· Clinical Research ·

Changes in axial length after vitrectomy for rhegmatogenous retinal detachment combined with choroidal detachment

Ji–Peng Li, Jun Xu, Meng Zhao

Beijing Tongren Eye Center, Beijing Key Laboratory of Ophthalmology and Visual Science, Beijing Tongren Hospital, Capital Medical University, Beijing 100730, China

Correspondence to: Meng Zhao. Beijing Tongren Eye Center, Beijing Key Laboratory of Ophthalmology and Visual Science, Beijing Tongren Hospital, Capital Medical University. No.1 Dongjiaomin Xiang, Dongcheng District, Beijing 100730, China. zhaomeng_jasmine@sina.com

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Abstract

● **AIM:** To report the postoperative axial length (AL) changes in rhegmatogenous retinal detachment combined with choroidal detachment (RRD-CD) patients.

● **METHODS:** The medical records of 97 consecutive patients from January 2015 to December 2018 were reviewed. Patients included were divided into RRD-CD and RRD only groups. All patients had received AL measurements before pars plana vitrectomy (PPV) and before silicone oil removal (SOR). The changes in AL of the two groups were compared. In addition, the potential factors related to AL changes were analyzed.

● **RESULTS:** AL elongation after PPV was 1.01 mm [interquartile range (IQR): 0.37, 1.79; *P*=0.02] in the RRD-CD group, which was greater than in RRD only group (0.15 mm, IQR: 0.04, 0.41; *P*<0.001). AL increased 0.06 mm per 1 mm Hg intraocular pressure changes in the RRD-CD group (R^2=0.11, *P*=0.03). RRD-CD patient was 11.42 times (3.54-46.80) more likely to experience post-PPV AL elongation of more than 1 mm [*P*<0.001, Akaike information criterion (AIC)=92.33, area under the curve (AUC)=0.839].

● **CONCLUSION:** RRD-CD patients are very likely to have a postoperative elongation of AL. The primary intraoclular lens implantation using presurgery AL data may cause a significant refractive error in RRD-CD patients who underwent PPV.

● **KEYWORDS:** rhegmatogenous retinal detachment; choroidal detachment; axial length; pars plana vitrectomy

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INTRODUCTION

As advances have emerged in microsurgical instrumentation on small-gauge pars plana vitrectomy (PPV), phacovitrectomy surgery has, therefore, become a popular procedure in treating rhegmatogenous retinal detachment (RRD)[1-3]. Axial length (AL) and keratometric value measured before surgery are greatly important in calculating the intraocular lens (IOL) power in RRD patients undergoing combined phacovitrectomy.

The accuracy of AL measurement can be affected by several factors. High retinal detachment in the upright position[4], macula-off status[4-5], staphyloma in pathological myopia (PM) patients[6] and low intraocular pressure (IOP)[6-7] may cause underestimation of AL. The IOL power calculation accuracy can be significantly improved using calibrated AL readings obtained from partial optical coherence interferometry (PCI) compared with ultrasound[8]. The AL measurement using optical biometry with adjustment to identify a posterior peak corresponding to ultrasound can minimize the effect of macular-off on the AL result[9]. A high level of consistency of AL measured before and after PPV has been shown in both macula-sparing RRD cases[10] and macula-off RRD cases[4-5]. In RRD cases treated by combined surgery, selection of the IOL power using AL data measured before PPV is reported to result in a small biometric error and a slight myopic shift within the tolerable range in most cases[11].

Rhegmatogenous retinal detachment combined with choroidal detachment (RRD-CD) is a kind of RRD with a specific low IOP character and is reported to affect 8.6%-19.2% of the RRD population in China[12-13]. The need for cataract extraction during PPV is present in RRD-CD cases due to difficulties in viewing the fundus or dealing with proliferative vitreoretinopathy[1]. The report on the postoperative changes of AL in RRD-CD patients is rare. Investigating AL changes will contribute to the accurate selection of IOL power and ensure the desired postoperative refraction in RRD-CD patients planning to have combined surgeries.

The present study evaluated the AL changes post PPV in RRD-CD patients compared with RRD patients. The potential factors influencing AL after the PPV surgery were further investigated.

SUBJECTS AND METHODS

Ethical Approval This retrospective consecutive cohort study was approved by the Ethics Committee of Beijing Tongren Hospital and adhered to the Declaration of Helsinki. Informed consent was waived due to the retrospective nature of the study.

Subjects Medical records of RRD patients who underwent PPV combined with silicone oil tamponade in Beijing Tongren eye center from January 2015 to December 2018 were reviewed.

Inclusion criteria: the records of RRD patients who 1) underwent PPV combined with silicone oil tamponade in our hospital; 2) underwent silicone oil removal (SOR) in our hospital after PPV; 3) had AL measurements by the same machine before PPV and before SOR. Based on the type of retinal detachment, the patient records were categorized into RRD-CD and RRD only. CD was defined as detecting peripheral choroidal detachment by either binocular indirect ophthalmoscopy examination or ultrasound scans[14].

Exclusion criteria: 1) the records lacking the AL measurement; 2) the records without the description of presurgery choroidal status; 3) the AL measurement severely impacted by dense vitreous hemorrhage or dense fibro-membrane that involved the fovea; 4) macula-on RRD.

Methods All patients had received AL measurements before PPV and before SOR surgery. AL of each patient was measured before PPV by partial coherence interferometry (PCI; IOL Master®, Carl Zeiss, Jena, Germany) and ultrasound (US; Ocuscan RxP®, Alcon Laboratories, Fort Worth, TX, USA). More than ten AL measurements were taken for each eye by one skilled operator using PCI and US, and the mean value was used. When a posterior peak was not automatically selected in PCI, AL measurements were manually adjusted by the biometry operator shifting the signal peak selection from the default anterior peak to a more posterior peak with a signal-to-noise ratio of 2 dB or more. Simultaneously, AL was measured by A-scan and confirmed by B-scan of the detached retinal configuration (Ocuscan RxP®, Alcon Laboratories, Fort Worth, TX, USA). The A-scan measurement was carried out by adjusting the ultrasound gain to detect the signal of the wall of the eyeball based on the configuration obtained from the B-scan[9]. The A-scan biometry result was selected if the PCI result was significantly different from that of the A-scan biometry in cases with multiple peak signals. The AL measurement before SOR was carried out using both PCI with adjusted formula and A-scan biometry with adjusted ultrasound velocity[15]. The results from the PCI and the A-scan were compared. According to the clinical examination of the optical media and the silicone oil status, the same operator determined the final AL result after comparing the A-scan and PCI. The changes in AL before PPV and before SOR were compared between the two groups.

IOP was measured by a non-contact air tonometer (Nidek Tonoref 3). No fewer than three measurements were taken in each eye, and the mean value was recorded. The following patients data were included: age, gender, IOP before each surgery, refractive error, presence of PM, the time interval between the two surgeries, IOP after each surgery, and medication for IOP control. PM was diagnosed by the presence of posterior scleral staphyloma through indirect biocular ophthalmoscopy[16].

The 23-gauge PPV was performed by two surgeons separately. All patients had silicone oil tamponade. Drainage of suprachoroidal fluid or cryotherapy was performed in some RRD-CD patients.

Statistical Analysis Statistical analysis was performed using R version 3.20 (http://www.R-project.org). Patient characteristics were retrieved from their medical charts and recorded in Epidata Entry Clientversion2.0.3.15 (http://epidata.dk). Mean and standard deviation (SD) were calculated for continuous data following a normal distribution. Medians with interquartile range (IQR) were calculated for continuous data not following a non-normal distribution. The independent-samples *t*-test, paired *t*-test, or Mann-Whitney *U* test was performed to compare the two groups' data. The Kruskal-Wallis test was performed to compare the data from three groups. The Chi-square test or Fisher's exact test was carried out for discrete data. To explore the potential factors that may influence AL changes, we divided patients into two groups: patients with AL changes more than 1 mm and patients with AL changes less than 1 mm. Variables were compared between the two groups. Variables with a *P*-value less than 0.3 were further enrolled in a binary backward stepwise Logistic regression model. One variable was included or excluded from the model each time by comparing the Akaike information criterion (AIC) value; the model that had the lowest AIC was chosen. The linear regression was performed to analyze the changes of AL and IOP. *P*-value less than 0.05 was considered to be a statistically significant difference.

RESULTS

A total of 97 cases were included in this study, with 42 in the RDD-CD group and 55 in the RRD group. In the RRD-CD group, there were 28 males and 14 females, with a mean age of 52.24±10.59y. In the RRD group, there were 38 males and 17 females, with a mean age of 53.16±13.02y. There was no significant difference in gender distribution (P=0.71) and age (P=0.97) between the two groups.

Characteristics of Patients Before Pars Plana Vitrectomy Surgery The RRD-CD group had lower IOP than the RRD group [8.0 (7.0, 9.0) *vs* 13.0 (12.0, 15.6) mm Hg, P<0.001]. In the affected eyes, the median AL in the RRD-CD group was 23.75 (23.23, 25.28) mm, which was similar to that in the

Table 1 The basic characteristics of RRD-CD and RRD patients median (IQR)

Characteristics	RRD-CD (*n*=42)	RRD (*n*=55)	*P*
Age (mean±SD, y)	52.24±10.59	53.16±13.02	0.71
Males, *n* (%)	28 (66.7)	38 (69.1)	0.97
PM, *n* (%)	3 (7.1)	5 (9.1)	1
IOP (mm Hg)	8.0 (7.0, 9.0)	13.0 (12.0, 15.6)	<0.001
AL affected (mm)	23.75 (23.23, 25.28)	24.68 (23.27, 26.95)	0.07
AL contralateral (mm)	24.66 (24.00, 26.99)	24.32 (23.13, 26.49)	0.09
ΔAL (mm)	0.92 (0.40, 2.45)	-0.07 (-0.52, 0.22)	<0.001

RRD-CD: Rhegmatogenous retinal detachment with choroidal detachment; RRD: Rhegmatogenous retinal detachment; PM: Pathological myopia; IOP: Intraocular pressure; AL: Axial length; ΔAL: Difference between the two eyes; SD: Standard deviation; IQR: Interquartile range.

Table 2 The characteristics of RRD-CD and RRD patients before SOR median (IQR)

Characteristics	RRD-CD (*n*=42)	RRD (*n*=55)	*P*
Time interval between PPV and SOR (d)	154 (112, 201)	159 (128, 223)	0.32
Incidence of IOP elevation, *n* (%)	26 (73.4)	23 (43.4)	0.23
IOP before SOR (mm Hg)	15.3 (13.3, 19.50)	16.0 (14.0, 19.50)	<0.001
IOP changes (mm Hg)	8.00 (4.00, 12.75)	3.00 (1.00, 7.00)	0.001
AL of affected eye (mm)	24.70 (23.97, 27.05)	24.88 (23.41, 27.43)	0.73
AL of contralateral eye (mm)	24.75 (24.01, 27.02)	24.23 (23.09, 26.45)	0.09
Changes of AL affected (mm)	1.01 (0.37, 1.79)	0.15 (0.04, 0.41)	<0.001
Changes of AL contralateral (mm)	0.01 (-0.03, 0.06)	0.02 (-0.01, 0.05)	0.38
Phacovitrectomy, *n* (%)	3 (7.2)	6 (10.7)	0.73

RRD-CD: Rhegmatogenous retinal detachment with choroidal detachment; RRD: Rhegmatogenous retinal detachment; PPV: Pars plana vitrectomy; SOR: Silicon oil removal; IOP: Intraocular pressure; AL: Axial length; IQR: Interquartile range.

RRD group [24.68 (23.27, 26.95) mm, *P*=0.07]. The difference between the affected eye and contralateral eye was greater in the RRD-CD group than in the RRD group [0.92 (0.40, 2.45), *vs* -0.07 (-0.52, 0.22) mm, *P*<0.001). The AL of the affected eye was shorter than the contralateral eye in the RRD-CD group (*P*=0.003). There was no significant difference in AL between the affected eye and contralateral eye in the RRD group (*P*=0.09; Table 1).

Characteristics of Patients Before Silicone Oil Removal Surgery The interval time between two surgeries was 154 (112, 201)d in the RRD-CD group and 159 (128, 223)d in the RRD group (*P*=0.32). There were three patients (7.2%) in the RRD-CD group and six patients (10.7%) in the RRD group who had phacovitrectomy (*P*=0.73; Table 2).

There were 26 patients (73.4%) in the RRD-CD group who had a history of IOP>30 mm Hg in two consecutive follow-ups, similar to 23 patients (43.4%) in the RRD group (*P*=0.23). The difference of IOP measured before PPV and SOR was significant greater in the RRD-CD group than in the RRD group (*P*=0.001; Table 2). The IOP before SOR was greater than IOP before PPV in the RRD-CD group (*P*<0.001). There were no significant changes of IOP in the contralateral eye in the RRD-CD group (*P*=0.56).

Changes in Axial Length The AL before SOR in the RRD-CD group was longer than that before PPV (24.49±2.45 *vs* 25.76±2.64 mm, *P*=0.02). The AL before SOR in the RRD group was not significantly different from that before PPV (25.46±2.85 *vs* 25.77±3.02 mm, *P*=0.58; Figure 1). The difference in AL in the affected eye between the two measurements was significant more in the RRD-CD group than that in the RRD group (*P*<0.001; Table 2). There was no significant difference in AL changes in the contralateral eye in the two groups (*P*=0.38; Table 2).

Factors Related to Axial Length Changes Between Two Surgeries The 0.1 mm error in AL is reported to be equivalent to an error of about 0.27 D in the spectacle plane[17]. We divided all patients into two groups, depending on whether the difference in AL measured before PPV and before SOR was greater than 1 mm in the binary Logistic regression analysis. The greatest AIC was achieved in the final model. After adjusting the effect of the presence of PM (*P*=0.19), IOP before PPV (*P*=0.18), changes of IOP (*P*=0.18), and sustained elevation of IOP in postoperative follow-up (*P*=0.58), RRD-CD patients were 18.90 times [95% confidence intervals (CI), 5.2-69.2] more likely to have axial elongation after PPV than RRD patients (*P*<0.001, AIC=92.33, AUC=0.839; Figure 2).

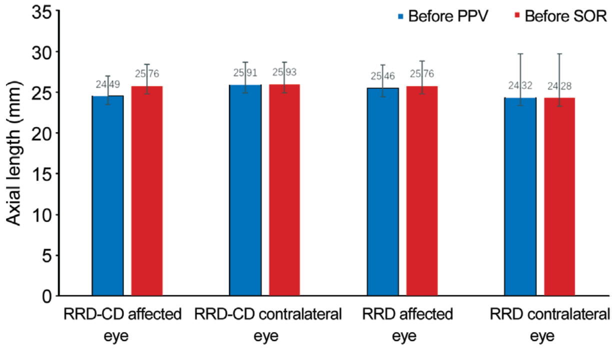

Figure 1 The axial length changes in the two groups.

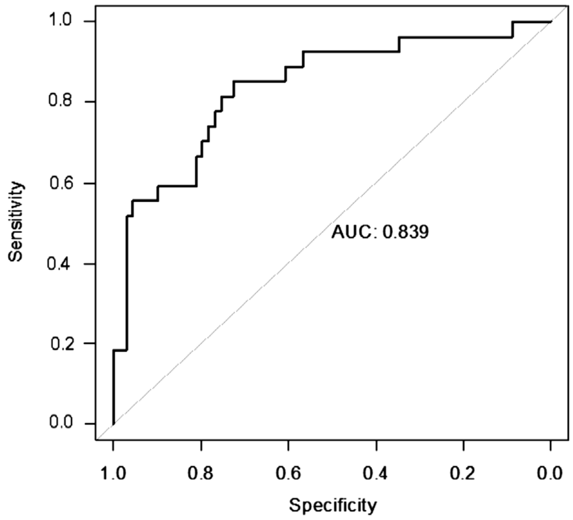

Figure 2 The receiver operating characteristic curve of the logistic model on factors related to axial length changes.

We further investigated the relationship between AL changes and IOP changes. In linear regression analysis, the difference of AL measured before PPV and before SOR was related to IOP difference before PPV and before SOR in the RRD group and the RRD-CD group. AL increased 0.06 mm when IOP measured before SOR was 1 mm Hg greater than that measured before PPV (r=0.06, R^2=0.11, P=0.03) in the RRD-CD group, while AL increased 0.02 mm (r=0.02, R^2=0.11, P=0.01) in the RRD group. The variation of AL measured between two surgeries was more significant in the RRD-CD group than in the RRD group (P=0.01).

DISCUSSION

Combined PPV and cataract extraction were required in complicated retinal detachment cases. The best postoperative refractive prediction after the PPV combined with cataract extraction surgery depends on the correct estimation of IOL power using accurate pre-operative biometric measurements. AL is one of the critical parameters in the IOL power calculation formula. RRD-CD is a specific RRD. In this study, significant axial elongation after PPV was identified in the RRD-CD group but not in the RRD group. RRD-CD patients were more likely to have axial elongation after PPV than other patients without choroidal detachment.

To exclude the effect of different operators and machines on AL-repeated measurements, we had one operator use one set of PCI and US to measure each patient's AL. We also examined the contralateral AL before PPV and before SOR to ensure that the repeated AL measurement was reliable. The consistency of AL in the contralateral eye showed the high reproducibility of the biometric data. To minimize the effect of subretinal fluid movement on the AL measurement when patients were examined from a supine position in the A-scan to a sitting position in the PCI, identifying the signal of the eyeball and configuration of retinal detachment was confirmed by a simultaneously performed B-scan. The results of the A-scan and the PCI were compared[11]. It has been reported that the macula-off status may influence the measurement of AL[4-5]. Therefore, we ruled out macular-on cases to lessen the impact of macular-on status on AL measurement. Therefore, our study only included cases with macula-off RRD in both groups.

Previous studies have shown that no significant changes in AL were detected in RRD patients[10,18]. Compared to the predicted spherical equivalent following combined phacovitrectomy using the presurgery AL data, the tolerable myopic shift was observed as -0.41±0.67[10] or -0.40±1.07 D[19]. Thus, RRD patients' previous results indicate that the pre-operative AL measurement is reliable data for calculating the IOL power[4-5,10-11]. We found a similar result that no significant AL changes before and after PPV were seen in RRD patients. However, contrary to previous findings in RRD patients without CD, we found an axial elongation after PPV in RRD-CD patients with a median increment of 1.01 (0.37, 1.79) mm, which was also significantly greater than that of RRD patients.

The AL measurement accuracy can be affected by macular-off[4-5], and the height of RD[4]. Accuracy can be significantly improved using calibrated AL readings obtained with PCI compared with ultrasound, especially in macular-off cases[8-9]. We used the same adjusted PCI measurement of AL in both groups; the change of AL was observed only in the RRD-CD group. The underestimation of AL in the macular-off patients may not account for AL shortening before PPV in the RRD-CD group.

PM is combined with staphyloma, fix esotropia, and poor fixation[20]. AL measurement can be affected by gaze direction shifts in myopia[21], the distance between the fovea and bottom of staphyloma[22], and fixation instability[20,23]. AL measurement using PCI is more accurate than A-scan in patients with PM[24]. We used PCI and A-scan to measure AL in both groups, in which the prevalence of PM was similar. Only the RRD-CD group showed AL elongation after PPV. In the logistic analysis, the RRD-CD is related to AL elongation after balancing the PM effect. Therefore, the AL measurement inaccuracy in PM patients cannot be the reason for the AL changes in RRD-CD patients.

Ultrasound measurement of the AL is artificially increased due to decreased velocity of sound waves in silicon oil[25]. The AL measurement by PCI is more accurate than A-scan in patients with silicon oil tamponade[15]. All patients enrolled in our study had silicon oil tamponade. Both the PCI and A-scan measured the AL in the eyes with silicone oil tamponade. The result of AL before PPV was similar to that before SOR in the RRD group. Consequently, silicon oil on the changes of AL in the RRD-CD group can be ruled out.

The IOP changes can also affect AL[7,26]. We used the logistic regression model to balance the effect of initial low IOP, IOP difference between the two surgeries, and elevated IOP after PPV. We found that RRD-CD was still an independent factor related to the elongation of AL after balancing the effect of IOP changes.

After ruling out the effect of silicone oil tamponade, we found that the axial elongation in RRD-CD patients in our study is 1.0 (0.37, 1.79) mm, which is higher than the previous one reported 0.104 mm in RRD patients[6]. After balancing the effect of PM and the difference of IOP, our results suggested that the presence of RRD-CD is related to AL elongation after the PPV. The well-known inflammation pathological nature of the RRD-CD may take account for it. The presence of presurgery swelling choroidal and choroidal detachment and the resolution of CD after PPV surgery may account for the changes of AL in RRD-CD patients[27].

Underestimated IOL power using the pre-operative AL measurement would be expected to be above 3D according to the previous work on the relationship of AL to the IOL power calculation[17]. Our findings indicated that using underestimated pre-operative AL measurements to calculate IOL power in RRD-CD patients might result in intolerable refractive errors after combined phacovitrectomy.

Alternatively, it has been reported that intraocular lens calculations using contralateral-eye biometry for phacovitrectomy for macula-off RRD are accurate and better than those from same-eye biometry[5]. Our study found that AL difference between the affected eye and the contralateral eye was more significant before PPV than before SOR in RRD-CD patients. Even in cases before SOR, AL difference between the affected eye and the contralateral eye existed in RRD-CD patients. According to AL difference between the two eyes from our study, referencing to AL in the contralateral eye before PPV in RRD-CD patients may lead to inaccurate IOL power calculation.

Altogether, separate IOL implantation with accurate post-PPV AL measurement in RRD-CD patients may be an option. Using postoperative AL data in the IOL power calculation would be more accurate than using presurgery AL data, which may help to achieve a better postoperative visual outcome with less refractive error.

IOP changes can affect the measurement of AL. After medical normalization of IOP from an elevated level, AL decrease was reported to be 0.06 mm per 10 mm Hg decrease of IOP[7]. The trabeculectomy or glaucoma drainage device (GDD) surgery was reported to cause a 0.006-0.01 mm[26,28] decrease of AL per 1 mm Hg decrease of IOP. The -0.08 D myopic shift was expected in surgery with cataract extraction when IOP per 1 mm Hg changed in patients who underwent trabeculectomy or glaucoma drainage surgery for glaucoma[29]; -0.11 D myopic shift was expected in patients who underwent PPV for RRD[6]. We further investigated the relationship between the IOP and AL variations. A positive linear relationship of IOP to AL was found in both RRD-CD and RRD groups in our study. AL increased 0.06 mm per 1 mm Hg of IOP increase in RRD-CD patients, more significant than the 0.02 mm in RRD patients. According to the previous work on AL relationship to the IOL power calculation[17], there would be an estimated 0.18 D myopia shift if RRD-CD IOP increased by one mmHg after combined surgery in our study which is greater than the previously reported as 0.08-0.11 D[6,29]. It may be suggested that the IOP changes can lead to AL changes in both RRD patients and RRD-CD patients, but the influence of IOP changes on AL changes is more significant in RRD-CD patients.

This study's limitation is its retrospective design. There were few combined surgery cases in both groups (three patients in the RRD-CD group and six patients in the RRD group). Therefore, we failed to investigate the actual *vs* predicted refractive error in IOL power calculation after combined phacovitrectomy. Further research with more cases who underwent phacovitrectomy is needed to investigate the effect of RRD-CD on the differences between actual refractive error and predicted refractive error. Selection bias was also presented because the enrolled patients were in a tertiary hospital. Most of the patients included in our study were complicated cases. Further studies with macular-on RRD-CD may be carried out to confirm the result of the axial elongation of RRD-CD after PPV in macular-on conditions. A non-contact technique may help measure the axial length and eliminate corneal indentation bias in RRD patients with hypotony. Furthermore, a comparison of the AL pre-SOR and post-SOR was not performed.

In conclusion, this study offers valuable insight into the significant increase of AL after PPV in RRD-CD patients, which has not been well investigated previously. A significant refractive error may be predicted if primary IOL implantation is performed in the phacovitrectomy using the presurgery AL data in RRD-CD patients, especially in those with low IOP. The secondary IOL implantation can be an optimal choice to achieve better visual acuity by more accurate IOL power calculation using AL data measured after PPV.

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