Original Article

Scleral Buckling under a Slit-lamp Illumination System with a Contact Wide-angle Viewing Lens Compared with an Indirect Ophthalmoscope

Seung Yong Choi[1], Youlim Lee[1], Mirinae Kim[1], Young-Hoon Park[1,2]

[1]Department of Ophthalmology and Visual Science, The Catholic University of Korea College of Medicine, Seoul, Korea
[2]Catholic Institute for Visual Science, The Catholic University of Korea College of Medicine, Seoul, Korea

Purpose: To investigate the outcomes of scleral buckling surgery performed under a slit-lamp illumination system (Visulux) with a contact wide-angle viewing lens (Mini Quad) in patients with rhegmatogenous retinal detachment (RRD) and to compare these outcomes with those of surgery performed under an indirect ophthalmoscope.

Methods: By retrospective review of electronic medical records, patients with RRD who had undergone scleral buckling surgery were identified. Scleral buckling surgeries were performed with two illumination instruments, a slit-lamp (SL group) and an indirect ophthalmoscope (IO group). Subretinal fluid drainage, cryopexy, and intravitreal gas injection were performed optionally. At 6 months after surgery, anatomical and functional outcomes were evaluated and compared between the two groups. Operation time was also compared between the two groups.

Results: Of the 45 total patients (45 eyes), 28 were included in the SL group, and 17 were included in the IO group. In the SL and IO groups, the primary anatomical success rate was 89.3% and 88.2%, respectively (p = 0.92). The logarithm of the minimal angle of resolution change, which reflects improvement in best-corrected visual acuity after surgery, was -0.19 ± 0.38 in the SL group and -0.21 ± 0.63 in the IO group; this difference was not statistically significant (p = 0.91). The mean operation time was significantly shorter in the SL group (78.9 ± 11.8 minutes) than in the IO group (100.0 ± 13.9 minutes, p < 0.001), especially for patients who underwent additional procedures such as subretinal fluid drainage and cryopexy (81.4 ± 12.9 and 103.5 ± 12.3 minutes, respectively, p < 0.001).

Conclusions: Scleral buckling surgery performed under a slit-lamp illumination system yielded a similar anatomical success rate and similar functional improvement in RRD compared with surgery performed under an indirect ophthalmoscope. The slit-lamp system could save time, especially in bullous RRD, which requires additional subretinal fluid drainage.

Key Words: Indirect ophthalmoscope, Retinal detachment, Scleral buckling, Slit lamp

Two surgical procedures, scleral buckling and pars plana vitrectomy, are widely utilized for the treatment of rhegmatogenous retinal detachment (RRD) [1-3]. The scleral buckling procedure consists of localizing retinal breaks, fixing the buckle element on the sclera (with or without cryopexy), and draining the subretinal fluid by external sclerotomy. To localize the retinal breaks, surgeons usually use an indirect ophthalmoscope with scleral indentations [3,4].

Scleral buckling surgery performed with an indirect ophthalmoscope has several drawbacks, such as inversion of the retinal image [5], the need to shift the surgeon's position to the opposite site of the retinal break, discomfort caused by the surgeon's position during retinal visualization, and inability to share the indentation and cryopexy images with the assistant [6]. These problems can prolong the operation, cause surgeon fatigue, and limit training opportunities during fellowship residencies. To overcome these drawbacks, chandelier endoillumination with a wide angle viewing system [5,7-9], illumination with a surgical microscope [10], and illumination with a slit-lamp illumination system [11] have all been introduced as successful alternative methods for retina visualization in scleral buckling.

Conventional slit-lamp illumination [12,13] has not been widely used in vitreoretinal surgery because of the narrow visualization area. A previous report demonstrated that a slit-lamp illumination system with a handheld wide-angle–viewing contact lens enabled clear visualization of the retina during scleral buckling surgery, including cryopexy and external subretinal fluid drainage (SRFD). Thus, the slit-lamp system is a potential alternative method to an indirect ophthalmoscope [11].

In this study, we investigated the outcomes of scleral buckling surgery performed under a slit-lamp illumination system (Visulux, Zeiss, Oberkochen, Germany) with a contact wide-angle viewing lens (Mini Quad, Volk, Mentor, OH, USA) in patients with RRD. We also compared the surgical outcomes and operation times with those of scleral buckling surgery performed under an indirect ophthalmoscope.

Materials and Methods

A retrospective electronic medical record review was performed to identify patients with RRD who underwent scleral buckling surgery by a single skilled surgeon (YHP) between August 2010 and February 2016.

This study was conducted with the approval of the institutional review board of Seoul St. Mary's Hospital, College of Medicine, the Catholic University of Korea (KC12RISI0673). The investigators followed the tenets of the Declaration of Helsinki. The investigation was performed without requirement of informed consent because all date used in this retrospective study were fully anonymized.

Patients who underwent scleral buckling with pars plana vitrectomy were not included in this study. Although some participants had conditions that might not be suitable for scleral buckling surgery alone (e.g., visually significant cataract, mild vitreous hemorrhage, retinal breaks near the posterior pole, or mild proliferative vitreoretinopathy), they were included if they had undergone scleral buckling alone based on the surgeon's decision. Patients who underwent scleral buckling surgery between January 2013 and June 2013 were excluded to allow for a 6-month learning period for the new surgical procedure after the first application of the slit-lamp illumination system. History of trauma or refractive surgery was not an exclusion criterion.

All patients underwent a complete preoperative evaluation, which included comprehensive history taking, best-corrected visual acuity (BCVA) measurement on the logarithm of the minimal angle of resolution (logMAR) scale, slit-lamp biomicroscopy, measurement of intraocular pressure, measurement of axial length by optical coherence biometry (IOLMaster, Carl Zeiss, Jena, Germany), fundus examination with a contact wide angle viewing lens (Superquad 160, Volk) that can localize retinal breaks and determine the extent of retinal detachment, and optical coherence tomography to confirm macular involvement. Retinal break sites were classified clockwise into the superior (from 10.5 to 1.5 o'clock), side (nasal or temporal, from 1.5 to 4.5 o'clock or 7.5 to 10.5 o'clock), and inferior (from 4.5 to 7.5 o'clock) areas; the extent of RRD was calculated in the same manner.

After conjunctival peritomy and application of a traction suture, indentation was performed to identify retinal breaks with the use of additional illumination methods according to group. All procedures were performed under a surgical microscope. In the slit-lamp illumination group (SL group), the fundus was illuminated using a slit-lamp illumination system. This system used a hand-held contact wide-angle viewing lens placed by an assistant; a built-in image inverter was activated to generate an upright image
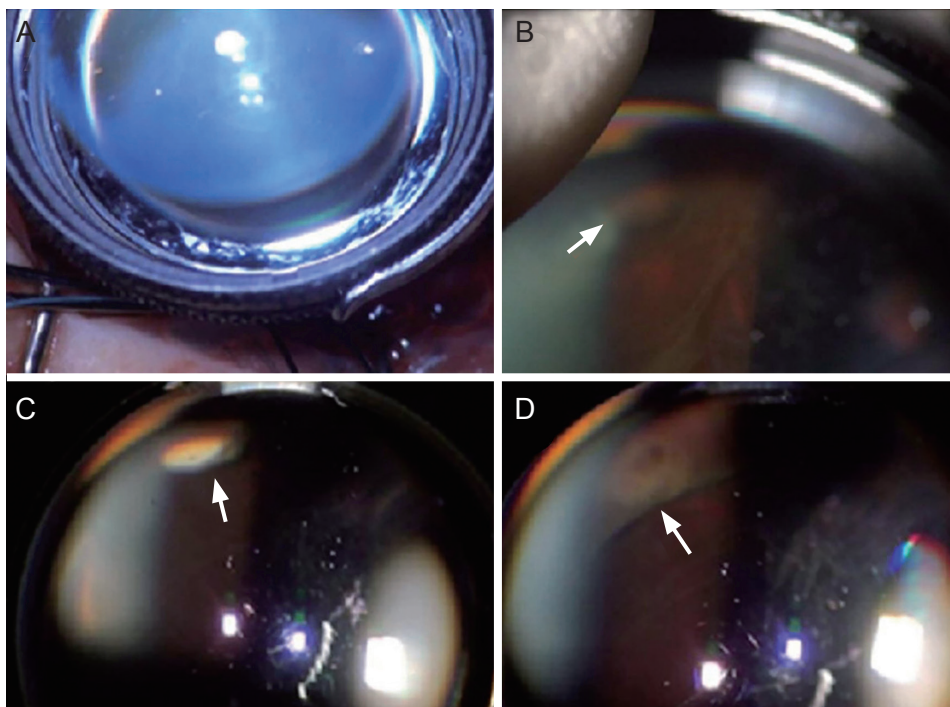
Fig. 1. Surgical photographs of scleral buckling surgery performed using slit-lamp illumination combined with a contact wide-angle viewing system for rhegmatogenous retinal detachment. (A) A general view of retinal detachment before scleral buckling surgery. (B) The retinal tear site with scleral indentation (arrow). (C) Whitening of the retina during cryopexy (arrow). (D) Successful application of a buckling band on tear site (arrow) after tightening of the fixation scleral suture.

of the retina. In the indirect ophthalmoscope illumination group (IO group), an indirect ophthalmoscope was used for fundus visualization with the patient in the standing position. After localization and marking of retinal breaks, a silicone sponge (506-silicone; Labtician, Oakville, ON, Canada) was sutured to the marking area for fixation of the buckling band. External SRFD was performed for all patients except those who had shallow RRD (subretinal depth less than half the length of a 30-gauge needle bevel) and risk of retinal injury during needle puncture. Next, cryopexy was performed for patients with attached retinal tear sites that were placed under indentation by the cryopexy probe. Intravitreal octafluoropropane (C3F8) gas was optionally injected for patients with residual subretinal fluid in the superior, nasal, or temporal quadrant after fixation of the buckling band.

Before completion of the surgery, an elevated buckling band was assessed using the same illumination methods. Fig. 1A-1D shows these procedures performed using a slit-lamp illumination system in greater detail.

All surgeries were performed under general anesthesia; operation time was calculated from the recorded start time to the end time of the surgery and did not include induction or recovery time for general anesthesia. To evaluate anatomical and functional outcomes at 6 months after sur-

gery, postoperative BCVA, treatment failure rate, RRD recurrence rate, and presence of other complications were investigated. These postoperative outcomes were compared between the two groups (SL group and IO group). Statistical analyses were carried out with IBM SPSS ver. 19.0 (IBM Corp., Armonk, NY, USA); a p-value <0.05 was defined as statistically significant.

Results

In total, 45 eyes of 45 patients were included in the study. The female / male ratio was 22 / 23, and the mean patient age was 32.4 ± 15.0 years (range, 15 to 64 years). Twenty-eight patients underwent scleral buckling surgery using slit-lamp illumination combined with a contact wide-angle viewing system (SL group), whereas 17 patients underwent scleral buckling surgery using an indirect ophthalmoscope for fundus visualization (IO group). All included eyes were phakic, except for one eye in the SL group with pseudophakia. All buckling surgery procedures were performed in the segmental buckle manner, and no patient had an encircling band or more than 1 buckle band.

The mean age was 32.5 ± 15.5 years (range, 15 to 64 years) in the SL group and 32.3 ± 14.6 years (range, 17 to

Table 1. Characteristics of the patients with rhegmatogenous retinal detachment grouped by illumination type

Characteristics	Slit-lamp illumination group (n = 28)	Indirect ophthalmoscope group (n = 17)	p-value
Age (yr)	32.5 ± 15.5 (range, 15–64)	32.3 ± 14.6 (range, 17–64)	0.96
Female : male	12 : 16	10 : 7	0.31
Right eye : left eye	20 : 8	10 : 7	0.40
History of trauma	1	3	0.13
History of refractive surgery	5	2	0.60
Axial length (mm)	26.21 ± 1.38 (range, 23.87–28.60)	26.14 ± 1.99 (range, 22.32–29.83)	0.90

64 years) in the IO group; these ages were not significantly different (p = 0.96, Student's t-test). The sex ratios of the two groups were different: the SL group contained a higher proportion of males (12 females, 16 males), whereas the IO group contained a higher proportion of females (10 females, 7 males). However, these proportions were not significantly different (p = 0.31, chi-square test). In the SL and IO groups, right eye dominance was observed (20 / 8, and 10 / 7, respectively) (p = 0.40). The SL group included one eye with a history of trauma and 5 eyes with a history of refractive surgery; the IO group included 3 eyes and 2 eyes with a history of trauma and a history of refractive surgery, respectively (p = 0.13, p = 0.60, respectively). Most patients showed myopia. The mean axial length was 26.21 ± 1.38 mm (range, 23.87 to 28.60 mm) in the SL group and 26.14 ± 1.99 mm (range, 22.32 to 29.83 mm) in the IO group; the mean axial lengths of the two groups were not significantly different (p = 0.90, Student's t-test) (Table 1).

Four eyes (14.3%) and no eyes (0%) in the SL group and the IO group had multiple retinal breaks, respectively (p = 0.11, Fisher's exact test). The rates of large retinal breaks at the 2 o'clock position were similar between the SL (3 eyes, 10.7%) and IO (1 eye, 5.9%) groups (p = 0.13). More eyes had macula-off RRD in the IO group (10 eyes, 58.8%) than in the SL group (9 eyes, 32.1%), but this difference was not statistically significant (p = 0.08, chi-square test).

In the SL group, the mean preoperative BCVA was 0.37 ± 0.47 overall, 0.87 ± 0.49 in the subgroup of macula-off patients, and 0.14 ± 0.23 in the subgroup of macula-on patients. These values were not significantly different from those in the IO group: 0.70 ± 0.63 overall, 1.09 ± 0.53 in the subgroup of macula-off patients, and 0.14 ± 0.13 in the subgroup of macula-on patients (p = 0.06, 0.36, and 0.99, re-

spectively, Student's t-test) (Table 2).

The retinal break sites were also similar between the two groups. In the SL group, retinal breaks occurred in the superior area in 3 eyes (10.7%), the side (nasal and temporal) area in 13 eyes (46.5%), and the inferior area in 12 eyes (42.9%). In the IO group, retinal breaks occurred in the superior area in 4 eyes (23.5%), the side area in 5 eyes (29.4%), and the inferior area in 8 eyes (47.1%). There was no significant difference in the distribution ratios of retinal break sites (p = 0.90, Fisher's exact test). In the SL group, 17 eyes (60.7%) showed a large extent of RRD (more than 2 quadrants of the retina). The result was similar in the IO group, with 11 eyes (64.7%) showing a large extent of RRD (more than 2 quadrants of the retina) (p = 0.20, chi-square test). The mean extent of retinal detachment was not different between the SL (4.04 ± 1.43 hours) and IO (4.41 ± 1.20 hours) groups (p = 0.10). During scleral buckling surgeries, 14 eyes (50.0%) in the SL group and 13 eyes (76.5%) in the IO group underwent external SRFD (p = 0.08) and 27 eyes (96.4%) in the SL group and 16 eyes (94.1%) in the IO group underwent cryopexy (p = 0.72). Additional intravitreal gas injection was performed in 14 eyes (50.0%) in the SL group and 13 eyes (76.5%) in the IO group (p = 0.08) (Table 2). No scleral perforation, subretinal or vitreous hemorrhage, or other scleral buckling intraoperative complications occurred in either group.

In the SL and IO groups, the primary anatomical success rates (completely attached retina) were 89.3% (25 out of 28 eyes) and 88.2% (15 out of 17 eyes), respectively (p = 0.92) (Table 3). Among the patients who experienced treatment failure, 2 in the SL group and 2 in the IO group showed retinal breaks in the inferior area; another patient in the SL group showed a retinal break in the nasal area. All patients who experienced treatment failure underwent pars plana

Table 2. Preoperative and intraoperative findings and intraoperative procedures for patients with rhegmatogenous retinal detachment according to illumination method

Characteristics	Slit-lamp group (n = 28)	Indirect ophthalmoscope group (n = 17)	*p*-value
Multiple retinal breaks (eyes)	4 (14.3)	0 (0)	0.11
Large retinal breaks (eyes)	3 (10.7)	1 (5.9)	0.13
Macula involvement (eyes)	9 (32.1)	10 (58.8)	0.08
Preoperative BCVA (logMAR)	0.37 ± 0.47	0.70 ± 0.63	0.06
Macula-off patients	0.87 ± 0.49	1.09 ± 0.53	0.36
Macula-on patients	0.14 ± 0.23	0.14 ± 0.13	0.99
Retinal break site (eyes)			0.90
Superior	3 (10.7)	4 (23.5)	
Side (nasal or temporal)	13 (46.5)	5 (29.4)	
Inferior	12 (42.9)	8 (47.1)	
Extent of detachment (eyes)			0.20
<2 quadrants	11 (39.3)	6 (35.3)	
≥2 quadrants	17 (60.7)	11 (64.7)	
Mean extent (clock hours)	4.04 ± 1.43	4.41 ± 1.20	0.10
Additional procedure (eyes)			
Subretinal fluid drainage	14 (50.0)	13 (76.5)	0.08
Cryopexy	27 (96.4)	16 (94.1)	0.72
Intravitreal gas injection	14 (50.0)	13 (76.5)	0.08

Values are presented as number (%) or mean ± standard deviation.
BCVA = best-corrected visual acuity; logMAR = logarithm of the minimal angle of resolution.

Table 3. Treatment success rate, postoperative visual acuity, and mean operation time in patients with rhegmatogenous retinal detachment according to illumination method

Characteristics	Slit-lamp group (n = 28)	Indirect ophthalmoscope group (n = 17)	*p*-value
Treatment success (eyes, %)	25 (89.3)	15 (88.2)	0.92
Postoperative BCVA (logMAR)	0.18 ± 0.26	0.49 ± 0.42	0.004
Macula-off patients	0.35 ± 0.38	0.69 ± 0.46	0.11
Macula-on patients	0.10 ± 0.14	0.21 ± 0.09	0.07
Improvement in BCVA after surgery	-0.19 ± 0.38	-0.21 ± 0.63	0.91
Macula-off patients	-0.51 ± 0.53	-0.40 ± 0.76	0.72
Macula-on patients	-0.04 ± 0.13	+0.07 ± 0.14	0.07
Operation time (min)	78.9 ± 11.8 (range, 55–100)	100.0 ± 13.9 (range, 70–125)	<0.001
Patients who underwent SRFD and cryopexy with/without gas injection	81.4 ± 12.9 (n = 13)	103.5 ± 12.3 (n = 13)	<0.001
Patients who underwent only cryopexy	76.2 ± 10.8 (n = 13)	85.0 ± 15.0 (n = 3)	0.25

BCVA = best-corrected visual acuity; logMAR = logarithm of the minimal angle of resolution; SRFD = subretinal fluid drainage.

vitrectomy, with the exception of 1 patient in the SL group, who underwent additional pneumatic retinopexy. No patient with treatment failure had findings of proliferative vitreoretonopathy.

The mean postoperative BCVA was 0.18 ± 0.26 in the SL group and 0.49 ± 0.42 in the IO group; these values were

significantly different ($p = 0.004$, Student's t-test). However, the mean improvement in BCVA was -0.19 ± 0.38 in the SL group and -0.21 ± 0.63 in the IO group; these values were not significantly different ($p = 0.91$). Subgroup analysis of the macula-off patients showed no significant difference in mean postoperative BCVA (0.35 ± 0.38 in the SL group and 0.69 ± 0.46 in the IO group, $p = 0.11$) or mean improvement in BCVA (-0.51 ± 0.53 in the SL group and -0.40 ± 0.76 in the IO group, $p = 0.72$) between the two groups. A similar subgroup analysis of the macula-on patients revealed no difference between the two groups with respect to mean postoperative BCVA (0.10 ± 0.14 in the SL group and 0.21 ± 0.09 in the IO group, $p = 0.07$) or mean improvement in BCVA (-0.04 ± 0.13 in the SL group and $+0.07 \pm 0.14$ in the IO group, $p = 0.07$) (Table 3).

The mean operation time was 78.9 ± 11.8 minutes (range, 55 to 100 minutes) in the SL group and 100.0 ± 13.9 minutes (range, 70 to 125 minutes) in the IO group; these times were significantly different ($p < 0.001$). Subgroup analysis of the patients who underwent additional procedures such as SRFD and cryopexy (with or without intravitreal gas injection) revealed a significant difference between the 13 patients in the SL group (mean operation time, 81.4 ± 12.9 minutes) and the 13 patients in the IO group (mean operation time, 103.5 ± 12.3 minutes) ($p < 0.001$). Subgroup analysis of the patients who underwent only cryopexy as an additional procedure without SRFD or intravitreal gas injection revealed that the mean operation times were similar between the 13 patients in the SL group (mean operation time, 76.2 ± 10.8 minutes) and the 3 patients in the IO group (mean operation time, 85.0 ± 15.0 minutes) ($p = 0.25$, Mann-Whitney U-test) (Table 3). One patient in each group underwent only intravitreal gas injection as an additional procedure, with operation times of 80 minutes (SL group) and 100 minutes (IO group), respectively. A single patient with a pseudophakic eye underwent SRFD and cryopexy, with intravitreal gas injection as an additional procedure. The operation time for this patient was 80 minutes.

Discussion

Scleral buckling surgery is as effective as pars plana vitrectomy [2,3]. Selection of surgical methods depends on various factors; presence of an inferior retinal break, a peripheral break, and/or young age are all factors that could influence a surgeon to choose scleral buckling surgery [2,14,15]. However, inversion of the retinal image [5], operator position shifting, and uncomfortable bent-neck position while using an indirect ophthalmoscope are all potential factors in a surgeon's decision to avoid scleral buckling surgery. These factors are inconvenient and can increase the operation time during scleral indentation and cryopexy.

To overcome these drawbacks, several alternative methods have been introduced. Endoillumination (chandelier) with a wide angle-viewing system [5,7-9] is a well-characterized alternative method. This method can overcome the problems of retinal image inversion, operator position shifting, and the uncomfortable bent-neck position. The effectiveness of endoilllumination has been established by comparison with the conventional method using an indirect ophthalmoscope, indicating that endoillumination could have various applications for complicated or combined surgeries with vitrectomy [16-21]. Furthermore, this method has been shown to be a better method for training during residency fellowships [6]. However, endoillumination is also associated with potential risks, such as xenon light toxicity, damage to the lens caused by contact with an inserted optical fiber during surgical manipulation in phakic eyes, and infectious endophthalmitis at the full-thickness sclerotomy site [5]. The other alternatives developed also have certain limitations, such as high indentation and limited indications for the tear site on surgical microscope illumination [10], in addition to a narrow viewing angle of the optic fiber-free intravitreal surgical system [22].

Slit-lamp illumination systems have been applied in several trials for surgery for retinal detachment [11,23]. With a wide-angle viewing lens (which is known to confer good peripheral retinal visualization, especially in eyes with small pupils, media opacities, and even pseudophakia [5,23]), this illumination method has been reported to be as effective as the conventional method using an indirect ophthalmoscope [11]. The slit-lamp illumination system is another alternative method that is free from complications caused by full-thickness sclerotomy or lens injury caused by an instrument.

Here, we showed that the slit-lamp illumination system is as effective as the conventional method using an indirect ophthalmoscope in terms of anatomical success. In terms of functional success, the slit-lamp illumination group showed better postoperative visual acuity. While it is possible that the shorter surgical time and easier surgical pro-

cedures might have led to the improved surgical outcomes, we favor the explanation that a smaller proportion of macula-off patients was present in this group. Functional improvement according to macular involvement state was similar between the slit-lamp and indirect ophthalmoscope illumination groups.

The operation time was significantly shorter in the slit-lamp illumination group. This difference was even more prominent in patients who underwent SRFD. Some explanations for the difference in mean operation time are that less time is required compared to that with an indirect ophthalmoscope, the search for retinal break sites with indentation can be performed faster, and that cryopexy and/or confirming fine buckle band elevation can be performed faster. For instance, the procedure includes the time it takes to stand up from the operator's chair, to wear and adjust the indirect ophthalmoscope, to change the surgeon's location to the opposite site of the retinal break, and to sit down at the chair and reset the microscope. For patients with bullous RRD who require SRFD, a wide field of view can be especially important for understanding the anatomical orientation, making a decision about the position and extent of the buckle band, and properly selecting the SRFD site.

In addition to saving time, surgeons can eliminate the stress caused by having to bend their necks while using an indirect ophthalmoscope, which is very advantageous for surgeons with a neck problem or a heavy operation schedule. Moreover, in our experience, the slit-lamp illumination system requires a shorter learning period for an inexperienced surgeon than does the indirect ophthalmoscope.

With their wide-angle viewing lens advantage, scleral buckling surgeries with the slit-lamp illumination system could lead to reduced operation times and/or improved surgical outcomes. However, this study did not include patients with small pupils or corneal opacities and only one pseudophakic eye was included, meaning that we could not establish the superiority of the slit-lamp illumination system in certain patients with complications.

There are some disadvantages of the slit-lamp illumination system. Since the slit-lamp instrument is installed on the surgical microscope, the surgeon cannot use a non-contact wide-angle viewing system. For the same reason, this system requires that a hand-held contact lens be held by a well-trained assistant to obtain a clear view of the operating site during eyeball tilt, while using a bulky cryopexy probe, or during indentation of the posterior pole. Another disadvantage of this instrument is potential contamination of the surgical gloves of an inexperienced assistant caused by the bulky body of the slit-lamp with a light source and a moving rail while the traction sutures are held or while a Desmarres retractor is used.

In summary, the anatomical success and functional improvement achieved by scleral buckling surgeries using slit-lamp illumination combined with a contact wide-angle viewing system were not significantly different from those obtained by conventional scleral buckling surgery with an indirect ophthalmoscope. However, slit-lamp illumination showed many advantages, such as requiring less time (especially in bullous RRD, which needs additional subretinal fluid drainage), decreased surgeon stress, shared surgical view with the assistant, and improved safety compared to endoillumination. Thus, the slit-lamp illumination system is an effective and safe surgical technique for alternative retinal illumination during scleral buckling surgery. Further studies are needed to assess the advantages of this technique in additional patient groups (e.g., patients with small pupils, corneal opacities, pseudophakia, and complicated surgery with vitrectomy).

Conflict of Interest

No potential conflict of interest relevant to this article was reported.

Acknowledgement

References

1. Escoffery RF, Olk RJ, Grand MG, Boniuk I. Vitrectomy without scleral buckling for primary rhegmatogenous retinal detachment. *Am J Ophthalmol* 1985;99:275-81.
2. Ho CL, Chen KJ, See LC. Selection of scleral buckling for primary retinal detachment. *Ophthalmologica* 2002;216:33-9.
3. Schwartz SG, Flynn HW. Primary retinal detachment:

scleral buckle or pars plana vitrectomy? *Curr Opin Ophthalmol* 2006;17:245-50.

4. Schepens CL, Okamura ID, Brockhurst RJ. The scleral buckling procedures. I. Surgical techniques and management. *AMA Arch Ophthalmol* 1957;58:797-811.

5. Aras C, Ucar D, Koytak A, Yetik H. Scleral buckling with a non-contact wide-angle viewing system. *Ophthalmologica* 2012;227:107-10.

6. Narayanan R, Tyagi M, Hussein A, et al. Scleral buckling with wide-angled endoillumination as a surgical educational tool. *Retina* 2016;36:830-3.

7. Gogia V, Venkatesh P, Gupta S, et al. Endoilluminator-assisted scleral buckling: our results. *Indian J Ophthalmol* 2014;62:893-4.

8. Hu Y, Si S, Xu K, et al. Outcomes of scleral buckling using chandelier endoillumination. *Acta Ophthalmol* 2017;95:591-4.

9. Seider MI, Nomides RE, Hahn P, et al. Scleral buckling with chandelier illumination. *J Ophthalmic Vis Res* 2016;11:304-9.

10. Zhang Z, Liang X, Sun D, Peng S. The scleral buckling of primary rhegmatogenous retinal detachment under the surgical microscope. *Ophthalmic Surg Lasers Imaging* 2011;42:96-101.

11. Ohji M, Tano Y. Vitreoretinal surgery with slit-lamp illumination combined with a wide-angle-viewing contact lens. *Am J Ophthalmol* 2004;137:955-6.

12. McPherson SD Jr. A modified Zeiss operating slit-lamp microscope. *Trans Am Ophthalmol Soc* 1968;66:419-20.

13. Bonnet M. Biomicroscopy of the fundus in retinal detachment surgery. *J Fr Ophtalmol* 1979;2:209-16.

14. The repair of rhegmatogenous retinal detachments. American Academy of Ophthalmology. *Ophthalmology* 1996;103:1313-24.

15. Sharma A, Grigoropoulos V, Williamson TH. Management of primary rhegmatogenous retinal detachment with inferior breaks. *Br J Ophthalmol* 2004;88:1372-5.

16. Park SW, Kwon HJ, Kim HY, et al. Comparison of scleral buckling and vitrectomy using wide angle viewing system for rhegmatogenous retinal detachment in patients older than 35 years. *BMC Ophthalmol* 2015;15:121.

17. Setlur VJ, Rayess N, Garg SJ, et al. Combined 23-gauge PPV and scleral buckle versus 23-gauge PPV alone for primary repair of pseudophakic rhegmatogenous retinal detachment. *Ophthalmic Surg Lasers Imaging Retina* 2015;46:702-7.

18. Haug SJ, Jumper JM, Johnson RN, et al. Chandelier-assisted external subretinal fluid drainage in primary scleral buckling for treatment of rhegmatogenous retinal detachment. *Retina* 2016;36:203-5.

19. Li XJ, Yang XP, Lyu XB. Comparison of scleral buckling using wide-angle viewing systems and indirect ophthalmoscope for rhegmatogenous retinal detachment. *Int J Ophthalmol* 2016;9:1310-4.

20. Temkar S, Takkar B, Azad SV, Venkatesh P. Endoillumination (chandelier) assisted scleral buckling for a complex case of retinal detachment. *Indian J Ophthalmol* 2016;64:845-6.

21. Yan H. Scleral buckling with a noncontact wide-angle viewing system in the management of rhegmatogenous retinal detachment. *Eur J Ophthalmol* 2017;27:98-103.

22. Nawrocki J, Michalewska Z, Michalewski J. Optic Fibre Free Intravitreal Surgical System (OFFISS) in retinal detachment surgery. *Ophthalmic Surg Lasers Imaging* 2008;39:466-70.

23. Pagot V, Mathis A, Heldenbergh O, et al. Surgery of retinal detachment of patients with pseudophakia using the panfunduscope. *J Fr Ophtalmol* 1992;15:587-91.