Long-Term Ocular Biometric Variations After Scleral Buckling Surgery in Macula on Rhegmatogenous Retinal Detachment.

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Abstract

BACKGROUNG: Myopic shift and biometric ocular changes have been previously observed after scleral buckling (SB) surgery in retinal detachment, but long term-term outcomes had not yet been explored. The purpose of present study is to evaluate long term ocular biometric changes in patients with primary macula-on rhegmatogenous retinal detachment (RRD) treated with scleral buckling.

METHODS: in this retrospective, observational study, we reviewed the medical records of patients undergoing SB surgery for macula-on RRD. Ocular biometry was performed before and at the most recent visit after surgery. Axial length (AXL), anterior chamber depth (ACD), anterior corneal astigmatism and spherical equivalent in treated eyes were compared before and after surgery as well as with those of fellow eyes.

RESULTS: 34 eyes of 17 patients with a mean age of 57.0 ± 8.9 years were included. The mean follow-up duration was 50.9 ± 21.9 months (median 53.0; range, 12 to 82 months). A significant postoperative AXL increase of 0.83 mm and a concomitant myopic shift of 1.35 diopters was observed in the operated eyes ($p < 0.0001$). The preoperative axial length was the only predictive factor of axial length change after surgery ($B = 0.152$, 95% CI 0.059 to 0.245, $\beta = 0.668$, $P = 0.003$). Compared to fellow eyes, a postoperative ACD shallowing of 0.1 mm was found in operated eyes ($p < 0.05$), while there were no long-term changes of anterior corneal astigmatism.

CONCLUSIONS: we show that the preoperative axial length is the only predictive factor of AXL increase after SB surgery. Scleral encircling induces a concomitant long-term shallowing of the AC, therefore fourth generation intraocular lens (IOL) power calculation formulae, should be used for patients requiring cataract surgery after SB.

1. Background

Primary rhegmatogenous retinal detachment (RRD) median annual incidence rate, albeit at significant differences based on ethnicity and age, is estimated at 10.5 per 100,000 people with bilateral RRD occurring in the 7.26% of cases.[1]

Pars plana vitrectomy (PPV) and scleral buckling (SB) are the two principal surgical options to manage RRD and, in some selected and particularly severe cases, a combination of both procedures may be carried out. Even if several studies have tried to assess significant long-term anatomical and functional differences between the two techniques, the choice of a method at the expense of the other is not strongly supported by certain evidence, especially since each procedure may vary among centers and surgeons' experience. [2, 3] Nevertheless, each surgical treatment carries potential advantages and disadvantages. Specifically, SB surgery, by compressing the eye circumferentially, is known to cause myopic shift and axial length increase. However, most previous studies that have evaluated axial length changes following SB procedure have been limited to a maximum follow-up duration of 1 year and the long-term effects of scleral encircling are not yet clearly known.[4, 5] Furthermore, ultrasound biometry was used in the majority of previous reports while only few recent studies addressed this issue by using optical biometry.[6–9]

In the present paper, using optical biometry, we evaluated the long-term effects of scleral encircling on the main ocular biometric parameters by comparing changes in encircled eyes with changes in the contralateral eye. To rule out any potential bias related to retinal detachment only macula on RRD patients were included.

2. Methods

An institutional cross-sectional study, approved by the ethical board of the Sapienza University of Rome and in accordance with the tenets of the Declaration of Helsinki, was conducted reviewing medical files and reports of patients who were treated with SB for primary RRD with an anatomically successful repair. All patients, treated between January 2013 and January 2018 at the Ophthalmology Unit of the Policlinico Umberto I University Hospital of Rome, gave written informed consent to the study. Patients' fellows' eyes were used for comparison.

Inclusion criteria were defined as follows: 1) patients who underwent a single uncomplicated SB surgical procedure with a successful repair of a primary macula-on RRD, 2) a follow-up of at least 12 months after surgery, and 3) age > 18 years. Only patients with IOLMaster measurements of axial length (AXL) preoperatively and clear ocular media (nuclear color/opalescence, cortical, or posterior subcapsular lens opacity < 2, according to the Lens Opacities Classification System III), were included in this study.

Exclusion criteria in both eyes were: 1) presence of macular diseases such as prior or active myopic choroidal neovascularization, age-related macular degeneration, or any disease affecting the vitreo-macular interface, e.g. macular hole or epiretinal membrane, 2) history of uveitis or any ocular pathology other than non-complicated RRD history, 3) history of trauma, 4) previous ocular surgery, including refractive surgery, and 5) any further surgery during the follow-up period including cataract surgery.

All SB surgeries were performed by one experienced retinal surgeon (MG). After the positioning of a 240 encircling silicone band, a silicone sleeve was used to secure its ends (Mira; Mira Inc, Uxbridge, Massachusetts, USA). All eyes underwent external SRF drainage. As part of a standardized protocol, the circumference of the 240 encircling band was shortened by 10 mm and transscleral cryotherapy was performed to the retinal break(s). A 287 circumferential silicone scleral explant was finally positioned to support the break(s).

Before surgery, all patients underwent a complete ophthalmological evaluation including optical biometry in both eyes (IOL Master 500, Carl Zeiss Meditec, Dublin, CA), that was repeated at the last follow-up visit. The average of 5 repeated measurements per eye was used.

Preoperative and postoperative data collection included a complete medical and ophthalmic history, best-corrected visual acuity (BCVA), spherical equivalent, axial length, anterior chamber depth (ACD), anterior corneal astigmatism, lens status and intraocular pressure (IOP). Optical coherence tomography and careful binocular indirect retinal examination were assessed to evaluate the characteristics of the RDs and the presence of macular involvement.

Statistical analysis for this study was performed using SPSS (v.18 Chicago: SPSS Inc.). The Shapiro-Wilk test has been used to analyze normal distribution of data. Longitudinal measurements in the operated eyes were compared using the paired t –test or the Wilcoxon's signed ranks test, as appropriate. Categorical variables were compared using Fisher's exact test. Biometric measurements between operated and fellow eyes were compared using the paired t-test or the Wilcoxon's signed ranks test, as appropriate. Bivariate relationships were evaluated by the Spearman coefficient or the Pearson analysis, as appropriate. Backward stepwise linear regression analysis was used to investigate the preoperative factors associated with axial length changes after surgery. The potential prognostic factors included in the analysis were age, baseline axial length, baseline spherical equivalent, buckle extension and follow-up length. Data are reported as mean values ± standard deviation. P-values of < 0.05 were considered as statistically significant.

3. Results

A total of 34 eyes of 17 patients (9 men, 8 women) with a mean age of 57.0 ± 8.9 years (range, 39 to 82) were included to address the purposes of the present study. The mean follow-up duration was 50.9 ± 21.9 months (median 53.0; range, 12 to 82; 95% CI 39.70 to 62.19). Patients were all phakic in both eyes.

At baseline, there was no significant difference in ocular biometric measurements between RRD and fellow eyes ($p > 0.05$). Before surgery, mean axial length in RRD eyes was 24.5 ± 1.0 mm (median 24.3; range, 22.9 to 27.3; 95% CI 24.0 to 25.0). The preoperative clinical characteristics of RRD and fellow eyes are shown in Table 1.

Table 1
Baseline clinical characteristics of RRD and fellow eyes.

	Operated eyes	Fellow eyes	P-value
BCVA (logMAR)	0.05 ± 0.06	0.006 ± 0.02	0.01 °
Retinal detachment extent > 2 quadrants, n (%)	2 (12%)		
Number of retinal breaks, (%)	1 (88.2)		
	2 (11.8)		
Buckle extension (clock hour), mean SD	2.5 ± 1.5		
Axial length (mm)	24.5 ± 1.0	24.4 ± 1.0	0.4 *
Spherical equivalent (D)	-0.96 ± 1.87	-0.79 ± 1.71	0.3 °
Lens status (phakic/pseudophakic)	17/0	17/0	
Anterior chamber depth (mm)	3.29 ± 0.30	3.27 ± 0.33	0.5 *
Corneal astigmatism (D)	-1.29 ± 1.29	-1.05 ± 0.60	0.3 °
IOP (mmHg)	15.71 ± 1.96	15.76 ± 1.44	0.8 °

* Paired t-test, ° Wilcoxon’s signed ranks test

Compared to baseline, at last follow-up there was a mean increase in axial length of 0.83 mm (95% CI 0.72 to 0.95, $P < 0.0001$), a mean decrease in ACD of − 0.09 (95% CI -0.19 to 0.0007, $P = 0.049$), and a mean myopic shift of 1.35 diopters (95% CI -1.65 to -1.06, $P < 0.0001$). Compared to fellow eyes, axial length increased and ACD as well as spherical equivalent significantly decreased in operated eyes ($p < 0.05$), (Fig. 1a, b). Anterior corneal astigmatism did not differ significantly neither from baseline, within operated eyes, nor with respect to unoperated eyes ($P = 0.08$ and $P = 0.7$, respectively). No significant changes in IOP were found in both operated and fellow eyes ($P > 0.05$). Table 2 shows the longitudinal changes of all ocular biometric measurements in operated and fellow eyes.

Table 2
Postoperative results of ocular biometry of operated and fellow eyes

	Operated eye			**Fellow eye**			
	Baseline	**Last follow-up**	**P-value** [a]	**Baseline**	**Last follow-up**	**P-value** [a]	**P-value** [b]
Axial length (mm)	24.5 ± 1.0	25.4 ± 1.2	< 0.0001*	24.44 ± 1.0	24.52 ± 1.2	0.049*	
change	0.83 ± 0.23			0.08 ± 0.16			< 0.0001*
Anterior chamber depth (mm)	3.29 ± 0.30	3.19 ± 0.30	0.049*	3.19 ± 0.33	3.25 ± 0.37	0.1*	
change	-0.09 ± 0.18			0.06 ± 0.14			0.003*
Corneal astigmatism (D)	-1.29 ± 1.29	-1.53 ± 1.19	0.08°	-1.05 ± 0.60	-1.04 ± 0.65	0.7°	
change	-0.24 ± 0.43			0.02 ± 0.17			0.1°
Spherical equivalent (D)	-0.96 ± 1.87	-2.31 ± 1.92	< 0.0001°	-0.79 ± 1.71	-0.93 ± 1.70	0.3°	
change	-1.35 ± 0.57			-0.13 ± 0.45			< 0.0001°

[a] Comparison with baseline within the same eye

[b] Comparison between operated and fellow eyes

* Paired t-test, ° Wilcoxon’s signed ranks test

The average rate of change in axial length during the entire observation period was 0.024 ± 0.026 mm/month in the operated group and 0.002 ± 0.006 mm/month in the control group with a mean difference of 0.022 mm/month (95% CI 0.011 to 0.033, $P < 0.0001$).

In the overall sample of operated eyes, we found a significant correlation between axial length change and both the preoperative axial length ($r = 0.668$, $p = 0.003$) and preoperative spherical equivalent ($r = -0.546$, $p = 0.02$) (Fig. 2). AXL change was also inversely correlated to ACD change after surgery ($r = -0.526$, $p = 0.03$). No further correlation was found, specifically we did not observe any association between AXL change and the extent of segmental buckling.

Backward stepwise linear regression analysis showed that preoperative axial length was the only factor that independently correlated with axial length change after surgery ($B = 0.152$, 95% CI 0.059 to 0.245, $\beta = 0.668$, $P = 0.003$, adjusted $R^2 = 0.41$). That is, for every 1-mm increase in baseline axial length, there was a mean axial length increase of 0.15 mm after surgery.

4. Discussion

The present cross-sectional study showed that, compared to unoperated fellow eyes, scleral buckling for RRD induced an axial length increase of 0.83 mm with a mean myopic shift of 1.35 diopters. We also found a concomitant decrease in anterior chamber depth, while anterior corneal astigmatism was not significantly altered. Preoperative axial length was independently correlated with axial length increase after surgery. We found that for every 1-mm increase in baseline axial length, there was a mean axial length increase of 0.15 mm after surgery.

In the literature, there are only few reports that using optical biometry, addressed the issue of ocular biometric changes after scleral buckling for RRD [6–8], and there is only one study with a follow-up duration longer than 1 year.[9] Herein, we report the results of ocular biometric changes after a mean of 51 months from surgery. Our data showed that axial length changes after SB are substantially stable even in the very long term. Indeed, the reported short-term AXL increase in previous studies range from 0.58 to 1.31 mm. These differences in AXL changes among studies are probably related to differences in the surgical technique as well as in the baseline characteristics of patients. For instance, all previous studies included a different percentage of macula-off detachment. Although optical biometry accuracy is not theoretically affected by retinal elevation, significant underestimation of AXL measurements was however observed in RRD eyes with macular involvement. [10–12] To address this potential bias in the present study only macula-on RRD were selected.

Lee et al. in a recent retrospective investigation comparing, as in our study, AXL change between operated and fellow eyes, found an axial length increase of 1.31 mm after a mean follow-up of 26 months that did not significantly differ between myopic and highly myopic eyes.[9] On the contrary, our results showed that AXL change after surgery is strongly associated with preoperative AXL. However, in the study by Lee et al. it was not specified whether their evaluations were carried out in macula-on or macula off patients. In addition, no details were given regarding further surgical treatment performed in their cohort after RRD repair. These issues may have biased their results.

In contrast to our results, Wong et al, in a previous 12-month prospective study, found a significant association between AXL increase after surgery and the extent of segmental buckling.[8] Of note, in their study, 9 out of 17 patients (53%) received more than 4 clock hours segmental buckling compared to 12% only (2 out of 17 patients) of our series. Therefore, this apparent discrepancy may be attributed to differences in the surgical procedure, that is the use of more extensive segmental buckling in Wong's cohort.

Goezinne et al., in a prospective study, found transient ACD decrease after SB that returned to normal levels at 1 year after surgery.[6] In contrast, in our series we observed that, especially when comparing operated with fellow eyes, AC shallowing after SB persists in the long term, up to 51 months after surgery. Our results are somehow in line with two previous studies that reported significant post-SB ACD decrease up to 12 months after surgery. [7, 8]

ACD decrease after scleral encircling has been attributed to the anterior rotation of ciliary body associated with surgically induced ciliary congestion and subsequent forward shift of the iris-lens diaphragm.[13] Another potential mechanism should be the low IOP prior to surgery that may induce a transient deepening of AC.

In agreement with previous reports, that described transient corneal astigmatism increase up to 3 months after SB, we did not find any significant long-term postoperative change of anterior corneal astigmatism.[8, 14, 15] After a mean follow-up of 51 months we observed a mean increase of anterior corneal astigmatism of approximately 0.25 diopters from baseline.

The strengths of this work are the long follow-up, the comparison with fellow eye as well as the application of strict inclusion and exclusion criteria. Indeed, only eyes with macula-on RRD were selected and any further surgery before and after the SB procedure either in the operated or the fellow eye was an exclusion criterion. All SB surgeries were performed by the same experienced retinal surgeon using a standardized technique that involved a fixed 10-mm shortening of the encircling band and the use of the same buckle type in all cases. The shortcomings are the retrospective design and the small sample size.

5. Conclusions

Our results show that even in the long term the principal effects of SB on ocular biometric parameters is the increase of the AXL. We found that the preoperative axial length was the only predictive factor of AXL change after surgery. Axial length increase is the main determinant of the postoperative myopic shift observed in operated eyes. The effect of scleral encircling on refraction must be taken into account in combined vitrectomy and cataract procedures, in order to improve refractive outcomes in these cases. Further, given that scleral encircling induces a concomitant significant long-term shallowing of the anterior chamber, fourth generation IOL power calculation formulae, that account for ACD, should be used for patients requiring cataract surgery after SB.

Abbreviations

scleral buckling (SB); rhegmatogenous retinal detachment (RRD), axial length (AXL), anterior chamber depth (ACD), intraocular lens (IOL), pars plana vitrectomy (PPV), best-corrected visual acuity (BCVA), intraocular pressure (IOP).

Declarations

Ethics approval and consent to participate: approved by the ethical board of the Sapienza University of Rome; all patients gave written informed consent to the study

Consent for Publication: all authors consent to the publication of the manuscript

Availability of Data and Materials: we do not have permission to share data

Competing interests: the authors declare no conflict of interest.

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Figures

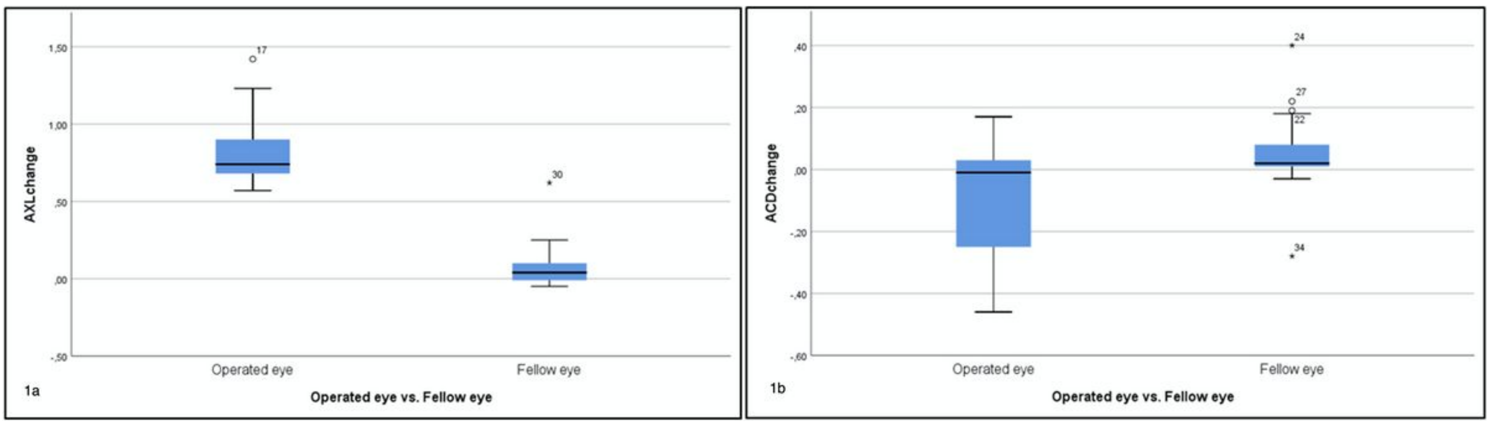

Figure 1

Boxplot showing (a) axial length (AXL) and (b) anterior chamber depth (ACD) change in operated and fellow eyes.

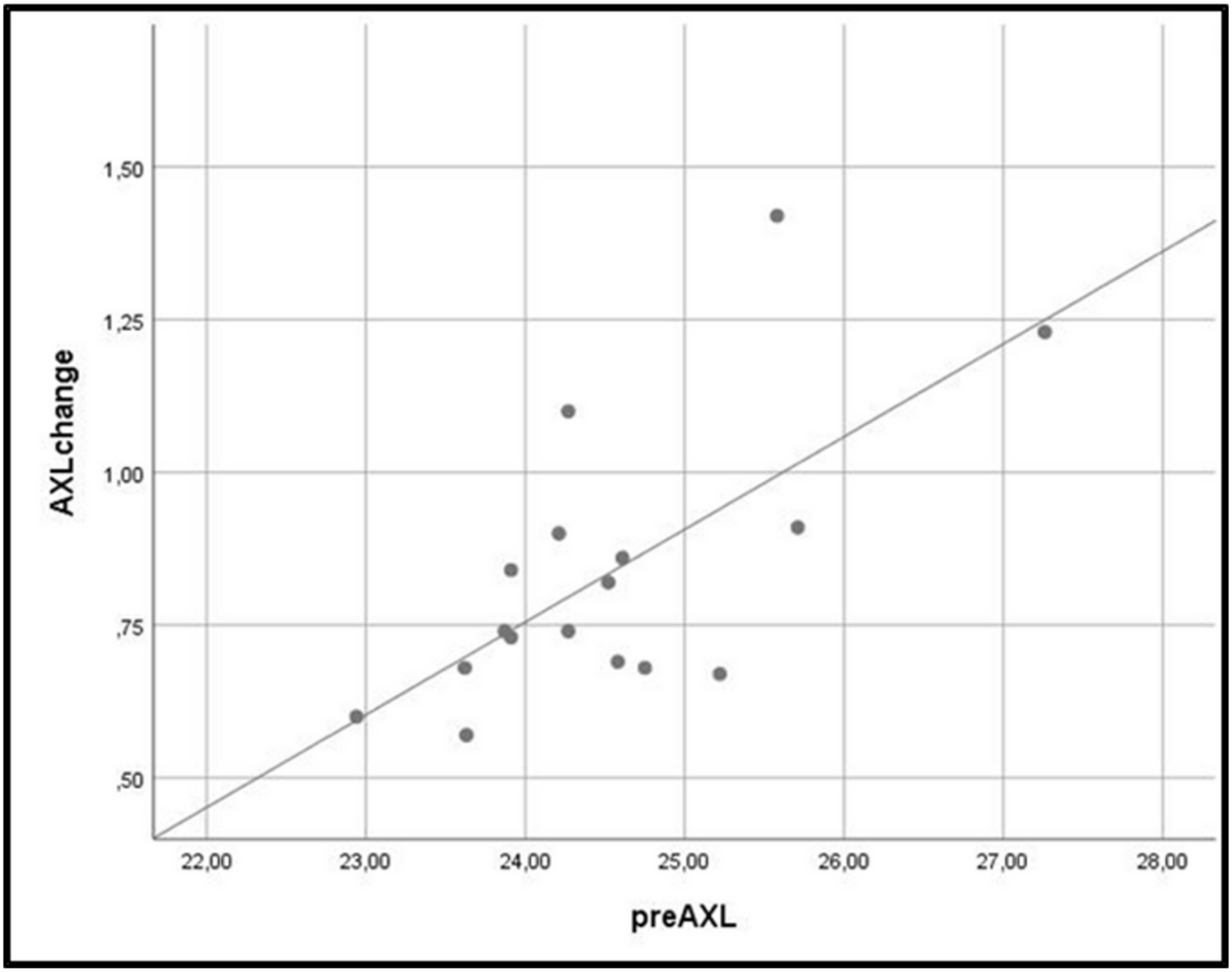

Figure 2

Scatterplot showing the correlation between preoperative axial length (AXL) and AXL change after surgery.