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Research Article

Long-term Outcomes of Combined Phacovitrectomy with Posterior Capsulectomy for Cataract Treatment in Pathologic Myopia

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ABSTRACT

Importance: To our knowledge, this is the largest Pathologic Myopia (PM) cohort undergoing combined phacovitrectomy with posterior capsulectomy for cataract treatment.

Background: PM has been documented as an independent risk factor of Retinal Detachment (RD). Coexisting vitreoretinal complications secondary to PM enhance RD incidence, while necessitating additional surgical manipulations to treat cataract than phacoemulsification alone.

Design: Retrospective case series.

Participants: 26 cataract patients (40 eyes) with underlying PM were enrolled from January 2016 to June 2019.

Methods: Participants were treated with a novel combination of phacoemulsification with pars plana vitrectomy (phacovitrectomy) and posterior capsulectomy. Intraocular lens (IOL) was implanted in the capsule bag. Posterior capsulectomy was performed using the 25-gauge vitrectomy cutter though the pars plana.

Main outcome measures: Best-Corrected Visual Acuity (BCVA) logMAR, stability of Spherical Equivalent (SE), intra-operative complications, short- and long-term post-operative complications were evaluated. Normal-distribution variables were described as means (± SD). Continuous variables not following a normal distribution (BCVA logMAR) were expressed as median (± IQR).

Results: A total of 40 eyes of 26 patients (age 53.5 ± 7.80 years, 65.4% female, pre-operative myopia -15.14 ± 5.93 D, axial length 29.69 ± 2.96 mm, intraocular pressure 16.05 ± 3.31 mm of Hg) were analyzed. Follow-up duration was 27.37 ± 7.19 months. 26 eyes (65%) had PM maculopathy. BCVA logMAR at final visit was 0.40 versus 0.75 preoperatively ($p<0.001$). Laser photocoagulation was required in 21 eyes (52.5%). No gas or silicon oil were used. All IOLs were stably placed in the bag without capsular tearing. No cases of post-operative RD were recorded.

Conclusions: Combined phacovitrectomy with posterior capsulectomy could provide safe and effective treatment for cataract in PM.

Keywords: Phacovitrectomy; Capsulectomy; Pathologic myopia

INTRODUCTION

Pathologic Myopia (PM) represents a major cause of irreversible vision loss [1-3]. It was originally described as high myopia accompanied by characteristic degenerative changes in the sclera, the choroid, and the retinal pigment epithelium (RPE) [4]. High myopia prevalence (<-9.00 diopters (D)) was approximately 70% in two population-based studies in China; the Beijing Eye Study and the Handan Eye Study [5,6]. This condition entails a significantly

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higher risk of retinal detachment (RD), compared to emmetropic eyes [7]. For instance, high myopia has been associated with a tenfold-higher risk of rhegmatogenous RD development [8]. In another study, RD was documented in 11.4% of PM patients, while 20% were diagnosed with peripheral retinal breaks predisposing to RD [9].

For cataract management in PM patients, most surgeons recommend standard phacoemulsification, posterior capsule preservation, and intraocular lens (IOL) placement. However, the aforementioned procedure is considered much more challenging when performed in PM eyes. Potential intra-operative complications include suprachoroidal hemorrhage, rupture of the posterior capsule, dropped lens material, and retinal tears [10]. Postoperatively, RD risk is still considered alarming despite advances in phacoemulsification technique [11]. In a 7-year evaluation, RD occurred in 8.1% of PM patients after cataract surgery [12]. Besides cataract, surgeons should be equally concerned about vitreoretinal abnormalities co-existing in the majority of PM eyes; such as vitreous degeneration, vitreo-macular traction, macular dystrophy, epiretinal membrane (ERM), and Macular Hole (MH) [13]. Apparently, none of these pathologies can be addressed via phacoemulsification alone. This procedure might also induce or accelerate PM-related macular pathologies, as it increases post-operative risk of Posterior Vitreous Detachment (PVD) [14]. Thus, an alternative surgical approach addressing both the cataract and the vitreoretinal abnormalities should be investigated in PM patients.

In this study, we propose a combined procedure for cataract management in PM eyes based on phacovitrectomy. Cataract was treated with standardized phacoemulsification, immediately followed by pars plana vitrectomy (PPV) for underlying vitreoretinal abnormalities and posterior capsulectomy. Our aim was to evaluate the outcomes and complications of this novel surgical combination in the PM subset of cataract patients.

MATERIALS AND METHODS

All phacovitrectomy surgeries were performed at Beijing Tongren Eye Center, Beijing Tongren Hospital, Capital Medical University, Beijing, China from January 2016 to June 2019. Enrolled patients fulfilled the following 5 criteria:

• Pre-operative myopia greater than −6.00 D;

• Cataract diagnosis;

• No history of prior RD;

• Signs of vitreous pathology including vitreous floaters, vitreous body opacification, and vitreous traction;

• Typical retinal lesions of pathologic myopia, such as myopic maculopathy (myopic choroidal neovascularization, lacquer cracks, myopic chorio-retinal atrophy), myopic traction maculopathy (myopic macular retinoschisis and myopic MH), abnormalities involving the optic nerve and/or its anatomic adjacency (myopic conus or myopic crescent, myopic optic neuropathy), and posterior staphyloma [4].

Written informed consent was obtained before each procedure, after having explained all implicated risks. Our study was conducted in accordance with the tenets of the Declaration of Helsinki, and approved by the Ethics Committee of the Beijing Tongren Hospital, Capital Medical University, Beijing, China.

Phacovitrectomy surgery (combined phacoemulsification with PPV) was performed in all cases. Procedures were performed under peribulbar block using 1:1 mixture of 2% lidocaine hydrochloride and 0.75% bupivacaine hydrochloride. All phacovitrectomies were performed by the same experienced vitreoretinal surgeon (Bei Tian). 3.0 mm-wide and a 1.5 mm-long clear corneal tunnel incisions were created at the temporal and nasal limbus, respectively. After filling the anterior chamber with a viscoelastic substance, a 6 mm continuous curvilinear capsulorhexis was created, followed by phacoemulsification and cortex removal. IOL implantation preceded posterior segment surgery. Post-operative refraction was set from -1 to -2 diopters (D). All IOLs were implanted in the capsular bag. Our surgical approach for PPV was based on a standard 3-port setup using 25-gauge instruments. When necessary, PVD was safely induced via suction with the vitrectomy probe around the optic nerve head. Laser photocoagulation was performed if peripheral retinal degeneration or retinal breaks were detected intraoperatively. Inner Limiting Membrane (ILM) was peeled over the macula in case of concomitant ERM or MH. To prevent Posterior Capsule Opacification (PCO) following PPV in all eyes, pars plana posterior capsulectomy was performed circumferentially at approximately 5 mm from the IOL's center (Figure 1).

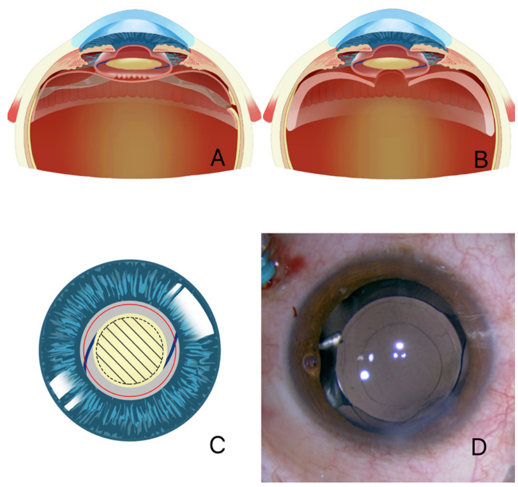

Figure 1: A) A retinal break is caused by anterior vitreous syneresis (right) B) Schematic for phacovitrectomy and pars plana posterior capsulectomy C) Top view of phacovitrectomy and pars plana posterior capsulectomy: the red line shows the anterior continuous curvilinear capsulorhexis (6mm diameter), the yellow surface represents the IOL (5.5 mm diameter), and the black dotted line delineates the posterior capsulectomy (5 mm diameter) D) Top view after pars plana posterior capsulectomy in one of our patients.

Visual Acuity (VA) was recorded with a decimal chart and converted to the logarithm of minimum angle of resolution (LogMAR) format. Finger counting, hand movement, and light perception were recorded as 1.5, 2.0 and 2.5 respectively on the LogMAR scale. Best Corrected Visual Acuity (BCVA), intraocular pressure (IOP) measurement, slip lamp examination, detailed dilated fundus examination, refraction, B scan, IOL master, and optical coherence tomography (OCT) were assessed at baseline. IOP, BCVA, fundus, and OCT were also evaluated on post-operative day 1, day 3, 1 week, 1 month, 3 months, 6 months, 12 months, 18 months, and at final visit. All intra-operative and post-operative complications were recorded.

Statistical analysis

Continuous numerical variables with normal distribution were presented as mean ± standard deviation (SD). Categorical variables were expressed by their corresponding percentages. For continuous variables not following a normal distribution, we used median and interquartile range (IQR). Statistical significance of the differences between pre-operative and post-operative BCVA was analyzed with Friedman test. Wilcoxon signed rank tests were used for paired comparisons, and p values were corrected. Statistical analysis was performed using SPSS 17.0 software for windows (SPSS Inc, Chicago, IL). All statistical tests were two-sided and considered statistically significant if p value was less than 0.05 (p<0.05).

RESULTS

26 patients (65.4% female) participated in this study. 28 eyes of 14 patients were bilaterally operated, and another 12 eyes of 12 patients were unilaterally included for a total of 40 eyes. In cases of bilateral involvement, surgeries were separated by a minimum interval of 1 week. Patient demographics are shown in Table 1. Axial length in 95% of the patients was longer than 26 mm. All patients (100%) had vitreous opacity, and retinal lesions characteristic of PM. Mean follow-up duration was 27.37 ± 7.19 months postoperatively.

Table 1: Patient demographics.

Parameter analyzed	Mean ± SD
Age (years)	53.5 ± 7.8
Preoperative visual acuity (logMAR)	1.63 ± 0.64
Preoperative best corrected visual acuity (logMAR)	1.02 ± 0.78
Preoperative intraocular pressure (mmHg)	16.05 ± 3.31
Preoperative spherical equivalent (D)	-15.14 ± 5.93
Axial length (mm)	29.69 ± 2.96
Central macular thickness (μm)	263.29 ± 66.35

Phacovitrectomy followed by posterior capsulectomy was accompanied by favorable visual outcomes. As illustrated in Table 2, median BCVA (logMAR) at final visit was 0.40, compared to 0.75 before the procedure (p<0.001). Mean spherical equivalent (SE) was -1.03 ± 0.81 D postoperatively versus -15.14 ± 5.93 D preoperatively, also yielding a statistically significant difference (p<0.001).

Table 2: Pre-operative and post-operative best corrected visual acuity (BCVA).

BCVA	Median (IQR)	X^2	p
Pre-operative BCVA (logMAR)	0.75 (0.60 - 1.30)		
Post-operative BCVA (logMAR) at 18 months	0.40 (0.15 - 0.70)*	45.515	<0.001
Post-operative BCVA (logMAR) at final visit	0.40 (0.10 - 0.70)*		
263.29 ± 66.35	263.29 ± 66.35	263.29 ± 66.35	263.29 ± 66.35

A postoperative increase in VA was recorded, although limited by the co-existing myopic maculopathy due to PM. The latter was further sub-categorized into four patterns of pathologic myopic maculopathy:

- Macular dystrophy (n=15 eyes),
- Macular ERM (n=5 eyes),
- Macular lamellar hole (n=3 eyes),
- Choroidal neovascularization scar (n=5 eyes).

12 of the 40 eyes operated had a normal macula. Although PM-related myopic maculopathy was present in 70% of enrolled eyes (28/40), 46.4% (13/28) had achieved logMAR BCVA of 0.5 or better at final visit. During PPV, laser photocoagulation was performed to treat round holes in the retina periphery and lattice degeneration in 52.5% (21/40) of eyes. Neither gas nor silicon oil tamponade were applied. All IOLs were successfully placed in the capsular bag without any incident of posterior capsule tearing or opacification. Post-operative IOP was less than 21 mm of Hg in all eyes during follow-up. Additional laser photocoagulation was never required. No eyes developed RD, choroidal detachment, Cystoid Macular Edema (CME), or other complications throughout the entire follow-up period.

DISCUSSION

Conventional cataract surgery might seem rather inadequate for PM-affected eyes. In part, this is due to their multi-factorial higher risk of post-operative RD. In a study of high-myopia eyes, 7.3% (n=12) presented with RD approximately 30.7 months after clear-lens extraction [15]. RD risk has been positively correlated with high myopia; and it can be proportionately higher in PM [16,17]. Peripheral retina abnormalities predisposing to RD are frequently encountered in PM eyes; including retinal degeneration and retinal holes [9,18,19]. The latter are not only challenging to detect preoperatively, but also to treat postoperatively due to posterior capsule opacity. Impaired peripheral visualization in the setting of pupillary adhesion/fixation should also be emphasized in PM patients undergoing IOL implantation. Ultimately, gold-standard management of PCO with YAG laser might also entail higher RD incidence [17,20,21]. A clear association was found between postoperative YAG laser/surgical posterior capsulotomy and the incidence of retinal detachment (11% vs. 5.5%) [15]. Last but not least, capsular contraction syndrome further predisposes to RD by increasing traction on the peripheral retina after cataract surgery.

Meanwhile, PM-related vitreoretinal abnormalities cannot be effectively addressed via phacoemulsification alone [4,22]. Vitreous degeneration are frequently encountered in PM eyes, including liquefaction, opacities, and posterior vitreous detachment (PVD) [23-25]. PVD is known to be further exacerbated by cataract surgery; the ensuing increase in vitreoretinal traction adds to the already elevated risk of both retinal tears and RD [26]. Unsurprisingly, RD can be substantially prevented when no tears are formed during posterior vitreous separation [27]. Thus, removal of an unhealthy vitreous body right after phacoemulsification can significantly benefit PM eyes in the long-term. Such a procedure also resolves visually-impairing floaters in the setting of extensive vitreous opacification due to PM [28,29]. In severely-symptomatic patients requesting a definite intervention for their floaters, successful PPV entails both visual and psychological benefits [30]. Furthermore, myopic maculopathy progresses in about 40% of highly myopic eyes [31] including retinoschisis, macular epiretinal membrane, macular hole and so on. Retinoschisis in particular has been associated with a 20%-60% increase in RD incidence in high-myopia patients [32]. Therefore, vitrectomy is usually recommended for pathologic maculopathy. In short, through phacovitrectomy, surgeons can not only treat the peripheral retinal degeneration and breaks, but also remove the vitreoretinal traction and treat the myopic maculopathy as well.

Posterior capsulotomy should also be considered during the management of cataract in PM patients. From our perspective, posterior capsulectomy is required among the last steps of the combined procedure we propose for cataract treatment in PM eyes. PCO can develop months to years after phacoemulsification; it is typically managed with YAG-laser capsulotomy. Approximately 20% of the eyes that underwent combined clear lens extraction and PPV for high myopia eventually required Nd: YAG capsulotomy in two studies [33,34]. Furthermore, postoperative capsule contraction syndrome might stretch the ora serrata retina, increasing RD risk. We should also take under consideration that PM eyes are not easily dilated postoperatively. The PCO and wrinkles formed by the posterior capsular contraction make it more difficult to exam the peripheral retina and perform laser treatment postoperatively. To prevent PCO, Mohamed et al. treated high-myopia eyes via refractive lens exchange combined with primary posterior vitrectorhexis.35 over a 12-month follow-up, no need for YAG-laser capsulotomy and no RD cases were recorded [35].

Phacovitrectomy has been tested in high-myopia eyes, yielding promising outcomes. In two studies, the aforementioned surgical combination was applied for clear lens refractive surgery [33,34]. In the study by Uhlmann et al. no RD or CME complications were reported after phacovitrectomy in 14 high-myopia eyes over 30 months of follow-up [33]. A similarly-designed study in a larger sample revealed only 1 case of RD (2.2%), among 45 eyes evaluated for 48 months postoperatively [34]. Recently, pars plana lensectomy was combined with PPV to treat cataract in a small series of 3 PM eyes from 2 patients; both of them reported visual improvement after the procedure [36]. With the exception of that case series, no alternative approaches to cataract treatment in PM eyes have been explored in the literature.

Our results favor the combination of phacovitrectomy with posterior capsulotomy in PM patients. Median BCVA (logMAR) improved from 0.75 preoperatively to 0.40 at final visit ($p<0.001$). Safety was highlighted by the fact that none of the 40 eyes experienced intra-operative or post-operative complications over 27 months of follow-up. No cases of RD, CME, or choroidal detachment occurred in our cohort throughout the study. During PPV, laser photocoagulation was required in 52.5% of the eyes for peripheral retinal holes and lattice degeneration. No additional laser photocoagulation was needed in any eye during follow-up. Post-operative IOP remained lower than 21 mm of Hg in all eyes.

This novel surgical approach enabled us not only to effectively resolve the patients' cataracts, but also to prevent long-term sequelae associated with their underlying PM, such as RD. PPV simultaneously addressed both peripheral retinal pathologies and manifestations of pathologic maculopathy due to PM. By limiting the risk of PCO and capsular contraction syndrome, we could preserve retina visualization over the 27-month follow-up; again, this contributes to the overall decrease in RD incidence, as it allows timely interventions when necessary. This surgical combination can also avoid disrupting the intraocular pressure balance between the anterior and posterior chambers during cataract surgery, which might tract the macular and cause macular edema after surgery; In high-myopia eyes undergoing uncomplicated cataract surgery, 9% were complicated with CME at 2 months postoperatively [37]. However, our approach was accompanied by zero CME incidences over 27 months. In the era of minimally-invasive and sutureless PPV [1,28,29] it might probably be even safer to treat cataract via phacovitrectomy in PM patients; especially if we co-evaluate the long-term treatment benefits. Our study was limited by its retrospective nature, the lack of a control group, and its relatively small sample size.

CONCLUSION

In conclusion, phacovitrectomy combined with posterior capsulectomy may be a safe and effective surgical combination for cataract treatment in PM patients. It may effectively address both the cataract pathology and the long-term risk of RD and myopic maculopathy in such patients postoperatively. Although the described phacovitrectomy technique is not new, its application in cataract patients with underlying PM has not been previously reported. We believe that a larger, prospective, randomized-controlled trial is warranted to statistically verify the overall effectiveness and safety of our combined surgical approach in PM patients with cataract.

REFERENCES

1. Iwase A, Araie M, Tomidokoro A, Yamamoto T, Shimizu H, Kitazawa Y, et al. Prevalence and causes of low vision and blindness in a Japanese adult population: The Tajimi Study. Ophthalmology.2006;113(8):1354-1362.
2. Xu L, Wang Y, Li Y, Wang Y, Cui T, Li J, et al. Causes of blindness and visual impairment in urban and rural areas in Beijing: The Beijing Eye Study. Ophthalmology.2006;113(7):1134-e1.
3. Hsu WM, Cheng CY, Liu JH, Tsai SY, Chou P. Prevalence and causes of visual impairment in an elderly Chinese population in Taiwan: The Shihpai Eye Study. Ophthalmology.2004;111(1):62-69.
4. Morgan IG, Ohno-Matsui K, Saw SM. Myopia. Lancet.2012;379(9827):1739-48.
5. Liu HH, Xu L, Wang YX, Wang S, You QS, Jonas JB. Prevalence and progression of myopic retinopathy in Chinese adults: The Beijing Eye Study. Ophthalmology.2010;117(9):1763-1768.
6. Gao LQ, Liu W, Liang YB, Zhang F, Wang JJ, Peng Y. Prevalence and characteristics of myopic retinopathy in a rural Chinese adult population: the Handan Eye Study. Arch Ophthalmol.2011;129(9):1199-1204.
7. Colin J, Robinet A. Clear lensectomy and implantation of a low-power posterior chamber intraocular lens for correction of high myopia: A four-year follow-up. Ophthalmology.1997;104(1):73-78.
8. Eye Disease Case-Control Study Group. Risk factors for idiopathic rhegmatogenous retinal detachment. Am J Epidemiol.1993;137(7):749-757.
9. Grossniklaus HE, Green WR. Pathologic findings in pathologic myopia. Retina.1992;12(2):127-133.
10. Chan E, Mahroo OA, Spalton DJ. Complications of cataract surgery. Clin Exp Optom.2010;93(6):379-389.
11. Williams MA, McGimpsey S, Abugreen S, Chan W, Sharkey JA, Best RM, et al. The incidence and rate of rhegmatogenous retinal detachment seven years after cataract surgery in patients with high myopia. Ulster Med J.2009;78(2):99.
12. Colin J, Robinet A, Cochener B. Retinal detachment after clear lens extraction for high myopia: Seven-year follow-up. Ophthalmology.1999;106(12):2281-2285.
13. Ohno-Matsui K, Lai TY, Lai CC, Cheung CM. Updates of pathologic myopia. Prog Retin Eye Res.2016;52:156-187.
14. Mirshahi A, Hoehn F, Lorenz K, Hattenbach LO. Incidence of posterior vitreous detachment after cataract surgery. J Cataract Refract Surg.2009;35(6):987-991.
15. Barraquer C, Cavelier C, Mejia LF. Incidence of retinal detachment following clear-lens extraction in myopic patients: Retrospective analysis. Arch Ophthalmol.1994;112(3):336-339.
16. Al-Suliman S, Mousa A. Frequency of retinal detachment after cataract surgery in highly myopic patients. Saudi Med J.2013;34(5):511-517.
17. Haug SJ, Bhisitkul RB. Risk factors for retinal detachment following cataract surgery. Curr Opin Ophthalmol.2012;23(1):7-11.
18. Ikuno Y. Overview of the complications of high myopia. Retina.2017;37(12):2347-2351.
19. Saw SM, Gazzard G, Shih Yen EC, Chua WH. Myopia and associated pathological complications. Ophthalmic Physiological Opt.2005;25(5):381-391.
20. Javitt JC, Tielsch JM, Canner JK, Kolb MM, Sommer A, Steinberg EP, et al. National outcomes of cataract extraction: Increased risk of retinal complications associated with Nd.-YAG laser capsulotomy. Ophthalmology.1992;99(10):1487-1498.
21. Wesolosky JD, Tennant M, Rudnisky CJ. Rate of retinal tear and detachment after neodymium: YAG capsulotomy. J Cataract Refract Surg.2017;43(7):923-928.
22. Chang L, Pan CW, Ohno-Matsui K, Lin X, Cheung GC, Gazzard G, et al. Myopia-related fundus changes in Singapore adults with high myopia. Am J Ophthalmol.2013;155(6):991-999.
23. Akiba J. Prevalence of posterior vitreous detachment in high myopia. Ophthalmology.1993;100(9):1384-1388.
24. Zejmo M, Forminska-Kapuscik M, Pieczara E, Filipek E, Mrukwa-Kominek E, Samochowiec-Donocik E, et al. Etiopathogenesis and management of high myopia Part II. Med Sci Monit.2009;15(11):RA252-255.
25. Wang X, Shen M, Wang R, Zhou Y, Li T, Xiao M, et al. Posterior precortical vitreous pockets in high myopia observed by enhanced vitreous imaging of spectral domain optical coherence tomography. Retina.2019;39(6):1100-1109.
26. Coppé AM, Lapucci G. Posterior vitreous detachment and retinal detachment following cataract extraction. Curr Opin Ophthalmol.2008;19(3):239-242.
27. Hovland KR. Vitreous findings in fellow eyes of aphakic retinal detachment. Am J Ophthalmol.1978;86(3):350-353.
28. Khan MA, Shahlaee A, Toussaint B, Hsu J, Sivalingam A, Dugel PU, et al. Outcomes of 27 gauge microincision vitrectomy surgery for posterior segment disease. Am J Ophthalmol.2016;161:36-43.
29. Khan MA, Kuley A, Riemann CD, Berrocal MH, Lakhanpal RR, Hsu J, et al. Long-term visual outcomes and safety profile of 27-gauge pars plana vitrectomy for posterior segment disease. Ophthalmology.2018;125(3):423-431.
30. Kim YK, Moon SY, Yim KM, Seong SJ, Hwang JY, Park SP. Psychological distress in patients with symptomatic vitreous floaters. J Ophthalmol.2017;2017.
31. Hayashi K, Ohno-Matsui K, Shimada N, Moriyama M, Kojima A, Hayashi WY, et al. Long-term pattern of progression of myopic maculopathy: A natural history study. Ophthalmology.2010;117(8):1595-1611.
32. Shimada N, Ohno-Matsui K, Baba T, Futagami S, Tokoro T, Mochizuki M. Natural course of macular retinoschisis in highly myopic eyes without macular hole or retinal detachment. Am J Ophthalmol.2006;142(3):497-500.
33. Uhlmann S, Wiedemann P. Refractive lens exchange combined with pars plana vitrectomy to correct high myopia. Eye.2006;20(6):655-660.

34. Zheng Q, Wu R, Yang S, Zhang Y, Li W. Clear lens phacoemulsification combined with vitrectomy to correct high myopia: Four years of follow-up. Ophthalmic Res.2013;49(2):73-80.

35. Mohamed TA, Soliman W, El Sebaity DM, Fathalla AM. Refractive lens exchange combined with primary posterior vitrectorhexis in highly myopic patients. J Ophthalmol.2017;2017.

36. Gologorsky D, Flynn Jr HW. Cataract surgery in the setting of severe pathologic myopia with high axial length: Use of pars plana lensectomy and vitrectomy. Clin Ophthalmol.2016;10:989.

37. Ashraf H, Koohestani S, Nowroozzadeh MH. Early macular changes after phacoemulsification in eyes with high myopia. J Ophthal Vision Res.2018;13(3):249.