and postoperatively. Postoperative refractive outcomes were compared with the predicted refractive value measured using an RK-F1 keratometer (Canon, Tokyo, Japan). Postoperative refraction and ACD were measured one month after surgery when the intraocular gas had completely disappeared.

Cataract surgery

Phacoemulsification and aspiration (via a 2.8-mm clear corneoscleral incision at the superior limbus) and posterior capsular implantation with an acrylic foldable IOL were performed following sub-Tenon's local anesthesia using 2% lidocaine in all patients.

Vitreous surgery

Phacoemulsification and aspiration (via a 2.8-mm corneoscleral incision) and posterior capsular IOL implantation with an acrylic foldable IOL were performed following retrobulbar local anesthesia using a combination of 2% lidocaine and 0.75% ropivacaine in all patients. By using a 25-gauge system (Constellation®; Alcon, Fort Worth, TX), a standard pars plana vitrectomy was performed in all cases. All cases had 3-port sclerotomies 3.5 mm from the limbus. A core vitrectomy was performed and, if not already present, a Posterior Vitreous Detachment (PVD) was induced after staining the vitreous cortex with triamcinolone acetonide. The PVD was induced as far from the vitreous base as possible. In cases with RRD, vitreous shaving with scleral indentation was performed more thoroughly relative to the other diseases. Any untreated retinal holes or tears and lattice degeneration were treated by endolaser photocoagulation. Retinal tears induced by PVD formation occurred in 8 of 26 MH cases. Gas tamponade using 20% SF6 was performed in patients with gas tamponade (patients with RRD or MH). Gas tamponade was not used in patients with ERM.

Types of IOL

X-70 (Santen, Osaka, Japan; A-constant: 119.4 for the IOLMaster) was used in 9 eyes (64%) with RRD, 4 eyes (29%) with MH, 9 eyes (38%) with ERM, and one eye (2%) with cataracts.

VA70AD (Hoya, Tokyo, Japan; A-constant: 118.7 for the IOLMaster) was used in 5 eyes (36%) with RRD, 10 eyes (71%) with MH, and 7 eyes (29%) with ERM.

XY-1 (Hoya; A-constant: 119.2 for the IOLMaster) was used in 6 eyes (25%) with ERM and 22 eyes (52%) with cataracts. AN6K (Kowa, Tokyo, Japan; A-constant: 119.0 for the IOLMaster) was used in 4 eyes (10%) with cataracts. SN6AT7 (Alcon; A-constant: 119.0 for the IOLMaster) was used in 1 eye (4%) with ERM.

CNL0T0 (Alcon; A-constant: 119.0 for the IOLMaster) was used in 3 eyes (7%) with cataracts. PCB00V (Abbot Medical Optics, Santa Ana, CA; A-constant: 119.0 for the IOLMaster) was used in 1 eye (4%) with ERM and 10 eyes (24%) with cataracts.

ZCV375 (Abbot Medical Optics; A-constant: 119.0 for the IOLMaster) was used in 2 eyes (5%) with cataracts.

The SRK/T formula was used to calculate IOL power [17]. We examined the mean difference in ACD (postoperative ACD minus preoperative ACD) and the mean rate of the difference in ACD relative to postoperative AL in each group.

Statistical analysis

All statistical analyses were performed using Statcel software (OMS Publishing, Saitama, Japan). Bartlett test was used for the comparison among 4 groups about the axial length and preoperative anterior chamber depth with normal distribution. On the other hand, Kruskal-Wallis test was used for the comparison among 4 groups regarding the other parameters without normal distribution. Mann-Whitney's U test was used for between-group comparison of the difference in ACD, the rate of difference in ACD relative to postoperative AL. The Wilcoxon signed-rank test was used for comparison between preoperative and postoperative AL, keratometry, and Intra Ocular Pressure (IOP) in each group, and surgical time between RRD cases and MH cases.

RESULTS

WThe mean preoperative AL was 24.8 ± 0.8 mm in the RRD group, 24.4 ± 0.7 mm in the MH group, 24.8 ± 0.6 mm in the ERM group, and 24.4 ± 0.7 mm in the cataract group. The mean preoperative AL was not different among the 4 groups (p>0.05). The mean preoperative ACD was 3.53 ± 0.28 mm in the RRD group, 3.20 ± 0.26 mm in the MH group, 3.25 ± 0.36 in the ERM group, and 3.17 ± 0.33 in the cataract group. The mean preoperative ACD was not different among the 4 groups (p>0.05). The mean refractive error was -0.77 ± 0.54 D in the RRD group, -0.65 ± 0.60 D in the MH group, -0.81 ± 0.77 D in the ERM group, and -0.22 ± 0.65 in the cataract group. The surgical time was 124.5 ± 41.0 min in the RRD group and 83.3 ± 48.6 min in the MH group, and the surgical time of the RRD group was significantly longer than that of the MH group (p<0.01) (Table 1).

Preoperative and postoperative AL, keratometry, and IOP were compared in each group. The differences in AL between the cataract and MH groups, in keratometry in the RRD, ERM, and Cataract were significant, and in IOP in the MH and cataract groups were significant (p<0.05) (Table 2). The mean ACD difference (postoperative ACD minus preoperative ACD) was 0.68 ± 0.38 mm in the RRD group, 1.12 ± 0.32 mm in the MH group, 1.04 ± 0.56 mm in the ERM group, and 1.00 ± 0.47 mm in the cataract group.

The mean ACD difference rate relative to postoperative AL was 2.8 ± 1.5% in the RRD group, 4.6 ± 1.3% in the MH group, 4.2 ± 2.3% in the ERM group, and 4.1 ± 1.9% in the cataract group.

The mean ACD difference of the RRD group was significantly shallower than the other groups (p<0.05).

In addition, the mean rate of difference in ACD relative to postoperative AL of the RRD group was significantly smaller than the other groups (p<0.05) (Table 3).

Table 1: Patient demographic and clinical characteristics.

	RRD	MH	ERM	Cataract	p-value	Statistical analysis
Age (years,mean±SD)	59.4±8.4	68.4±4.7	66.6±7.6	71.4±11.8	p<0.05	Kruskal-Wallis
(range)	(48-77)	(60-77)	(57-85)	(57-91)		
Sex						
Male	11	10	14	15		Kruskal-Wallis
Female	3	4	10	24		
Laterality	right 9	right 8	right 12	right 22	0.89	Kruskal-Wallis
	left 5	left 6	left 12	left 20		
Preoperative refraction(D)	-0.57±3.08	-0.866±2.01	-2.13±2.53	-2.37±3.57	0.414	Kruskal-Wallis
	(-5.125-7.625)	(-4.875-1.75)	(-5.625-0.375)	(-10.875-1.875)		
Predictive refraction(D)	-1.40±1.52	-0.91±1.02	-1.73±1.28	-1.04±1.17	0.049	Kruskal-Wallis
	(-3.43-0.73)	(-3.16-0.06)	(-4.36-0.15)	(-3.43-0.21)		
IOP before surgery mmHg)	12.7±2.1	14.4±3.3	14.4±3.2	14.4±3.1	0.12	Kruskal-Wallis
	(9-17)	(9-21)	(8-20)	(10-23)		
AL before surgery (mm)	24.8±0.8	24.4±0.7	24.8±0.6	24.4±0.7	0.89	Bartlett test
	(23.09-25.94)	(23.70-25.91)	(23.52-25.81)	(23.51-25.97)		
ACD before surgery (mm)	3.53±0.28	3.20±0.26	3.25±0.36	3.17±0.33	0.06	Bartlett test
	(3.08-3.95)	(2.79-3.66)	(2.61-3.87)	(2.51-3.8)		
Keratometry before surgery (D)	42.8±0.7	43.6±1.4	43.7±1.4	43.9±1.1	0.02	Kruskal-Wallis
	(41.57-43.92)	(40.38-45.72)	(41.70-46.65)	(41.72-46.18)		
IOP after surgery (mmHg)	13.4±2.5	12.6±2.9	14.4±3.2	11.9±2.6	0.01	Kruskal-Wallis
	(10-19)	(8-18)	(8-20)	(8-18)		
AL after surgery (mm)	24.8±0.8	24.3±0.7	24.8±0.7	24.3±0.7	0.96	Bartlett test
	(22.97-25.92)	(23.66-25.92)	(23.46-25.93)	(23.45-25.89)		
ACD after surgery (mm)	4.22±0.31	4.32±0.38	4.29±0.59	4.17±0.55	0.76	Kruskal-Wallis
	(3.72-4.66)	(3.59-5.04)	(2.39-5.27)	(2.34-5.15)		
Keratometry after surgery (D)	43.2±0.7	43.8±1.5	44.0±1.4	44.0±1.3	0.129	Kruskal-Wallis
	(41.9-44.13)	(40.91-46.29)	(41.02-46.59)	(41.73-46.85)		
Postoperative refraction (D)	-2.17±1.62	-1.56±1.24	-2.54±1.79	-1.26±1.57	0.01	Kruskal-Wallis
	(-5.875-0.125)	(-4.125-0.125)	(-6.125-0.25)	(-4.25-0.63)		

Refractive error (D)	-0.77±0.54 (-0.07 -2.01)	-0.65±0.60 (-1.325-0.705)	-0.81±0.77 (-3.02-0.15)	-0.22±0.65 (-1.645-0.915)	0.003	Kruskal-Wallis
ACD difference (mm)	0.68±0.38 (-0.01-1.43)	1.12±0.32 (0.56-1.49)	1.04±0.56 (-0.78-1.79)	1.00±0.47 (-0.26-1.83)	0.03	Kruskal-Wallis
Difference rate of ACD relative to AL (%)	2.8±1.5 (0.0-5.8)	4.6±1.3 (2.3-6.8)	4.2±2.3 (-3.1-7.0)	4.1±1.9 (0.0-7.7)	0.02	Kruskal-Wallis
IOL	X70:9 VA70AD:5	X70:4 VA70AD:14	X70:9 VA70AD:7 XY1: 6 SN6AT7:1 PCB00V:1	X70: 1 XY1:22 PCB00V:10 ZCV375:2 CLN0T0:3 AN6K:4		
Surgical time (min)	124.5±41.0 (70-195)	83.3±48.6 (46-190)			0.96	Wilcoxon signed-ranks test

Notes: Data are expressed as mean ± standard deviation and range.

Table 2: Axial length, keratometry, and intraocular pressure between before and after surgery in each case.

	Difference of AL between before and after surgery	Difference of keratometry between before and after surgery	Difference of IOP between before and after surgery	p-value of AL	p-value of keratometry	p-value of IOP
RRD	0.039	0.33	0.71	0.12	0.007	0.175
MH	0.06	0.15	1.8	0.001	0.051	0.016
ERM	0.01	0.24	1.2	0.34	0.001	0.113
Cataract	0.09	0.06	2.6	p<0.05	0.014	p<0.05

Notes: Data are expressed as mean ± standard deviation. Values for AL, keratometry, and IOP before and after surgery were analyzed using the paired t-test.

Table 3: Difference in anterior chamber depth and rate of difference of anterior chamber depth.

	Difference of ACD (95% CI)	Difference of rate of ACD relative to AL between before and after surgery (%)	p-Value of ACD	p-Value of the rate
RRD vs. MH	0.44 (-0.74--015)	2.6	0.004	0.004
RRD vs. ERM	0.35 (-0.10--0.73)	1.8	0.02	0.018
RRD vs. Cataract	0.31 (-0.579--0.047)	1.9	0.015	0.009
MH vs. ERM	0.088 (-0.209-0.384)	0.9	0.785	0.762
MH vs. Cataract	0.127 (-0.107-0.362)	0.7	0.359	0.373
ERM vs. Cataract	0.04 (-0.238-0.373)	0	0.729	0.79

Notes: Data are expressed as mean ± standard deviation. Values for ACD difference and the rate difference were analyzed using Mann-Whitney's U test.

DISCUSSION

Myopic shift following phacovitrectomy has been reported in patients with several vitreoretinal diseases, including ERM, MH, and RRD [9-14]. Higher myopic shifts after vitrectomy with gas tamponade have been reported more frequently in eyes with MH than in eyes with ERM [12]. Gas tamponade during anterior IOL replacement has been identified as a cause of myopic shift in eyes with MH [12,15,16].

When predicting postoperative ACD, it should be noted that the postoperative refractive error produced by an error in the postoperative ACD is strongly dependent on AL. Previous reports have revealed that a 0.25-mm error in the ACD in cases with a 24-mm AL leads to a postoperative refractive error of 0.3 D, and the corresponding prediction error increases from 0.1 D in a 30-mm long eye to 0.5 D in a 20-mm short eye [18]. Postoperative refractive error is affected by AL. Therefore, our study only included patients with an AL of 23.5-26 mm that was not significantly different among the groups.

The anterior IOL replacement was approximately 0.3-0.4 mm lower in the RRD group relative to other groups. Conversely, there was no difference in postoperative ACD between the MH, ERM, and cataract groups. Theoretically, an ACD below 0.3-0.4 mm leads to a myopic shift of approximately 0.3-0.5 D in patients with an AL of 23.5-26 mm.

The postoperative refractive error was approximately 0.7 D in the RRD group. One of the suspected causes of the postoperative refractive error is the anterior IOL replacement in the RRD group. The postoperative ACD in the RRD group was significantly shallower relative to the MH group, regardless of the fact that intraoperative gas tamponade was performed in both groups.

In RRD surgeries, thorough resection of the peripheral and anterior vitreous body was performed; however, in MH cases, this was not performed whenever a retinal tear was made during the surgery. In the current study, new tears during surgery occurred in 4 of the 14 MH cases; therefore, peripheral vitreous shaving was not performed as much in MH cases relative to the RRD group. In the absence of the anterior and peripheral vitreous body, intraocular gas easily causes the ciliary body to extend forward to the iris, resulting in shallow ACD following phacovitrectomy. The surgery time for RRD is generally longer in comparison to MH surgery. In the current study, the surgical time was significantly longer in the RRD group relative to the MH group. Previous reports suggested that postoperative inflammation of the anterior chamber was observed in many RRD cases, and that the long surgical time was associated with postoperative inflammation [19,20]. Therefore, RRD surgery leads to greater inflammation due to the surgery time and surgical technique relative to MH surgery. Postoperative inflammation of the anterior chamber and the IOL anterior displacement due to the intraocular gas tamponade might cause posterior synechia after the operation. This study excluded patients with apparent posterior synechia; however, some patients might have had posterior synechia that could not be seen by slit-lamp examination, resulting in shallow postoperative ACD, similar to previous reports [21].

Further studies measuring ACD by anterior optical coherence topography and that assess the relationship of the iris and the IOL and the state of the anterior vitreous after surgery are required as the previous report mentioned.

A previous report showed that vitrectomy leads to a -0.4 myopic shift; nevertheless, the ACD was unchanged in a pseudophakic case [22]. Other reports have attributed this myopic shift to the replacement of the vitreous gel with aqueous humor, which results in a slight decrease in the refractive value following vitrectomy [23-25]. A previous report stated that the myopic shift in vitrectomized eyes could be -0.5 D [25]. This was the suspected cause of the myopic shift observed in the MH and ERM groups in the present study. Further research on the cause of the myopic shift in MH and ERM patients is needed.

A major factor influencing IOL calculation is the AL measurement [26]. Based on estimations using the Sanders-Retzlaff-Kraff formula, an error of 100 μm in AL can lead to an error of 0.25 D in the IOL power [26]. The preoperative predicted refractive error might be considered lower compared to A-scan ultrasonography [27]. In this study, AL was measured using optic biometry in all cases. There was no difference between pre- and postoperative AL in any case. Therefore, the reason for myopic shift cannot be attributed to AL.

The IOP differed pre- and postoperatively in the MH, ERM, and cataract groups. A lower IOP affects the AL [28]; however, there were no cases of significant IOP reduction in this study and the pre- and postoperative ACD did not differ in any cases. The difference in IOP pre- and postoperatively does not appear to affect the postoperative ACD.

This study had several limitations. The observation period was one month. We adopted this observation period due to a report that indicated that ACD stabilization is achieved 1 month following surgery [21]. However, other reports have stated that postoperative refractive stabilization is achieved 3 months after operation [29,30]. Therefore, further studies with longer observation periods are needed.

Watanabe et al. have reported that postoperative ACD is affected by the haptic shape of the intraocular lens [21]. In the current study, a 6-mm IOL was used in cataract and ERM surgeries, whereas a 7-mm IOL was used in vitreous surgery with gas tamponade. The usage of a 7-mm IOL led to an earlier postoperative ACD stabilization [21]; however, further studies using the same type of IOL in all patients are needed.

Another limitation was the number of patients who underwent vitreous surgery, especially those with RRD and MH. Further studies with larger sample sizes are needed.

CONCLUSION

The effects of the intraocular gas tamponade on the IOL may also be the cause of the lower postoperative ACD in patients with RRD.

The postoperative ACD in patients with RRD is shallower compared to other patients, including patients with MH, making it one of the suspected causes of myopic shift in patients with RRD.

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