·Clinical Research·

Refractive errors in high myopic eyes after phacovitrectomy for macular hole

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Abstract

• AIM: To examine the refractive prediction error in high myopic eyes after phacovitrectomy.

• METHODS: This retrospective comparative case series included 91 eyes (18 high myopic eyes and 73 non-high myopic eyes) of 91 patients who underwent successful phacovitrectomy (phacoemulsification, intraocular lens implantation, and pars plana vitrectomy). The high myopic eyes were defined as the eye with more than 26.0 mm of axial length. The postoperative prediction error of mean error and mean absolute error were evaluated at 4mo postoperatively. Axial length and keratometry measurement were performed preoperatively and 4mo postoperatively using the IOL Master.

• RESULTS: The refractive outcome after phacovitrectomy showed significantly greater myopic shift in the high myopic eyes [-1.08±0.87 diopters (D)] than that in the non-high myopic eyes (-0.43±0.63 D, P=0.004). Axial length and keratometric value in the high myopic eyes were significantly increased(P=0.043, 0.037 respectively), whereas those in the non-high myopic group were not significantly increased (P=0.135, 0.347 respectively). The change of the axial length in the myopic eye (0.46±0.28 mm) was greater than that in the non-high myopic eye (0.11 ± 0.34 mm; P <0.001).

• CONCLUSION: High myopic eyes showed more myopic shift than non-high myopic eyes after phacovitrectomy. The cause of myopic shift in high myopic eyes seems to be attributed to actual elongation of the axial length in high myopia.

• KEYWORDS: axial length; high myopic eyes; keratometry; phacovitrectomy; refractive errors

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INTRODUCTION

High myopic eyes with a long axial length demonstrate less accurate refractive outcome in cataract surgery [1, 2]. Intraocular lens (IOL) power determination in this special group requiring a low-diopter power IOL is a challenging and important problem [2-4]. Refractive error after cataract surgery in high myopic eyes have been reported to be hyperopic shift in many studies [1,2,4,5]. However, refractive error after phacovitrectomy in high myopic eyes has not been reported yet. Phacovitrectomy, the combined surgery of pars plana vitrectomy (PPV) with phacoemulsification and IOL implantation has become a common procedure to patients with vitreoretinal pathology and a co-existing cataract [6-8]. Greater attention has been paid to improve postoperative refraction with anatomical success of the phacovitrectomy[9-13]. Several studies have reported a myopic shift in refraction in patients undergoing phacovitrectomy with axial length measurement using ultrasonography[10,11,13,14], whereas a recent study using optical biometry for axial length measurement has reported no myopia shift after phacovitrectomy [15]. However, most of the eyes examined are non-high myopic eyes. Studies for high myopic eyes using optical biometry are limeted so far. We examined, therefore, the postoperative refraction error in high myopic eyes after phacovitrectomy.

SUBJECTS AND METHODS

Subjects This retrospective study was performed for patients who underwent successful combined phacoemulsification, foldable IOL implantation, and PPV for stage 3 or stage 4 macular holes between 2011 and 2012. The study design followed the tenets of the Declaration of Helsinki for biomedical research and was approved by the Institutional Review Board of the Catholic University of Korea in Seoul, Korea.

Table 1 Clinical characteristic of subjects in the study

Characteristics	High myopic (*n*=18)	Non-high myopic (*n*=73)	aP
Age (a)	54.9±8.0	53.5±6.7	0.516
Gender (M/F)	5/13	31/42	0.254
Axial length (mm)	26.46±0.52	22.75±0.38	<0.001[a]
Keratometric values (D)	42.22±2.57	44.01±1.56	<0.001[a]
Intraocular pressure (mm Hg)			
Preoperative	16.23±0.95	15.94±0.84	0.213
Postoperative	18.54±1.03	18.33±0.89	0.387

Continuous variables are expressed as *n* or mean ± standard deviation. [a]Student's *t*-test was used for continuous parameters and the Chi-squared test was used for numeric parameters.

Exclusion criteria as follows: eyes with foveal detachment, history of acute angle closure glaucoma, previous trauma, uveitis and posteria synechia, eyes with silicone oil injection, eyes implanted with minus IOLs, and IOL insertion into the sulcus due to rupture of the posterior capsule. All subjects were divided into two groups according to the axial length: high myopic eyes (axial lenth >26.0 mm); and non-high myopic eyes (axial length ≤26.0 mm).

Methods All of the enrolled patients underwent in advance the following examinations: autrorefraction (Auto-Ref-Keratometer, RK-5®, Canon, Japan), slit-lamp examination, intraocular pressure measurement, fundus examination, and ultrasonographic B-scan. The axial length and keratometer by IOL Master (Carl Zeiss Meditec Inc., Dublin, CA, USA) were measured pre- and 4mo postoperatively. One trained person examined the refractive errors of all the patients. The predicted postoperative refraction error was calculated as mean error and mean absolute error 4mo postoperatively. The mean error was calculated as the difference between the predicted and the actual spherical equivalent postoperative refraction (*i.e.* actual postoperative spherical equivalent minus predicted spherical equivalent). The mean absolute postoperative prediction error was estimated as the absolute value of the mean error of the postoperative prediction error.

Surgical technique Single surgeon (Jee D) performed all of the phacovitrectomies, performed under general or retrobulbar anesthesia [bupivacaine, lidocaine (4:6 mixed solution)]. After making three sclerotomies using a 23-gauge troca, we constructed a 3 mm clear corneal temporal incision followed by injection of viscoelastic material. We made a 5 to 5.5 mm continuous curvilinear capsulorhexis using the forceps. Phacoemulsification was performed by the stop-and-chop technique, and irrigation and aspiration was done to remove the remaining cortex. An acryl soft IOL (AcrySof IQ, SN60WF®; Alcon, Inc., Forth Worth, TX, USA) with IOL constant 118.7 was inserted into the capsular bag without enlargement of the corneal wound. Biometric calculations of IOL power were performed using the Haigis formula. The viscoelastic material was removed thereafter. A standard 3-port PPV was performed with an Accurus 23-gauge system® (Alcon, Inc., Forth Worth, TX, USA). After fluid-air exchange was done, perfluorocarbon gas (14%) was injected to refill the vitreous cavity. No suture was required for sclerotomy site reapproximation.

IOP control during vitrectomy was done within from 20 mm Hg to 25 mm Hg. IOP was transiently increased to over 40 mm Hg less than 2min in case of risk at the bleeding during the procedure. IOP lowering drug was used when postoperative IOP increased to over 25 mm Hg to prevent optic nerve damage.

Statistical Analysis Difference between the high and non-high myopic eyes was assessed by unpaired *t*-test for continuous parameters using SPSS® (version 17.0;SPSS Inc., Chicago, IL, USA). Within each group, the difference between pre- and postoperative values was analyzed with respect to the axial length and keratometric measurement using a paired *t*-test. A *P* value <0.05 was considered statistically significant.

RESULTS

The records of 91 patients (91 eyes) were reviewed. The following patients were excluded: 2 patients with IOL insertion in the sulcus, 2 patients with incomplete closure of macular hole, and 4 patients who were unable to follow up. Thus, 18 eyes of 18 high myopic patients and 73 eyes of 73 non-high myopic patients were enrolled in this study.

The relationship between the two groups of high myopic and non-high myopic eyes was shown in the Table 1. The two groups were well balanced overall for demographic and baseline ocular characteristics including age, gender, and intraocular pressure.

As shown in Table 2, the high myopic group had a significant greater myopic shift (-1.08±0.87 D) than the non-high myopic group (-0.43±0.63 D) in the mean numeric errors (*P*=0.004). The mean absolute error was also greater in the high myopic eyes (1.12±0.75 D) than in the non-high myopic eyes (0.49±0.36 D; *P*=0.039). As shown in Table 3, the percentage of the refractive error within ± 0.50 D and ±1.00 D of the planned refraction is lower in the high myopic group than in the non-high myopic group (*P*=0.043, 0.029 respectively).

Table 4 shows the change of axial length after phacovitrectomy. The postoperative axial length was

Table 2 Refractive errors in high myopic and non-high myopic eyes after phacovitrectomy

Variables	High myopia (*n*=18)	Non-high myopia (*n*=73)	*P*
Mean error (D)	-1.08±0.87	-0.43±0.63	0.004[a]
Mean absolute error (D)	1.12±0.75	0.49±0.36	0.039[a]

Continuous variables are expressed as *n* or mean±standard deviation. D: Diopters. [a]*P* <0.05, Student's *t*-test.

Table 3 Percentage of eyes achieving the planned refraction after phacovitrectomy

Variables (%)	High myopia (*n*=18)	Non-high myopia (*n*=73)	*P*
Eyes with MAE<0.5 D	3 (16.6%)	31 (42.4%)	0.043[a]
Eyes with MAE<1.0 D	6 (33.3%)	45 (61.6%)	0.029[a]

MAE: Mean absolute error; D: Diopters; [a]*P* <0.05, Chi-squared test.

Table 4 Change of axial length in high myopic and non-high myopic eyes after phacovitrectomy

Group	Preoperative	Postoperative	Difference	[a]*P*
High myopia (mm)	26.49±0.51	26.95±0.76	0.46±0.28	0.043[a]
Non-high myopia (mm)	22.91±0.59	23.02±0.76	0.11±0.34	0.135

Continuous variables are expressed as mean ± standard deviation. [a]*P* <0.05, paired *t*-test.

Table 5 Change of keratometric value in high myopic and non-high myopic eyes after phacovitrectomy

Groups	Preoperative	Postoperative	Difference	[a]*P*
Keratometric values (D)				
High myopia	42.22±2.57	42.47±2.65	0.26±0.26	0.037[a]
Non-high myopia	44.01±1.56	44.10±1.65	0.08±0.40	0.347
Astigmatism (D)				
High myopia	0.90±0.76	1.05±1.11	0.15±0.78	0.218
Non-high myopia	0.88±0.91	1.04±0.36	0.16±0.58	0.272

[a]*P* <0.05, paired *t*-test; D: Diopters. Continuous variables are expressed as mean±standard deviation.

significantly longer than the preoperative axial length in the high myopic eyes (*P*=0.043). However, in the non-high myopic eyes, the postoperative axial length was not significantly increased than the preoperative axial length (*P*=0.135). The change of the axial length in the high myopic eyes (0.46±0.28 mm) was greater than in the non-high myopic eye (0.11±0.34 mm; *P*<0.001). We did not detect staphyloma by funduscopic examination or B-scan ultrasonography.

Table 5 shows the change of the keratometric value after phacovitrectomy. The mean postoperative keratometric values in the high myopic eyes was significantly greater than preoperative keratometric values (*P*=0.037). However, in the non-high myopic eyes, there was no significant difference between the pre- and postoperative keratometric values (*P*=0.347). The change of the keratometric value in the high myopic eyes (0.26 ±0.26 D) was greater than that in the non-high myopic eyes (0.08±0.40 D; *P*<0.001).

The pre- and postoperative keratometric astigmatism in the high myopic group and the non-high myopic group were demonstrated in Table 5. Corneal astigmatism did not change after phacovitrectomy in both groups.

Table 6 shows adjusted predictive refractive errors using postoperative axial length for IOL calculation. No significant difference was found in adjusted mean error (*P*=0.226) and mean absolute error (*P*=0.087) between high myopic and non-high myopic eyes.

DISCUSSION

Our study demonstrated that the high myopic eyes showed significantly greater myopic shift than the non-high myopic group, and showed a significant increase in axial length and keratometric value than non-high myopic group. The significant increase of axial length and keratometric values in high myopic eyes is a possible reason for greater myopic shift in high myopic eyes.

Table 6 Adjusted refractive errors using postoperative axial length for IOL calculation in high myopic and non-high myopic eyes after phacovitrectomy

Variables	High myopia (*n*=18)	Non-high myopia (*n*=73)	[a]*P*
Mean error (D)	-0.26±0.20	-0.18±0.26	0.226
Mean absolute error (D)	0.27±0.17	0.20±0.15	0.087

Continuous variables are expressed as *n* or mean ± standard deviation. D: Diopters. [a]*P* <0.05, Student's *t*-test.

The change of axial length after phacovitrectomy may be influenced by measurement device such as optical biometry or ultrasound sonography. The optical biometry is not affected by macular pathology such as macular holes and epiretinal membrane by measuring from the front of the cornea to the retinal pigment epithelium, whereas ultrasound sonography could be the source of erroneous underestimation of the axial length due to a thicker retina. Recent studies using IOL Master with Haigis formula reported that no significant difference in axial length was found between the preoperative and postoperative axial length measurement [9, 15] However, all the eyes of the patients enrolled in their studies were non-high myopic eyes except for only one eye [9, 15]. In our study, the high myopic eyes showed the increase of postoperative axial length, whereas the non-high myopic group did not. Our results suggested that true increase of the axial length occurred in high myopic eyes after phacovitrectomy. In vitrectomy, sclera thinning or stretching in or around the sclerotomy sites may occur with intraocular pressure rise intra- and postoperatively.

We hypothesized that high myopic eyes had the susceptibility of actual axial length elongation and a greater steepening in corneal curvature because of thinner sclera. High myopic eyes had a thinner sclera and cornea, which are more susceptible to stretching by the intraocular pressure.

The above hypothesis is supported by several previous studies. A significant reduction in the diameter of the sclera collagen fibrils and the rate of proteoglycan synthesis is found in the development of myopia, which leads to sclera thinning, the loss of sclera tissue and the weakening of the scleral mechanical properties during sclera remodeling[16-18]. Similar changes may occur in the cornea in the development of myopia. Thus, thinned and less rigid cornea and sclera of the high myopic eyes may have the more deformational change in response to the global wall stress during phacovitrectomy.

It is well known that eyes with high myopia had thinner corneas and high myopic eyes have lower ocular rigidity than non-high myopic eyes[19-21]. Therefore in high myopia, corneal rigidity as part of the global rigidity is likely to be low. Thus, high myopic eyes with thinner and less rigid cornea are more susceptible to the deformation, which leads to steepening of the cornea curvature after phacovitrectomy. The finding of the present study is contrary to the result from a recent study showing no significant change in keratometric values after phacovitrectomy[12].

According to the Schmid *et al* [22], global wall stress is equal to IOP ($r/2t$), in which "r" is the inner radius of the globe, and "t" is the wall thickness. In high myopic eyes, inner radius of the globe is longer, and the globe wall is thinner compared with non-high myopic eyes. If the IOP during phacovitrectomy is the same between high myopic and non-high myopic eyes, the global wall stress should be higher in high myopic eyes than in non-high myopic eyes. Thus, a given IOP during surgery may cause a greater scleral stretching and steepening in cornea curvature along the slcerotomy sites in high myopic eyes, because of reduced ocular rigidity, increased wall stress and sclera thinning.

From this perspective, new concerns can arise about high myopic eyes. There is a possibility of damage on the retinal nerve fiber layer by the scleral stretching during phacovitrectomy in high myopic eyes. High myopic eyes itself are known to have thinner retinal nerve fiber layer which is vulnerable to the damage [23-25]. Additional stress caused by phacovitrectomy may damage the retinal nerve fiber layer in high myopic eyes. Unfortunately, our study was not designed to evaluate this concern. Further study about this matter is needed in the future. The problems from phacovitrectomy are contrary to those from cataract surgery in high myopic eyes, in which postoperative hyperopic changes occurs[2,4,5].

Eyes implanted with minus IOLs excluded from this study. Because IOL geometry changes considerably at the transition from plus to minus powers, a corresponding change is obtained in the necessary IOL constants [26]. Thus, plus and minus IOLs must have different sets of IOL constants. If existing constants for plus IOLs are also used for minus IOLs, hyperopic refractive errors are created. To exclude this potential bias, we excluded the patients with minus IOLs.

Corneal astigmatism did not change postoperatively in high myopic eyes or non-high myopic eyes. The 23-gauge sutureless vitrectomy system may have reduced astigmatism caused by scleral suturing, whereas Slusher *et al* [27] reported seven cases of severe persistent astigmatism after the 20-gauge sutured vitrectomy.

One limitation of this study is that sample size of this study group is not balanced. High myopic group had only 18 eyes, whereas non-high myopic eyes had 73 eyes. One possible reason for this is that prevalence of high myopic eyes having received phacovitrectomy is originally low. However, when the prevalence of disease is different like this study, sample size would be better not to be adjusted artificially to equal size to avoid distortion of results. Another limitation is the retrospective design in which significant biases may affect the selection of controls. However, in this case, we used age and sex matched controls to minimize selection biases.

In conclusion, myopic shift after phacovitrectomy in high myopic eyes was greater than in non-high myopic eyes due to true increase in axial length and keratometric value in high myopic eyes. Ophthalmologist performing phacovitrectomy of high myopic eyes should be aware of this shift in order to select an appropriate intraocular lens and to achieve desirable postoperative visual outcome.

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