Refractive Outcomes following Vitrectomy and Phacovitrectomy in Rhegmatogenous Retinal Detachment

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Abstract

Background

Cataracts are commonly seen during the diagnosis of rhegmatogenous retinal detachment (RRD) or occur following its surgical management. Refractive changes following combined phacoemulsification and vitrectomy (phacovitrectomy) can affect the quality of vision. This study aimed to evaluate the refractive changes following vitrectomy versus phacovitrectomy in patients with RRD.

Methods

A total of 96 patients who underwent retinal surgery for RRD in one eye, between August 2016 and January 2018, were enrolled and divided into three groups. In 18 eyes, 23-gauge transconjunctival sutureless vitrectomy (23G TSV) was performed (group A); 25G TSV was performed in 49 eyes (group B), and phacovitrectomy with 25G TSV was performed in 29 eyes (group C). Silicone oil was injected after the surgery in all three groups. Anterior and posterior corneal astigmatism, axial length (AL), and anterior chamber depth (ACD) were measured at baseline and postoperatively at 1 week, 1 month, and 3 months.

Results

Anterior and posterior corneal astigmatism did not change, and AL continued to increase for 3 months after surgery, whereas ACD decreased postoperatively but quickly returned to baseline in groups A and B. In group C, anterior and posterior corneal astigmatism, AL, and ACD increased postoperatively, and corneal astigmatism returned to baseline by 3 months, but AL and ACD continued to increase for 3 months.

Conclusion

Vitrectomy alone does not affect anterior or posterior corneal astigmatism. Following vitrectomy, the AL increases, while the ACD decreases transiently. When vitrectomy is combined with phacoemulsification for cataract removal, the anterior and posterior corneal astigmatism increases transiently, while AL and ACD are enlarged for several months following surgery.

Background

Loss of visual function in rhegmatogenous retinal detachment (RRD) can be prevented by prompt vitreoretinal surgical intervention. In geriatric patients presenting with vitreoretinal disorders, cataracts are often a comorbid diagnosis. In the absence of cataracts, the vitreoretinal surgery, together with silicon oil filling, could accelerate the process of cataractogenesis to some extent. Thus, combined phacoemulsification and vitrectomy has been advocated as an effective and safe procedure in the

management of patients with both cataract and posterior segment disease[1]. However, refractive changes following such surgeries can affect the quality of vision and cannot be ignored. Therefore, our study aimed to evaluate the refractive outcomes following vitrectomy versus phacovitrectomy in patients with RRD.

Methods

Patients

This retrospective study analyzed the data of a total of 96 patients with RRD who underwent vitrectomy or phacovitrectomy, between August 2016 and January 2018. In 18 eyes, 23-gauge transconjunctival sutureless vitrectomy (23G TSV) was performed, while 25G TSV was performed in 49 eyes, and phacoemulsification combined with 25G TSV (phacovitrectomy) was performed in 29 eyes. Silicone oil was injected in all eyes at the end of surgery.

Procedures

Surgery was performed under local or general anesthesia by a single surgeon. The standard three-port technique without scleral buckling was used for vitrectomy in all eyes, of which 18 eyes underwent 23G TSV, and 49 eyes underwent 25G TSV. The retinal holes were closed by laser. After the fluid-air exchange, silicone oil was injected to replace the air entirely and fill the vitreous cavity.

For 29 eyes that underwent phacovitrectomy, the cataract removal was performed first. A 3.2 mm scleral incision was made superiorly with two side-ports at the 10 and 2 o'clock positions. A continuous curvilinear capsulorhexis was created, followed by phacoemulsification and aspiration of the crystalline lens. Bleeding points were electrocoagulated. The three-port 25G TSV was then performed. All retinal holes were closed using the laser. Finally, the intraocular lens (IOL) was implanted in the capsular bag. The scleral incision was sutured using 10-0 polyamide under minimal tension, and silicone oil was injected. AL was measured by AL Scan (NIDEK, Japan). Anterior and posterior corneal astigmatism and ACD were measured by Pentacam (OCULUS, Germany).

Statistical analysis

Statistical Package for the Social Sciences (SPSS) software Version 21.0 (SPSS Inc., Chicago, IL, USA) was used for all statistical analyses. All data are represented as the mean value $\pm$ standard deviation (mean $\pm$ SD). Differences between groups were analyzed by repeated measures. When statistically significant, the Least Significant Difference (LSD) was further calculated. $P < 0.05$ were considered statistically significant.

Results

A total of 96 patients were enrolled and divided into three groups. In 18 eyes, 23G TSV was performed (Group A); 25G TSV was performed in 49 eyes (Group B), and phacovitrectomy in 29 eyes (group C).

Anterior corneal astigmatism

Changes in anterior corneal astigmatism following surgery occurred only in group C (Table 1). The anterior corneal astigmatism increased significantly from baseline (1.73 ± 0.56 , $P < 0.05$) to 2.28 ± 0.64 at 1 week, and 2.23 ± 0.77 at 1 month. At postoperative month 3, the anterior corneal astigmatism receded back (1.75 ± 0.65) to baseline. Fig. 1 shows the trends in corneal anterior astigmatism changes at different time points for all three groups.

Table 1 Changes in anterior corneal astigmatism

	<i>n</i>	Baseline	Post-surgery			<i>F</i>	<i>P</i>
			1 week	1 month	3 months		
Group A	18	1.72±0.62	1.78±0.70	1.80±0.65	1.75±0.68	0.036	0.988
Group B	49	1.71±0.73	1.74±0.69	1.76±0.72	1.76±0.76	0.078	0.898
Group C	29	1.73±0.56	2.28±0.64 ^{*†‡}	2.23±0.77 ^{*†‡}	1.75±0.65	6.47	0.001
<i>F</i>		0.001	6.14	4.24	0.006		
<i>P</i>		0.99	0.003	0.017	0.994		

Data are presented as mean ± SD unless otherwise indicated

^{*} $P < 0.05$ compared with baseline; [†] $P < 0.05$ compared with Group A; [‡] $P < 0.05$ compared with Group B

Posterior corneal astigmatism

Following surgery, the posterior corneal astigmatism in group C increased significantly at 1 week (0.63 ± 0.18) and 1 month (0.59 ± 0.15) follow up, compared to baseline (0.40 ± 0.13 , $P < 0.05$). No such changes were observed in groups A and B (Table 2). Fig. 2 shows the trends of posterior corneal astigmatism in three groups at different time points before and after surgery. Three months following surgery, the increased posterior corneal astigmatism in group C decreased to baseline. No significant difference in corneal astigmatism was observed between the three groups at baseline or 3 months after surgery ($P > 0.05$).

Table 2 Changes in posterior corneal astigmatism

	<i>n</i>	Baseline	Post-surgery			<i>F</i>	<i>P</i>
			1 week	1 month	3 months		
Group A	18	0.38±0.15	0.40±0.16	0.43±0.13	0.39±0.15	0.299	0.808
Group B	49	0.39±0.16	0.40±0.16	0.41±0.16	0.40±0.16	0.263	0.755
Group C	29	0.40±0.13	0.63±0.18*†‡	0.59±0.15*†‡	0.40±0.14	21.39	<0.001
<i>F</i>		0.087	19.93	13.28	0.039		
<i>P</i>		0.917	<0.001	<0.001	0.962		

Data are presented as mean ± SD unless otherwise indicated

**P* < 0.0 compared with baseline; †*P* < 0.05 compared with Group A; ‡*P* < 0.05 compared with Group B

Axial length

Compared with baseline, there was a significant increase in AL at 1 week, 1 month, and 3 months (*P* < 0.05) following surgery in all three groups (Table 3). Fig. 3 shows the trends of axial length at different times for the three groups. No significant differences were observed between the three groups at the baseline, 1 month, and 3 months after surgery. At 1 week, the AL in group C (26.05 ± 0.61 , *P* < 0.05) increased significantly compared to group A (25.69 ± 0.50) and group B (25.64 ± 0.56).

Table 3 Changes in axial length

	<i>n</i>	Baseline	Post-surgery			<i>F</i>	<i>P</i>
			1 week	1 month	3 months		
Group A	18	25.37±0.49	25.69±0.50*	25.56±0.57*	25.57±0.60*	24.56	<0.001
Group B	49	25.36±0.56	25.64±0.56*	25.52±0.53*	25.52±0.56*	5.07	0.003
Group C	29	25.38±0.53	26.05±0.61*†‡	25.47±0.62*	25.56±0.66*	227.6	<0.001
<i>F</i>		0.024	5.05	0.13	0.067		
<i>P</i>		0.977	0.008	0.877	0.935		

Data are presented as mean ± SD unless otherwise indicated

**P* < 0.05 compared with baseline; †*P* < 0.05 compared with Group A; ‡*P* < 0.05 compared with Group B

Anterior chamber depth

In group A, the ACD decreased significantly compared to baseline at week 1 (2.76 ± 0.15 vs. 2.58 ± 0.17 , *P* < 0.05). In group B, there was a significant decrease at week 1 (2.46 ± 0.15) and month 1 (2.64 ± 0.16),

compared to baseline (2.75 ± 0.14 , $P < 0.05$). In group C, the ACD increased significantly following surgery and remained at the same level throughout the follow up (Table 4). Fig. 4 shows the ACD at different times for the three groups.

Table 4 Changes in anterior chamber depth

		Post-surgery				<i>F</i>	<i>P</i>
	<i>n</i>	Baseline	1 week	1 month	3 months		
Group A	18	2.76±0.15	2.58±0.17*	2.70±0.17	2.74±0.15	4.45	0.013
Group B	49	2.75±0.14	2.46±0.15*†	2.64±0.16*	2.76±0.13	44.05	<0.001
Group C	29	2.75±0.15	3.02±0.16*†‡	2.94±0.17*†‡	2.94±0.17*†‡	12.46	<0.001
<i>F</i>		0.048	120.05	30.86	16.27		
<i>P</i>		0.953	<0.001	<0.001	<0.001		

Data are presented as mean ± SD unless otherwise indicated

* $P < 0.05$ compared with baseline; † $P < 0.05$ compared with Group A; ‡ $P < 0.05$ compared with Group B

Statistically significant differences were found among all three groups at week 1 ($P < 0.05$), with the most pronounced ACD increase in group C (3.02 ± 0.16) followed by group A (2.58 ± 0.17). The least increase was seen in group B (2.46 ± 0.15). During follow up at months 1 and 3, the ACD increase was more obvious in group C than in groups A or B.

Discussion

Currently, vitrectomy is commonly combined with cataract surgery in clinical practice for the treatment of both RRD and cataracts. The refractive changes following surgery play an important role in the quality of vision. The size of vitrectomy incision, suturing of vitrectomy ports, intraocular fillers (type, nature, density, and volume), and the size and suturing of cataract incision influences the postoperative refractive status of the eyeball to varying degrees.

Pentacam is an accurate modality for measuring corneal changes [2]. In the past, the A-scan ultrasound was used to measure the distance between the anterior surface of the cornea and the inner limiting membrane of the retina to measure AL. The AL Scan is an optical biometer that measures the distance between the anterior surface of the cornea and the retinal pigment epithelium with a superior accuracy compared to the A-scan ultrasound. Since the AL Scan is based on the principle of partial coherence interferometry, the results were not affected by silicone oil, and there was good agreement between the AL Scan and IOLMaster in measuring the AL [3-5]. Thus, we justify the use of Pentacam for measuring corneal astigmatism and ACD and AL Scan for measuring AL.

Mechanisms in post-surgical corneal astigmatism

Postoperative corneal astigmatism that appears following vitrectomy arises mainly from the scleral three-port incision and the physical traction of suturing. These factors inconsistently change the corneal refractive power in every diameter, resulting in the formation of corneal astigmatism [6-8]. With the development of minimally invasive vitrectomy techniques in recent years, the diameter of the vitreous-cutting head has become thinner, making the surgery “sutureless.” Some groups reported that sutureless 23G and 25G vitrectomy eliminated the inconsistent changes of corneal refractive power in every diameter [9]. Park DH et al. found that during 23G TSV with silicone oil filling, the cornea could still undergo a transient change in refraction resulting mainly from the tension and filling volume of silicone oil [10].

In combined surgery (phacovitrectomy), the main reason for corneal astigmatism was cataract surgery, especially the thermal injury caused by phacoemulsification and the sutures after operation [11]. Electrocoagulation of bleeding vessels could cause shrinkage of scleral collagen fibers, resulting in wound contraction. This not only changed the corneal curvature but also led to a steeper cornea at the corresponding site and thus corneal astigmatism [12]. Sayed KM et al. described that a transscleral incision for phacoemulsification was associated with no significant effect on corneal astigmatism, especially in the absence of suturing, and only the corneal surface irregularity index increased in the early postoperative period, which usually returned to baseline after 6 months [13].

A larger and longer cataract surgical incision destroyed the structure of the corneal dome more severely, leading to a more significant postoperative corneal astigmatism [14]. Translimbal incision more likely causes corneal astigmatism than transscleral tunnel incision [15], and tighter sutures caused noticeable changes in corneal astigmatism [16].

In the current study, we eliminated the inconsistent changes of corneal refractive power in every diameter during 23G TSV and 25G TSV by making the procedure sutureless. This explains why both the anterior and posterior corneal astigmatism did not change significantly following surgery. In the phacovitrectomy group, the anterior and posterior astigmatism increased most obviously at post-surgical week 1 and returned to baseline by 3 months. The possible reasons being the thermal injury of electrocoagulation, and physical traction exerted by the sutures. Our findings were similar to previous studies that reported cataract surgery as the main cause of corneal surface astigmatism in combined phacovitrectomy [11, 12].

Mechanisms influencing the post-surgical axial length

During phacovitrectomy, the change in AL is mainly caused by vitrectomy since cataract surgery had no significant effect on AL [17]. The suturing of the three-port incision shortens the scleral length in the axial direction, which in turn results in a shortening of the AL, with no apparent relationship to the properties of the fillers [18]. Federman JL et al. believed that the reason for the postoperative increase in AL might be measurement errors. They used an A-scan ultrasound that measured the distance between the anterior

surface of the cornea and the inner limiting membrane of the retina. Thus, the measurement was smaller than the real length before the recovery of the retina. But when the retina was reset, the AL measurement tended to be accurate, but longer [19]. Huang C et al. used the IOL master and similarly found that the AL increased after combined phacovitrectomy. However, they speculated that the physical property of fillers was different from that of the vitreous and could not provide sufficient support for the eyeball. With simultaneous lens removal, the eyeball deformed and tended to elongate [20-22]. Furthermore, the gas-liquid exchange and the transient high intraocular pressure (IOP) during vitrectomy could also contribute to axial elongation [23]. Silicone oil, a commonly used filler, is a viscous substance, which could redistribute the liquid density of the vitreous cavity, producing a certain tension that increases the eyeball's AL [24]. Certain groups postulated that the combination of low preoperative IOP along with postoperative normal or high IOP could result in a long eyeball [17].

The AL changes were positively correlated with the viscosity and filling amount of silicone oil [23, 25]. Also, the IOL does not provide enough brace to the eye compared to the original lens, so it was necessary to increase the amount of silicone oil to support the eyewall to some extent. This effect was transient and usually returns to baseline between a week to a month following surgery [20-22], after which period, the AL tended to be stable [26].

In our study, the AL of three groups increased the most in week 1, and these changes lasted until 3 months after surgery. We believe the main reasons for this AL increase were due to the tension exerted by silicone oil on the eyewall, as well as the transient high IOP of gas-liquid exchange. We eliminated the influence of suturing and measurement error by making the surgery sutureless and by using the AL Scan for AL measurements. There was a minimal increase in AL at 3 months compared to 1 month, possibly due to head position, inflammation, and IOP fluctuations. The phacovitrectomy group showed the most AL change at week 1, probably due to the temporary effect of silicon oil tension and lens removal.

Mechanisms influencing post-surgical anterior chamber depth

During vitrectomy, the ACD decreases due to the tension and viscosity of silicone oil and prone positioning, which displaces the iris-lens septum forwards [20, 27]. Surgical trauma and scleral suturing could lead to ciliary body edema and effusion, resulting in a shallow anterior chamber [20]. ACD is also positively correlated with IOP, which means that a low postoperative IOP might result in a shallow anterior chamber [28].

In contrast, the ACD tends to increase during phacovitrectomy. The crystalline lens is disc-shaped with an anteroposterior diameter of about 5 mm, whereas the thickness of the IOL is approximately 1 mm, resulting in insufficient anterior segment support following cataract surgery. Also, the anterior segment pressure is eliminated after lens removal, which increases ACD. The effect of vitrectomy-related factors is relatively small compared to cataract surgery-related factors, and so the ACD tends to increase in combined phacovitrectomy [29].

When using silicone oil, a more substantial filling volume has a greater influence on ACD [30]. Scleral suturing is more likely to cause a shallower anterior chamber than a sutureless incision [20]. A large scleral incision that is sutured tight causes a more pronounced ciliary body edema and has a more considerable influence on ACD [20, 31]. ACD showed the most obvious change during the first post-surgical week. With wound healing and the stabilization of the filling and IOL, the ACD gradually returned to baseline by 2 to 4 months after surgery [1, 32].

In our study, the ACD decreased the most during the first week following 23G TSV and 25G TSV. The tension and viscosity of silicone oil and the prone patient positioning that promotes anterior displacement of the iris-lens septum could have caused the observed effect. Some degree of ciliary body edema and effusion might have influenced the final ACD. We found that with phacovitrectomy, the ACD increased due to IOL implantation and vitrectomy, as discussed previously. This change was most obvious at post-surgical week 1 and lasted until 3 months. ACD changes were more obvious in the phacovitrectomy group than the 23G TSV and 25G TSV groups. Besides, statistically significant differences between 23G TSV and 25G TSV groups were more pronounced in the 25G TSV group. This might be due to the small sample size of the 23G TSV group.

This study has a few limitations. First, this was a retrospective study with a small sample size per group. Second, results were obtained for only 3 months of follow up after the surgery. Third, since all measurements were performed before the removal of oil and sutures, the influence of these factors on the refractive changes cannot be ruled out. Nevertheless, this study compared the refractive changes between some of the widely practiced new surgical techniques. We recommend large-sample, prospective studies with longer follow-up to accurately determine the changes in refractive error following vitrectomy versus phacovitrectomy.

Conclusions

Vitrectomy alone affects AL and ACD. Corneal astigmatism changes only if sutures are applied during vitrectomy. However, obvious changes occur in corneal astigmatism, AL, and ACD following combined phacovitrectomy. Specific surgical steps minimize post-phacovitrectomy-refractive changes. For example, during phacovitrectomy, it is imperative to maintain a minimally invasive and gentle surgical approach to minimize post-surgical inflammation and scarring. The choice of an appropriate intraocular filler, its filling volume, and the degree of suture tightness influence the refractive outcome. We recommend a moderate volume of filler and moderate suture tightness for optimal refractive outcomes.

Abbreviations

ACD: Anterior chamber depth; AL: Axial length; IOL: Intraocular lens; IRB: Institutional Review Board; LSD: Least Significant Difference; RRD: Rhegmatogenous retinal detachment

Declarations

Ethics approval and consent to participate

The study design was approved by the Institutional Human Experimentation Committee and Institutional Review Board (IRB) at the Second Hospital of Jilin University (3D5172173429) and adhered to the tenets of the Declaration of Helsinki. All subjects received details of the nature and possible consequences of the study, following which they provided their oral informed consent. They only needed to do some examinations and there was no any harm, so they just provided their oral informed consent.

Consent for publication

All of the authors agreed to publish the article. All identifying information has been appropriately anonymized, and there is no identifying images used within the manuscript.

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

N.L. collected and analyzed the data and drafted the manuscript, J.Z. designed the study methodology, F.L., S.C., Z.S., and C.S. helped collect the data. All authors have read and approved the final manuscript.

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Figures

Figure 1

Changes in anterior corneal astigmatism over time

Figure 2

Changes in posterior corneal astigmatism over time

Figure 3

Changes in axial length over time

Figure 4

Changes in anterior chamber depth over time