Original Article

Ocular Biometric Changes Following Scleral Buckle Surgery for Rhegmatogenous Retinal Detachment

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ABSTRACT

Introduction: Rhegmatogenous retinal detachment (RRD) is separation of neurosensory retina and Retinal Pigment Epithelium, due to full-thickness retinal breaks. Scleral Buckling (SB) is extraocular procedure done to reattach retina by counteracting vitreoretinal traction and altering globe's geometry.

Objective: To study various ocular changes and visual outcomes after buckling among patients of RRD.

Methodology: A longitudinal observational study was conducted with prospective data collection in a tertiary health care centre from 2019 November to 2021 December after ethical clearance. It included 40 RRD patients who underwent scleral buckling (sizes 279, 276, and 281), recruited by consecutive sampling technique. Study excluded tractional detachment or pathologies affecting retinal visualisation. All patients were evaluated for visual acuity, refraction, intraocular pressure (IOP), axial length (AL) and anterior chamber depth (ACD) both preoperatively and post-operatively at one week, one month, and three months. Statistical analysis was done with Microsoft Excel Sheet using appropriate statistical tests.

Result: Visual acuity showed significant (p-value <0.05) improvement at three months post-operatively. Mean AL increased from pre-operative 24.15 mm to 26.00 mm at one week, decreased to 25.55 mm at one month and further reduced to 25.02 mm at three months post-operatively. Mean ACD decreased from pre-operative 3.20 mm to 2.60 mm at one week, then 2.81 mm at one month and three months post-operatively. Mean IOP rose from pre-operative 12.10 mmHg to 16.45 mmHg at one week, 14.10 mmHg at one month and 13.95 mmHg at three months post-operatively. At three months, Compound myopic astigmatism was noted in 75% of patients on AR and 45% on manual refraction.

Conclusion: The ocular biometric changes following buckling tend to gradually return to baseline, along with visual improvement. These findings support the safety and efficacy of the procedure; also emphasising the importance of continued post-operative monitoring to ensure optimal visual outcomes.

Key words: Anterior chamber depth; axial length; intraocular pressure; refraction; rhegmatogenous retinal detachment; scleral buckle.

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INTRODUCTION

Retinal Detachment (RD) is the separation of neurosensory retina and Retinal Pigment Epithelium (RPE) with accumulation of subretinal fluid (Wolf and Zinkernagel, 2018). Rhegmatogenous retinal detachment (RRD), the most common type, occurs due to full-thickness retinal breaks through which vitreous enters the subretinal space (Parikh et al., 2019).

Scleral Buckling (SB) is an extraocular procedure done to reattach retina in uncomplicated RRD with identifiable breaks with adequate chorioretinal adhesions, by counteracting the vitreoretinal traction. By altering the globe's geometry, it induces changes in axial length, anterior chamber depth, intraocular pressure, refractive status, globe volume, ocular rigidity etc., which can contribute to retinal reattachment (Thompson, 2018).

Axial Length (AL), the distance between the cornea and the RPE- Bruch's membrane junction (Bhardwaj and Rajeshbhai, 2013), changes post-operatively based on the buckle type, material, location and height (Thompson, 2018).

Anterior Chamber Depth (ACD), the distance between the corneal endothelium and the anterior lens surface, may decrease post-operatively, particularly with encircling, due to reduced retinochoroidal circulation and ciliary body oedema (Goezinne et al., 2010). The resolution of oedema occurs within a month (Kawana et al., 2006).

Intraocular Pressure (IOP), the pressure exerted by the intraocular contents on the eyeball (Khurana and Khurana, 2021), rises in early post-operative period due to narrowing of trabecular iris angle (Cekic et al., 2015).

Buckling can induce refractive changes, including astigmatism from altered corneal curvature; shifts in spherical equivalent due to changes in AL, ACD, and lens position; or higher-order aberrations (Thompson, 2018).

The study aimed to assess the various ocular changes seen after buckling, which helped optimise surgical planning and post-operative care. Understanding these changes enables surgeon to select appropriate techniques, like opting segmental buckles in high astigmatism. Patients can also be counselled regarding the potential refractive shifts and the possibility of needing corrective lenses or surgery.

METHODOLOGY

This was a longitudinal observational study conducted after ethical approval in a Tertiary health care centre between November 2019 to December 2021, for a period of 26 months. Data collection was done prospectively.

The sample size of 40 was calculated based on previous study by Huang et al. Preoperative Axial length among the study population was 23.97 ± 2.31 mm (Huang et al., 2016). Thus, the sample size was:

$$n = \frac{Z\alpha^2\,\sigma^2}{d^2}$$

$$= \frac{(1.96)^2 \text{ X } (2.31)^2}{(0.8)^2}$$

$$= \frac{20.49}{0.64}$$

$$= 32.03$$

Adding 10% loss to follow up, **n = 35.23 ≈ 40;** where, Zα = Standard table value for 95% CI = 1.96; σ = Standard Deviation = 2.31; d = precision = 0.8.

The sample size thus consisted of 40 eyes from 40 patients with rhegmatogenous retinal detachment who were scheduled for scleral buckle surgery, recruited by consecutive sampling technique.

Patients of the age group 18 years to 70 years of either gender, undergoing Scleral buckling for Rhegmatogenous retinal detachment, who were compliant for regular follow-up and were willing to consent were included in the study. This study excluded patients with Vitreous haemorrhage or any pathology hindering the visualisation of retina, patients with Tractional retinal detachment and patients with cataract.

Ethical clearance was obtained from the Institutional Ethics Committee (Reference number: BMCRI/PG/352/2019-20) and informed consent was taken from all the patients. Statistical analysis was done with Microsoft Excel software using appropriate statistical tests.

Paired t-test has been applied to measure the difference between the baseline values and values at various time intervals Post Operatively. The p-value of <0.05 considered statistically significant.

Patients underwent detailed ocular examination such as Visual Acuity using logMAR chart, Anterior-segment evaluation by Slit-lamp bio-microscopy, Manual refraction, Automated Refraction (AR), IOL Master for Axial length, Anterior-segment Optical Coherence Tomography (AS-OCT) for Anterior Chamber Depth, Applanation Tonometry (AT) for Intraocular Pressure and Indirect Ophthalmoscopy. The patients were followed-up at 1 week, 1 month and 3 month post-operatively and the same parameters were assessed.

AR works on Scheiner's principle and the Optometer principle (Abrams and Duke-Elder, 2019). IOL Master is a type of non-contact optical biometry, which works on the principal of Optical Coherence Biometry. It measures AL as the optical path length between the anterior surface of cornea and RPE layer (Dong et al., 2018). AS-OCT is a non-contact imaging modality which works on the principal of Low Coherence Interferometry (Waheed et al., 2018). AT is a contact procedure which works on Imbert-Fick law (Goldmann, 1954).

Surgical procedure includes the placement of Scleral buckle of desired size secured along with 240 band with drainage of subretinal fluid with cryotherapy and suitable tamponade.

RESULT

This study included 40 patients, of whom 27 were male and 13 were female, with ages ranging from 18 to 70 years (mean age: 35.67 years). Nineteen patients (47.5%) had diminution of vision (DOV) in the right eye, while 21 patients (52.5%) had DOV in the left eye. Thirty-five patients (87.5%) were phakic, four (10%) were pseudophakic, and one (2.5%) was aphakic.

Nineteen patients (47.5%) presented with subtotal retinal detachment, 16 patients (40%) had total RD, three patients (7.5%) had inferior RD, and one patient (2.5%) each had nasal and superior RD. The macula was involved (macula-off) in 36 patients (90%) and spared (macula-on) in four patients (10%).

The PVR changes were observed in 23 patients (57.5%). Among them, Grade A PVR was seen in six patients (26.08%), Grade B in 10 patients (43.47%), and Grade C in seven patients (30.43%).

Twenty-five patients (62.5%) underwent a 279 segmental buckle procedure, nine patients (22.5%) underwent a 276 segmental buckle, and six patients (15%) underwent a 281 segmental buckle.

Among the 19 patients with Subtotal RD, 6 patients (31.57%) underwent 276SB and 13 patients (68.42%) underwent 279SB. Among the 16 patients with Total RD, three patients (18.75%) underwent 276SB, six patients (37.5%) underwent 281SB and seven patients (43.75%) underwent 279SB. Patients with nasal, superior and inferior RD underwent 279SB.

The Logarithm of the Minimum Angle of Resolution (logMAR) of the Visual Acuity was used to compare initial pre-operative vision with the vision at one week, one month and three months of post-operative follow-up periods. There was an improvement in vision during subsequent post-operative follow-ups. Significant Difference (p-value <0.05) between the Baseline Value and Post-operative Value was seen at one month and three months (Table 1). Patients with good pre-operative vision had good visual outcome. Patients with total RD, irrespective of the type of buckle used, showed an improvement in BCVA, considering poor pre-operative BCVA.

IOL master was used to assess the Axial length at the time of presentation, first week of follow-up, first month of follow-up and third month of follow-up. At the time of presentation, the mean Axial length was found to be 24.15 mm. After 1 week of surgery, it had increased to 26.00 mm. After one month of surgery, it had dropped to 25.55 mm. After three months of surgery, it was 25.02 mm. Significant Difference between the Baseline Value and Post-Operative Value was seen at one week, one month and three months (Table 2). This shows that the patients initially showed an increase in AL which subsequently reduced over time.

Table 1: Visual acuity.

		Mean ±	Std. Deviation	Mean Difference	95% Confidence Interval		p-value
					Lower	Upper	
Pair 1	Vn Pre-op	1.9880 ±	1.11971	0.48650	0.11903	0.85397	0.011
	Vn 1 Week	1.5015 ±	0.46229				
Pair 2	Vn Pre-op	1.9880 ±	1.11971	0.93950	0.60166	1.27734	<0.001
	Vn 1 Month	1.0485 ±	0.17505				
Pair 3	Vn Pre-op	1.9880 ±	1.11971	1.26850	0.95186	1.58514	<0.001
	Vn 3 Month	0.7195 ±	0.19724				

Table 2: Axial length.

		Mean ±	Std. Deviation	Mean Difference	95% Confidence Interval		p-value
					Lower	Upper	
Pair 1	ALPre-op	24.1588 ±	1.98295	-1.84200	-2.03474	-1.64926	<0.001
	AL 1Wk	26.0008 ±	1.99949				
Pair 2	ALPre-op	24.1588 ±	1.98295	-1.40100	-1.59272	-1.20928	<0.001
	AL 1M	25.5598 ±	1.95647				
Pair 3	ALPre-op	24.1588 ±	1.98295	-0.86850	-1.06695	-0.67005	<0.001
	AL 3M	25.0273 ±	1.88197				

The AS-OCT was used to assess the Anterior Chamber Depth at the time of presentation, at first week follow-up, at first month follow-up and at third month of follow-up. At the time of presentation, the mean ACD was found to be 3.20 mm. After one week of surgery, it had reduced to 2.60 mm. After one month of surgery, it was 2.81 mm. After three months of surgery, it was 2.81 mm. Significant Difference between the Baseline Value and Post-operative Value was seen at one week, one month and three months (Table 3). This shows that patients initially had a decrease in ACD but it normalised during the follow-up period.

Applanation Tonometry was used to measure the intraocular pressure at the time of presentation, one week, one month and three months of follow-up. The mean intraocular pressure at the time of presentation was found to be 12.10 mmHg, with lowest value of 6 mmHg and highest value of 20 mmHg. At one week of follow-up, it had increased to 16.45 mmHg, with lowest being 12 mmHg and highest being 26 mmHg. At one month of follow-up, it was 14.10 mmHg, with lowest being 12 mmHg and highest being 22 mmHg. At three months of follow-up, it was 13.95 mmHg, with lowest being 12 mmHg and highest being 18 mmHg. Significant Difference

Table 3: Anterior chamber depth.

		Mean ±	Std. Deviation	Mean Difference	95% Confidence Interval		p-value
					Lower	Upper	
Pair 1	ACD Pre-op	**3.2005 ±**	**0.80733**	0.59575	0.46416	0.72734	**<0.001**
	ACD 1Wk	**2.6048 ±**	**0.66551**				
Pair 2	ACD Pre-op	**3.2005 ±**	**0.80733**	0.38900	0.27682	0.50118	**<0.001**
	ACD 1M	**2.8115**	**0.75408**				
Pair 3	ACD Pre-op	**3.2005 ±**	**0.80733**	0.38400	0.27890	0.48910	**<0.001**
	ACD 3M	**2.8165 ±**	**0.84538**				

between the Baseline Value and Post-Operative Value was seen at one week, one month and three months (Table 4). The patients showed an increase in IOP in immediate post-operative period which normalised during subsequent follow-ups.

The Spherical Equivalent of AR was used to compare the pre-operative refraction with post-operative refraction at follow-up of one week, one month and three months. The mean spherical equivalent of Automated refraction at the time of presentation was found to be -1.52 D; post-operatively it was -2.86 D at one week, -2.15 D at one month and -1.98 D at three months. Significant Difference between the Baseline Value and Post-Operative Value is seen at one week, one month and three months (Table 5). Patients with error in AR were excluded from statistics.

Table 4: Intraocular pressure.

		Mean ±	Std. Deviation	Mean Difference	95% Confidence Interval		p-value
					Lower	Upper	
Pair 1	IOP Pre-op	12.100 ±	3.6219	-4.3500	-5.6527	-3.0473	<0.001
	IOP 1Wk	16.450 ±	3.4637				
Pair 2	IOP Pre-op	12.100 ±	3.6219	-2.0000	-3.1856	-0.8144	0.002
	IOP 1M	14.100 ±	2.2165				
Pair 3	IOP Pre-op	12.100 ±	3.6219	-1.8500	-2.9662	-0.7338	0.002
	IOP 3M	13.950 ±	1.9994				

Table 5: Manual refraction.

		Mean ±	Std. Deviation	Mean Difference	95% Confidence Interval		p-value
					Lower	Upper	
Pair 1	M.Ref Preop	-2.0294 ±	5.22904	1.01471	0.76385	1.26556	0.000
	M.Ref 1W	-3.0441 ±	5.39331				
Pair 2	M.Ref Preop	-2.0536 ±	5.51612	0.36607	0.05447	0.67767	0.023
	M.Ref 1M	-2.4196 ±	5.22151				
Pair 3	M.Ref Preop	-2.0536 ±	5.51612	0.24107	-0.14261	0.62475	0.208
	M.Ref 3M	-2.2946 ±	5.03141				

Twenty-nine (72.5%) patients at first post-operative week had developed Compound myopic astigmatism; of which 19 patients were of 279 SB, nine patients were of 276 SB and one patient was of 281 SB. Twenty-nine (72.5%) patients at first post-operative month had developed Compound myopic astigmatism; of which 19 patients were of 279 SB, nine patients were of 276 SB and one patient was of 281 SB. Thirty (75%) patients at third post-operative month had developed Compound myopic astigmatism; of which 20 patients were of 279 SB, nine patients were of 276 SB and one patient was of 281 SB. Aphakic patient showed Simple myopic astigmatism and all four pseudophakic patients showed Compound myopic astigmatism at the end of study period.

The Spherical Equivalent of Manual refraction was used to compare the pre-operative refraction with post-operative refraction at follow-up of one week, one month and three months. The mean spherical equivalent of Manual refraction at the time of presentation was found to be -2.02 D; post-operatively it was -3.04 D at one week, -2.41 D at one month and -2.29 D at three months. Significant between the Baseline Value and Post-operative Value is seen at one week and one month (Table 6). Patients with dull glow were excluded from statistics.

Twelve (30%) patients at first post-operative week had developed Compound myopic astigmatism; of which nine patients were of 279 SB and three patients were of 276 SB. Fifteen (37.5%) patients at first post-operative month had developed Compound myopic astigmatism; of which 12 patients were of 279 SB and three patients were of 276 SB. Eighteen (45%) patients at third post-operative month had developed Compound myopic astigmatism; of which 14 patients were of 279 SB and four patients were of 276 SB. Aphakic patient showed Mixed astigmatism and among the pseudophakic patients, two patients (50%) showed Compound myopic astigmatism and two patients (50%) showed Mixed astigmatism.

At the end of the study period, all 40 patients (100%) showed reattachment.

Table 6: Automated refraction.

		Mean ±	Std. Deviation	Mean Difference	95% Confidence Interval		p-value
					Lower	Upper	
Pair 1	AR Preop	-1.52917 ±	4.613707	1.333333	1.05052	1.616146	0.000
	AR 1W	-2.86250 ±	4.520112				
Pair 2	AR Preop	-1.47917 ±	4.731779	0.680556	0.307513	1.053598	0.001
	AR 1M	-2.15972 ±	4.442049				
Pair 3	AR Preop	-1.47917 ±	4.731779	0.506944	0.03231	0.981579	0.037
	AR 3M	-1.98611 ±	4.137673				

DISCUSSION

Scleral Buckling is an extraocular procedure done to repair and reattach retina. It is considered in patients with uncomplicated RRD. It alters the geometry of the eye leading to various changes including axial length, anterior chamber depth, intraocular pressure and refraction.

This study included a total of 40 patients of RRD planned for Scleral Buckling. Among which, 19 patients had Subtotal RD. Macula was involved in 36 patients. PVR changes were seen in 23 patients. The authors used Silicone buckle in this study. Twenty-five patients underwent 279 Segmental Buckle, nine patients underwent 276 Segmental Buckle and six patients underwent 281 Segmental Buckle.

An improvement in the Visual Acuity was noted during the post-operative period. The preoperative Visual acuity ranged from Perception of Light to 6/9, at one week follow-up it ranged from Hand movements to Counting fingers, at one month of follow-up it ranged from Counting fingers to 6/24 and at three months of follow-up it ranged from 6/60 to 6/9. Better visual acuity at the time of presentation was associated with better visual outcome at the end of the three months.

Axial Length (AL) is the distance between the cornea and the RPE- Bruch's membrane junction (Bhardwaj and Rajeshbhai, 2013). Changes in axial length depends on the type of buckle, material used, location of the buckle and its height (Thompson, 2018). Segmental buckles can cause hyperopia. Encircling buckles can either increase or decrease the axial length. The axial length values in this study are comparable to a study conducted by Huang C *et al.,* in which the pre-operative AL in RRD patients was 23.97 ± 2.31 mm, post Scleral buckling, it was 25.13 ± 3.11 mm at 6 months and 25.25 ± 2.07 mm at 12 months (Huang et al., 2016).

Anterior Chamber Depth (ACD) is the distance between the corneal endothelium and the anterior pole of crystalline lens or intraocular lens. Encircling buckles can reduce uveal or retinochoroidal circulation causing ciliary body oedema. The forward rotation of ciliary body, forward shift of iris-lens diaphragm and the compression of the vitreous by the encircling buckle, decreases the ACD (Goezinne et al., 2010). The resolution of ciliary body oedema occurs after one month of the procedure (Kawana et al., 2006). The ACD values of this study are comparable to a study conducted by Karti O *et al.,* in which the mean preoperative ACD in RRD patients was 3.09±0.49 mm; post Scleral buckling it was 2.72±0.41 mm at one week, 2.94±0.37 mm at one month and 2.98±0.38 mm at three months (Karti et al., 2012).

Intraocular Pressure (IOP) is the pressure exerted by the intraocular contents on the eyeball (Khurana and Khurana, 2021). It rises significantly in the post-operative period due to narrowing of trabecular iris angle after buckling surgery (Cekic et al., 2015). The IOP values of this study are comparable to a study conducted by Goezinne et al. in which the preoperative IOP in RRD patients was found to be 14.2±3.7 mmHg, on the first post-operative day it was 19.4±5.4 mmHg. The mean IOP in their study was not significantly different in one week, one month, three months, six months, nine months and 12 months (Goezinne et al., 2010).

Buckling can cause refractive errors such as Astigmatic error due to changes in corneal curvature, Change in spherical equivalent due to changes in axial length, ACD and position of crystalline lens and Higher-order aberrations (Thompson, 2018). These mean spherical equivalent values of this study comparable to a study conducted by Nassaralla Junior et al., in which the pre-operative mean spherical equivalent was found to be -1 D; post-operatively it was -3.59 D at one month, -2.95 D at three months and -2.78 D at six months (Junior and Nassaralla, 2003).

The results of this study were comparable with the variables of other similar studies. Thus, this study helps in assessing the various changes seen following Scleral buckling. This further helps in planning the suitable procedure for the patients and preventing complications.

The limitations of this study include the smaller sample size and shorter duration of study, which need to be overcome in future studies with large study group and period of over six months.

The authors analysed the patients preoperatively in terms of the above-mentioned parameters and individualised the surgery as per patient needs. Due to the modifications implemented, the authors were able to get a better visual outcome and the complications have also been reduced. Hence, the authors have been following up the same for all patients and patient satisfactory has also improved.

This study can help us preoperatively modify the surgical approach in patient of RRD, planned for buckle surgery. The type of buckle and its height is decided according to the pre-operative axial length. In patients with higher axial length, the authors kept the height shorter. Segmental buckles were preferred in such patients and hard silicone buckles were avoided. The type of buckling also helps in maintaining the ACD. Encircling buckles tend to reduce ACD further and hence were avoided in patients with pre-existing shallow ACD. The authors can drain the subretinal fluid according to pre-operative IOP status. Similarly, the type of buckle, the height and position help in reducing the post-operative refractive errors. For myopes, soft buckles with shorter height are used to prevent further increase in myopia. This application of the outcomes of this study into guiding future surgeries makes this study unique. This study helps in making scleral buckling and its physics more acceptable, preventing the known complications.

CONCLUSION

The results of this study suggested that Scleral buckling causes ocular changes, which will almost return to the pre-operative status in due course of time, along with improvement in visual acuity. Evaluation of these parameters and modifications accordingly are essential in order to plan for the procedure and minimise post-operative complications. The application of modifications in pre-operative status of scleral buckle surgery is unique in this study, which has not been done earlier to the best of our knowledge.

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