ORIGINAL RESEARCH

A Comparative Study of Traditional Scleral Buckling to a New Technique: Guarded Light Pipe with Heads-Up Three-Dimensional Visualization

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Purpose: The guarded light pipe is a recently described alternative endoillumination technique to chandelier illumination. We sought to compare the outcomes of scleral buckling (SB) under indirect ophthalmoscopy (ID) to heads-up three-dimensional visualization with a guarded light pipe (3DGLP).

Methods: A retrospective comparative study was performed, including 47 eyes that underwent SB for rhegmatogenous retinal detachment (RRD) repair with either traditional ID (n = 31) or 3DGLP (n = 16).

Results: The single surgery anatomic success rate was 87.0% in the ID group and 87.5% in the 3DGLP group. The final anatomic success rate was 100% in both groups. The median (interquartile range) post-operative logMAR was 0.10 (0.0–0.20) in the ID group and 0.08 (0.02–0.69) in the 3DGLP group (p = 0.51). The median operative time was 107 (94–123) minutes in the ID group and 100 (90–111) minutes in the 3DGLP group (p = 0.25). Among eyes that underwent subretinal fluid drainage, the operative time was significantly longer in the ID group compared to the 3DGLP group, 113 (100–135) minutes vs 93 (85–111) minutes (p = 0.035). There were no post-operative complications in the ID group and one complication of self-resolving vitreous hemorrhage associated with a malfunctioning cryoprobe in the 3DGLP group (p = 0.34). There were no cases of post-operative cataract progression in either group.

Conclusion: Compared to traditional SB, 3DGLP improves ergonomics and educational value with similar anatomical, visual, intra and post-operative outcomes and may result in shorter operative time in cases requiring subretinal fluid drainage.

Keywords: endoillumination, heads up visualization, NGENUITY, scleral buckle, light pipe, retinal detachment

Introduction

Rhegmatogenous retinal detachment (RRD) is a sight-threatening condition with an incidence of 1 in 10,000 persons per year.[1] This number is likely to increase with the continued global rise in the incidence of myopia.[2,3] Scleral buckling (SB) is a well-known technique for the treatment of RRD and is preferred in certain patient populations, such as young, phakic patients.[4–6] Studies evaluating long-term outcomes of SB demonstrate excellent visual and anatomic results.[7–9] However, the development of pars plana vitrectomy (PPV), especially smaller gauge, has caused a shift towards PPV over SB.[10–12] Medicare claims data from 2000 to 2011 revealed that while the annual number of PPVs more than doubled, SB declined by two-thirds.[13] In England between 2000 and 2018, PPV increased four-fold while SB decreased by two-thirds.[14]

Multiple studies have evaluated SB and PPV for RRD repair and have demonstrated comparable results.[9,15–27] The trend towards PPV has many factors, but most commonly includes quicker and easier visualization with microscope-integrated wide-field viewing, excellent illumination tools, and reduced SB volume in fellowship programs.[28,29] Traditional SB relies on indirect ophthalmoscopy which can result in a smaller field of view with less experienced surgeons. With lower SB in surgical training programs, it also generally has a steeper learning curve with a larger number

of surgical modifications required to achieve optimal outcomes.[30] Lastly, traditional SB poses an additional challenge for trainees as only the person operating the indirect can visualize the retina unlike vitrectomy where multiple observers can perform and witness a single surgical maneuver.

Recent advances have sought to address the drawbacks of traditional SB techniques compared to PPV. Endoillumination systems, such as chandelier illumination, provide wide-angle illumination that allows both the surgeon and assistant to view the intra-operative steps and eliminates the inconvenience and time required to repeatedly adorn the indirect ophthalmoscope.[29] An additional tool that has improved surgical visualization is heads-up three-dimensional (3D) visualization systems, such as the NGEUNITY system.[31] In 2020, another iterative approach to SB was described that utilizes the NGENUITY system with an alternative endoillumination system, a guarded light pipe.[31] The safety and efficacy of this technique has not been formally evaluated in a larger case series. Here, we present a retrospective comparative case series of patients that underwent RRD repair with SB using either traditional indirect ophthalmoscopy or NGENUITY 3D visualization with guarded light pipe endoillumination.

Patients/Materials and Methods
Study Design
A single-center, retrospective study was performed on a consecutive series of 47 eyes with RRD repaired by primary SB by a single surgeon (JBM), with the assistance of clinical fellows and residents, from July 2016 to September 2021 at Massachusetts Eye and Ear (MEE). Inclusion criteria was defined as patients that underwent primary SB with indirect ophthalmoscopy or the NGENUITY system (NGENUITY, Alcon Inc., Fort Worth, Texas, US) and guarded light pipe. The decision of whether to perform traditional SB or under NGENUITY visualization with the guarded light pipe was not based on case complexity, but rather the availability of the NGENUITY platform. The medical charts of the two groups were retrospectively reviewed. Data collection included patients' demographics, comprehensive eye examination, pre-operative characteristics, intra-operative variables, and post-operative outcomes. The study was conducted in accordance with the tenets set forth in the Declaration of Helsinki and Health Insurance Portability and Accountability Act Regulation. All necessary authorizations were obtained from the MEE Institutional Review Board. Patients' informed consent was not required by the institutional review board (Protocol #2019P000119) as this is a retrospective study and patient data were kept confidential by using only deidentified data.

Pre-Operative and Post-Operative Evaluations
Each patient had a complete pre-operative evaluation, including medical history, symptoms, duration of RRD, measurement of best-corrected visual acuity (BCVA), slit-lamp biomicroscopy, measurement of intraocular pressure, and fundoscopy. Extent of RRD, number and location of retinal breaks, and macular involvement were evaluated by fundus examination. Operative time for each procedure was recorded by operating room staff and did not include anesthesia induction or emergence. Patients were examined post-operatively at 1 day, 1 week, 1 month, 3 months, 6 months, and 1 year. In addition, data from the most recent ophthalmic examination was collected. Lens status was evaluated to assess for post-operative cataract progression, defined as a two-step progression of nuclear sclerosis (ie, 1+ NS to 3+ NS) or development of a visually significant cortical or posterior subcapsular cataract within 6 months of the surgery.[28,29]

Surgical Technique: Traditional Scleral Buckle
With the patient under general or MAC anesthesia, a conjunctival peritomy was performed and the four rectus muscles were isolated using 4–0 silk sutures. All retinal breaks were localized using indirect ophthalmoscopy and cryopexy was performed. The anterior and posterior edges of each break were externally marked. A segmental or circumferential encircling buckle was sutured to the sclera and upon physician discretion subretinal fluid (SRF) drainage was performed. The buckle was secured in the desired position at the equator and the height was modified. An anterior chamber paracentesis was performed as needed to decrease the intraocular pressure. Intravitreal gas or air injection was used at the discretion of the physician and the conjunctiva was reapproximated. Subconjunctival injections of steroid and antibiotic were administered.

Surgical Technique: Guarded Light Pipe Endoillumination with Heads-Up 3D Visualization System

The procedure was performed similar to the traditional approach except that the retina was visualized with the NGENUITY system and a guarded light pipe as a replacement for the standard indirect ophthalmoscope. The technique was identical to that previously published.[32] The NGENUITY system was secured at the foot of the patient's bed. Surgeons and trainees wore polarized glasses for intra-operative viewing. The standard Alcon light pipe was modified to create the guarded light pipe by sliding on a Watzke-Allen silicon sleeve cut to allow only 5 mm of light pipe tip exposure (Figure 1A). After conjunctival peritomy, a single 25 or 27-gauge trocar cannula was inserted 3.5 to 4 mm posterior to the limbus in the pars plana and the guarded light pipe was inserted into the cannula (Figure 1B). The non-contact wide-angle RESIGHT Viewing System (Zeiss, Oberkochen, Germany) was brought into focus. A 360-degree scleral depressed examination was performed using the NGENUITY system and guarded light pipe to identify all breaks and the extent of detachment (Figure 1C). All breaks were treated with focal cryotherapy under direct visualization with the guarded light pipe (Figure 1D). The scleral band or buckle was secured in all intended quadrants without the NGENUITY system (in the traditional manner). SRF drainage was performed at the discretion of the physician. Direct visualization with the guarded light pipe was used to observe SRF drainage with a subretinal needle or to assess the amount of SRF if an external approach without the microscope was performed. The guarded light pipe was held in one hand and the other hand held the needle for SRF drainage. The assistant pulled the plunger until a satisfactory amount of SRF was removed. The buckle was then secured in the desired position and the height was confirmed and modified by direct visualization with the NGENUITY system. As needed, an anterior chamber paracentesis was performed. Intravitreal gas or air injection was used at the discretion of the physician. The cannula was then removed, the sclerotomy was sutured, and the conjunctiva was reapproximated. Subconjunctival injections of steroid and antibiotic were administered.

Outcome Measures

The primary outcome of the study was single surgery anatomic success and secondary outcomes included final anatomic success, visual acuity, operative time, and intra and post-operative complications.
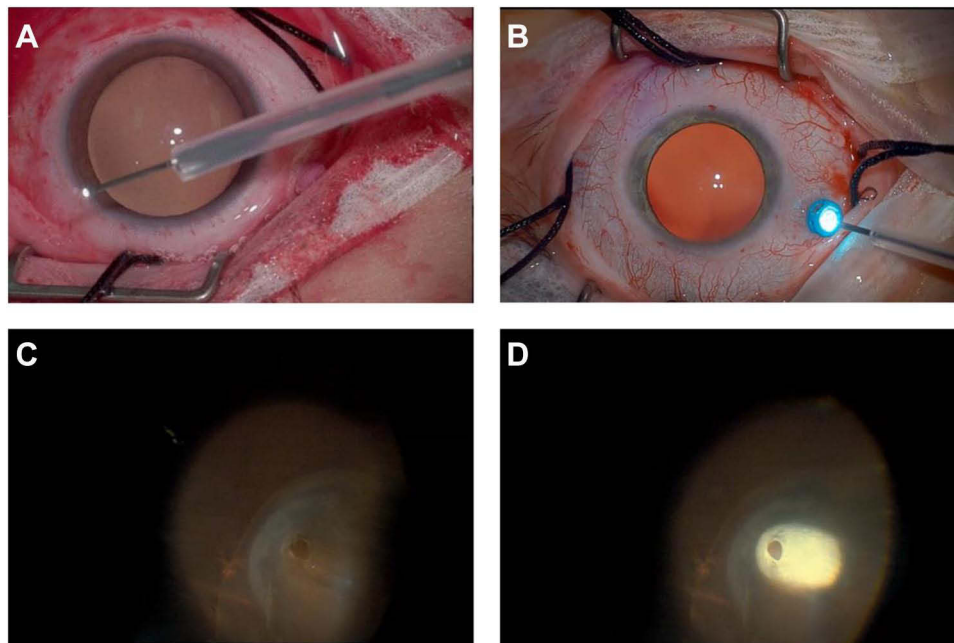

Figure 1 Photographs of primary scleral buckling while using heads-up three dimensional visualization and directly illuminating the retina with the guarded light pipe. (**A**) The guarded light pipe above the surgical field, the Watzke-Allen silicon sleeve is visible with 5 mm of light pipe tip exposure; (**B**) inserting the guarded light pipe into the cannula; (**C**) direct visualization of a retinal tear with the guarded light pipe; (**D**) cryotherapy to the same retinal tear under guarded light pipe illumination.

Statistical Analysis

Data was collected for analysis by chart review and analyzed using GraphPad Prism version 8.0.0. Snellen visual acuity was converted to the logarithm of the minimum angle of resolution unit (logMAR). Continuous variables were compared using the Mann–Whitney U non-parametric test. Binary and nominal variables were compared using the Fisher's exact test. All tests were two-tailed and statistical significance was considered when p value was less than or equal to 0.05.

Results

Demographics

A total of 51 primary SB procedures were performed between July 2016 and September 2021. The ID surgeries were performed between July 2016 and April 2021 and the 3DGLP surgeries were performed between May 2018 and August 2021. Four patients who were lost to follow-up were excluded. A total of 47 eyes of 44 patients were included in this study with 31 eyes in the Indirect Ophthalmoscopy (ID) group and 16 eyes in the heads-up 3D visualization with guarded light pipe (3DGLP) group. The demographics for each group were not significantly different (Table 1). The median follow-up duration was 28.1 months in the ID group and 11.6 months in the 3DGLP group (p = 0.10, Table 1).

Pre-Operative Characteristics

The pre-operative characteristics were not significantly different between the two groups (Table 1). Pre-operative BCVA was not significantly different between two groups (Table 1). All patients in both groups were phakic (Table 1).

Table 1 Demographics and pre-operative characteristics of patients who underwent primary scleral buckling for rhegmatogenous retinal detachment repair performed using either traditional methods with indirect opthalmoscopy or under heads-up 3D visualization with guarded light pipe for endoillumination

Characteristic[a,b]	Indirect Ophthalmoscopy	NGENUITY and Guarded Light Pipe	P-value[c]
Patients	29	15	
Eyes	31	16	
Age, median (IQR)	35 (24–40)	35 (28–49)	0.50
Gender Female, n (%)	15 (51.7%)	6 (40.0%)	0.54
Follow up time in months, median (IQR)	28.1 (6.4–46.4)	11.6 (5.0–23.2)	0.10
Macula on RRD, n (%)	23 (74.2%)	13 (81.3%)	0.73
Eye Right, n (%)	17 (54.8%)	7 (43.8%)	0.55
Symptom Onset, n (%)			
3 days or less	12 (38.7%)	3 (18.8%)	0.20
4 days - 2 weeks	4 (12.9%)	1 (6.3%)	0.65
2 weeks or greater	15 (48.4%)	12 (75%)	0.12
Pre-operative visual acuity			
BCVA LogMAR, median (IQR)	0.04 (0–0.44)	0.03 (0–0.18)	0.57
BCVA ≤ 20/40, n (%)	22 (71%)	13 (81.3%)	0.51
BCVA > 20/40 and < 20/200, n (%)	6 (19.4%)	1 (6.3%)	0.40
BCVA ≥ 20/200, n (%)	3 (9.7%)	2 (12.5%)	1.00
Myopia, n (%)	15 (48.4%)	10 (62.5%)	0.54
Pseudophakic, n (%)	0 (0%)	0 (0%)	1.00
PVD, n (%)	4 (12.9%)	1 (6.3%)	0.65
PVR, n (%)	3 (9.7%)	2 (12.5%)	1.00
History of Trauma, n (%)	5 (16.1%)	0 (0%)	0.15
History of RD in non-study eye, n (%)	4 (12.9%)	2 (12.5%)	1.00

Notes: [a]Mann–Whitney U non-parametric used to compare continuous variables. [b]Fisher's exact test used for binary and nominal variables. [c]Statistical significance was defined as p ≤ 0.05.
Abbreviations: BCVA, best-corrected visual acuity; PVD, posterior vitreous detachment; PVR, proliferative vitreoretinopathy; RRD, rhegmatogenous retinal detachment; IQR, interquartile range; RD, retinal detachment.

Table 2 Retinal detachment location and characteristic of retinal breaks among eyes that had primary scleral buckling for rhegmatogenous retinal detachment repair performed using either traditional methods with indirect opthalmoscopy or under heads-up 3D visualization with guarded light pipe for endoillumination

Characteristic[a,b]	Indirect Ophthalmoscopy (n = 31)	NGENUITY and Guarded Light Pipe (n = 16)	P-value[c]
Location of RD, n (%)			
Superior	11 (35.5%)	9 (56.3%)	0.22
Inferior	25 (80.6%)	11 (68.8%)	0.47
Temporal	27 (87.1%)	14 (87.5%)	1.00
Nasal	9 (29%)	3 (18.8%)	0.51
RD quadrants, mean±SD	2.32±0.70	2.31±0.87	0.93
Number of Retinal Breaks, n (%)			
No Retinal Break	0 (0%)	0 (0%)	1.00
One Retinal Break	9 (29%)	2 (12.5%)	0.29
Multiple Retinal Breaks	22 (71%)	14 (87.5%)	0.29
Location of Retinal Breaks, n (%)			
Superior	8 (25.8%)	10 (62.5%)	**0.026**
Nasal	4 (12.9%)	4 (25%)	0.42
Inferior	22 (71%)	7 (43.8%)	0.11
Temporal	19 (61.3%)	13 (81.3%)	0.20

Notes: [a]Mann–Whitney U non-parametric used to compare continuous variables. [b]Fisher's exact test used for binary and nominal variables. [c]Statistical significance was defined as p ≤ 0.05. *P* values highlighted in bold are statistically significant.
Abbreviations: RD, retinal detachment; SD, standard deviation; Bold font, statistically significant values.

Retinal Detachment Location

Neither the location of retinal detachment nor the number of quadrants involved was significantly different (Table 2). In terms of retinal break location, the 3DGLP group had a significantly higher number of superior retinal breaks compared to the ID group (62.5% vs 25.8%, p = 0.026, Table 2). Otherwise, there was no significant difference in the number of nasal, inferior, or temporal breaks (Table 2).

Operative Characteristics and Outcomes

The majority of patients underwent general anesthesia (Table 3). Buckle type was similar between both groups with the majority having a 42/70 buckle (Table 3). In all surgeries, a clinical fellow was present. Among the 31 ID cases, there were 12 different clinical fellows, and among the 16 3DGLP surgeries, there were 9 different clinical fellows. The fellows either assisted in or performed parts of the surgery depending on their experience and the complexity of the case. Among the 3DGLP cases included, some clinical fellows had prior experience with the 3DGLP technique, including 3 fellows that participated in two 3DGLP cases and 2 fellows that participated in three 3DGLP cases. SRF drainage was performed in 24 eyes (77.4%) in the ID group and 11 eyes (68.7%) in the 3DGLP group (Table 3). There were no intra-operative complications in either group. The operative times were not significantly different between the two groups (p = 0.25, Table 3). Among eyes with SRF drainage, the operative times in the 3DGLP were significantly shorter (p = 0.035, Table 3).

Post-Operative Outcomes (Table 4)

The single surgery anatomic success rate was 87.0% in the ID group and 87.5% in the 3DGLP group (p = 1.00, Table 4). Four eyes in the ID group and two eyes in the 3DGLP group required reoperation with a single PPV surgery. The final attachment rate was 100% in both groups (Table 4). The post-operative visual outcomes were similar, with no significant difference (Table 4). The majority of eyes had vision better than or equal to 20/40; 24 eyes (77.4%) in the ID group and 11 eyes (68.8%) in the 3DGLP group (Table 4). Among the entire cohort, only 1 eye had a post-operative complication (Table 4). One patient in the 3DGLP group experienced post-operative vitreous hemorrhage that resolved with

Table 3 Intra-operative characteristics of eyes that had primary scleral buckling for rhegmatogenous retinal detachment repair performed using either traditional methods with indirect opthalmoscopy or under heads-up 3D visualization with guarded light pipe for endoillumination

Characteristic[a,b]	Indirect Ophthalmoscopy (n = 31)	NGENUITY and Guarded Light Pipe (n = 16)	P-value[c]
Anesthesia Type, n (%)			
General	30 (96.8%)	15 (93.8%)	1.00
Monitored Anesthesia Care (MAC)	1 (3.2%)	1 (6.3%)	1.00
Clinical Fellow present, n (%)	31 (100%)	16 (100%)	1.00
Type of Scleral Buckle, n (%)			
42/70	26 (83.9%)	11 (68.8%)	0.27
220/240/270	2 (6.5%)	3 (18.8%)	0.32
276/240/270	2 (6.5%)	1 (6.3%)	1.00
220 segment	1 (3.2%)	0 (0%)	1.00
240/277/270	0 (0%)	1 (6.3%)	0.34
Additional Procedure, n (%)			
SRF Drainage	24 (77.4%)	11 (68.8%)	0.73
Subretinal hemorrhage after SRF drainage	2 (6.5%)	0 (0%)	0.54
Anterior Chamber Tap	16 (51.6%)	13 (81.3%)	0.06
Intravitreal Air Injection	2 (6.5%)	0 (0%)	0.54
Intravitreal Gas Injection	0 (0%)	1 (6.3%)	0.34
Intra-operative complications	0 (0%)	0 (0%)	1.00
Operative time (minutes), median (IQR)	107 (94–123)	100 (90–111)	0.25
Operative time with SRF drainage (minutes), median (IQR)	113 (100–135) (n = 24)	93 (85–111) (n = 11)	**0.035**

Notes: [a]Mann–Whitney U non-parametric used to compare continuous variables. [b]Fisher's exact test used for binary and nominal variables. [c]Statistical significance was defined as p ≤ 0.05. Bold font = statistically significant values.
Abbreviations: SRF, subretinal fluid; IQR, interquartile range.

Table 4 Post-operative outcomes of eyes that underwent primary scleral buckling for rhegmatogenous retinal detachment repair using either traditional methods with indirect opthalmoscopy or under heads-up 3D visualization with guarded light pipe for endoillumination

Characteristic[a,b]	Indirect Ophthalmoscopy (n = 31)	NGENUITY and Guarded Light Pipe (n = 16)	P-value[c]
Reattachment			
Single Surgery Anatomic Success Rate, n %	27 (87.1%)	14 (87.5%)	1.00
Reoperation, n %	4 (12.9%)	2 (12.5%)	1.00
Final Attachment, n %	31 (100%)	16 (100%)	1.00
Post-operative BCVA			
BCVA LogMAR, median (IQR)	0.10 (0.0–0.2)	0.08 (0.02–0.69)	0.51
BCVA ≤ 20/40, n	24 (77.4%)	11 (68.8%)	0.73
BCVA > 20/40 and < 20/200, n	5 (16.1%)	2 (12.5%)	1.00
BCVA ≥ 20/200, n	2 (6.5%)	3 (18.8%)	0.32
Post-operative complications, n %	0 (0%)	1 (6.3%)	0.34
Cataract progression,[d] n %	0 (0%)	0 (0%)	1.00

Notes: [a]Mann–Whitney U non-parametric used to compare continuous variables. [b]Fisher's exact test used for binary and nominal variables. [c]Statistical significance defined as p < 0.05. [d]Among eyes that did not require reoperation with pars plana vitrectomy.
Abbreviations: BCVA, best-corrected visual acuity; IQR, interquartile range.

observation. The etiology of the vitreous hemorrhage was due to a poorly functioning cryotherapy probe causing hemorrhage likely from the ciliary body; this was thought to be unrelated to NGENUITY visualization or the guarded light pipe. Among the eyes that did not require reoperation with PPV, there were no cases of cataract progression, and no cases required cataract surgery (Table 4).

Discussion

This study retrospectively compared traditional SB technique to a novel technique that utilizes heads-up 3D visualization with a guarded light pipe for the treatment of RRD.[32] This novel technique has only been reported once before, of which outcomes were not formally evaluated.[32] Here, we demonstrate comparable (p = 1.00) single surgery anatomic success rates between traditional SB (87.0%) and 3DGLP (87.5%) for the primary treatment of RRD. The visual outcomes, post-operative complications, reoperation rates, and final reattachment rates were not significantly different between the groups. There were no intra-operative complications in either group.

The primary reattachment rates reported here are comparable to success rates in case series of SB performed with traditional indirect ophthalmoscopy, as well as success rates reported using chandelier illumination, which have ranged from 83.3 to 100%.[28,29,33–43] The median operative time in both cohorts was similar to that reported by previous studies of primary SB with chandelier illumination.[28,39,44] Although there was no significant difference in operative times between the ID and 3DGLP groups, among eyes that required SRF drainage, there were significantly shorter procedure times in the 3DGLP. This result may reflect easier and faster visualization in the 3DGLP group as well as decreased time from not having to intermittently wear the indirect.

SB with 3DGLP compared to traditional SB using the indirect ophthalmoscope has several advantages. Compared to the traditional optical microscope and indirect ophthalmoscope, heads-up 3D visualization systems have improved depth of field, trainee and staff viewing, ergonomics, and video recording quality.[45–47] A 2021 study found that compared to the standard microscope, heads-up 3D visualization systems for anterior and posterior segment surgeries had comparable procedural complication rates and all retinal surgeons expressed the highest satisfaction score for the visualization system.[48]

In SB surgery, utilization of the endoillumination system avoids the cumbersome need to don an indirect ophthalmoscope multiple times throughout the surgery. It also allows both trainees and supervising physicians to view critical steps simultaneously, such as cryotherapy, drainage of SRF, and setting a good SB contour. Chandelier illumination has been shown to be safe, effective, decrease case duration, add educational value, and may improve primary reattachment rate and visual acuity in SB surgery.[28,29,33,35,39,43,49] The guarded light pipe used in this study may have certain advantages over chandelier illumination systems in SB surgery. The light pipe is a convenient and familiar tool to vitreoretinal surgeons with an ergonomic handle and has a lower cost than chandelier systems.[32] As indicated above, the guarded light pipe is created by sliding a trimmed Watzke-Allen sleeve onto the shaft of a light pipe. The guard limits insertion of the light pipe into the vitreous past the internal os of the trocar cannula and minimizes vitreous dragging, iatrogenic breaks, and retinal phototoxicity.[32] Compared to the chandelier illumination systems, the guarded light pipe improves the ability to directly illuminate the peripheral retina over 360 degrees and has better ergonomics and security of the surgeon's hand position.[32] This study helps to solidify the safety and efficacy of 3DGLP use in SB surgery, and given the aforementioned benefits, seems to be a reasonable alternative to both traditional SB with the indirect ophthalmoscope and SB using chandelier endoillumination systems.

Strengths of this study include its comparative nature and surgical consistency, as all surgeries were performed at a single center by a single surgeon with the assistance of multiple clinical fellows. The sample size, although small, is similar to that reported by the largest comparative study of traditional SB versus chandelier endoillumination SB, which reported on 49 cases.[29] Limitations of this study include the retrospective nature and lack of randomization. In addition, follow-up time in the 3DGLP group was shorter than the ID group, although this did not reach statistical significance. This difference is due to the fact that the ID surgeries were performed between July 2016 and April 2021 and the 3DGLP surgeries, a newer technique, were performed more recently between May 2018 and August 2021 allowing for more follow-up time in the ID group. All surgical cases included trainees which may confound the operative time analysis.

SB is an important vitreoretinal procedure for the repair of retinal detachment. While vitrectomy has certainly gained greater popularity over the past two decades, SB remains the best choice for many retinal detachments. Unfortunately, newer surgeons may be less comfortable performing a scleral buckle due to limited experience and difficulty visualizing all the breaks. We hope that the proposed NGENUITY scleral buckle with guarded light pipe, 3DGLP, offers a small but accommodating alternative for surgeons otherwise less comfortable with SB for retinal detachment repair. The guarded light pipe is a simple alternative to the chandelier illumination system. Certainly, future studies are needed to make a more definitive conclusion regarding the best techniques for SB surgery. It would be helpful to compare traditional SB techniques to newer approaches with sample sizes powered to detect noninferiority of the 3DGLP technique, evaluate outcomes such as operative time among novice and experienced surgeons separately, perform a comparative analysis of chandelier illumination versus the guarded light pipe, and to perform a cost analysis of the various approaches.

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Disclosure

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