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Decade of insights on causes of scleral buckle failure in retinal detachment

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巩膜扣带术治疗视网膜脱离失败原因分析的十年回顾研究

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摘要

目的:针对我院孔源性视网膜脱离巩膜扣带术失败的病例,分析其原因并探讨再次手术策略。

方法:单中心、回顾性、描述性研究。收集 2013 年 8 月至 2023 年 7 月期间在我院接受巩膜扣带术治疗的 368 例孔源性视网膜脱离患者(387 眼)的临床数据。分析视网膜脱离复发的原因以及再次手术的选择。

结果:共纳入分析 368 例患者(387 眼),其中包括 222 名男性和 146 名女性。平均年龄为 30.26±14.18 岁,平均随访时间为(48.33±20.39)mo。巩膜扣带术的成功率为 90.2%。有 38 眼出现了视网膜脱离复发的情况。根据手术记录分析巩膜扣带术失败的原因。复发原因包括:14 眼(36.8%,14/38)的垫压嵴异常(位置、高度或宽度)、11 眼(29.0%,11/38)的视网膜裂孔遗漏、10 眼(26.3%,10/38)的增生性玻璃体视网膜病变(PVR)、以及 3 眼(7.9%,3/38)的新裂孔。其中,8 眼(21.1%,8/38)再次进行了巩膜扣带手术,而其余 30 眼(78.9%,30/38)进行了经睫状体平坦部玻璃体切除术(PPV)。关于填充物,11 眼(36.7%,11/30)使用了硅油,12 眼(40.0%,12/30)使用了 C_3F_8 气体,7 眼(23.3%,7/30)使用了无菌空气。

结论:巩膜扣带术治疗孔源性视网膜脱离具有较高的成功率。垫压嵴异常、手术中遗漏裂孔、增生性玻璃体视网膜病变是导致巩膜扣带术失败的主要原因。针对巩膜扣带手术失败后的复发性视网膜脱离再次手术处理,再次巩膜扣带手术、玻璃体切除手术均有着较好的手术效果。

关键词:视网膜脱离;巩膜扣带术;失败原因;再手术

Abstract

• AIM: To investigate the underlying causes of surgical failure and reoperation management in patients with rhegmatogenous retinal detachment (RRD) who underwent scleral buckle surgery at our institution.

• METHODS: This was a single-center, retrospective, descriptive study. The clinical data of 368 patients (387 eyes) with RRD who underwent scleral buckling (SB) surgery between August 2013 and July 2023 at our institution were collected. The aim was to analyze the causes of recurrence and the rationale for selecting reoperation methods.

• RESULTS: Totally 368 patients (387 eyes) were included in the analysis, comprising 222 males and 146 females. The average age was 30.26±14.18 years, and the mean follow-up duration was (48.33±20.39) mo. The success rate of SB surgery was 90.2%. Recurrent retinal detachment occurred in 38 eyes. Based on surgical records, the causes of SB failure were analyzed. The recurrence causes included abnormal compression ridge position (position, height, or width) in 14 eyes (36.8%, 14/38), hole omission in 11 eyes (29.0%, 11/38), proliferative vitreoretinopathy (PVR) in 10 eyes (26.3%, 10/38), and new holes in 3 eyes (7.9%, 3/38). Among these, 8 eyes (21.1%, 8/38) underwent repeat SB surgery, while the remaining 30 eyes (78.9%, 30/38) underwent pars plana vitrectomy (PPV). Regarding tamponade agents, silicone oil was used in 11 eyes

(36.7%, 11/30), C_3F_8 gas in 12 eyes (40.0%, 12/30), and sterile air in 7 eyes (23.3%, 7/30).

• CONCLUSION: SB surgery demonstrates a high success rate in the treatment of RRD. However, abnormal compression ridge position, missed holes during surgery, and PVR are the primary causes of SB failure. After addressing the reasons for failure, re-SB surgery or PPV can be effective alternatives.

• KEYWORDS: retinal detachment; scleral buckling; cause of failure; reoperation
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INTRODUCTION

Rhegmatogenous retinal detachment (RRD) is a severe and potentially blinding disease. Scleral buckling (SB) surgery remains one of the classic surgical approaches for treating RRD, particularly suitable for younger patients with retinal detachment primarily caused by peripheral retinal holes[1-2]. Notably, sealing retinal holes effectively is the cornerstone of successful retinal reattachment surgery[3]. However, postoperative recurrence of retinal detachment represents a notable complication of SB for RRD. According to the literature, the success rate of SB for RRD is reported to be approximately 90%[4-7]. The surgical success rate depends not only on accurate identification of surgical indications but also on meticulous surgical technique, which plays a critical role in ensuring favorable outcomes. Although SB surgery for RRD has been recognized by clinical practice, the emergence of pars plana vitrectomy (PPV) and the ongoing advancements in minimally invasive PPV techniques in recent years have led to PPV being increasingly adopted in clinical settings. Consequently, proficiency in SB surgery has gradually become less common. Nevertheless, as a classic approach for retinal reattachment, SB retains distinct advantages and should not be overlooked. This article retrospectively analyzes indirect ophthalmoscopy-assisted SB surgeries for RRD performed at our hospital between August 2013 and July 2023. The aim is to evaluate the surgical success rate, investigate postoperative recurrence cases, explore the underlying causes of recurrence, and assess the efficacy of re-treatment.

PARTICIPANTS AND METHODS

Ethical Approval This study followed the tenets of the Declaration of Helsinki and was approved by the Ethics Committee of our institution. All subjects were duly informed and consented to participate in the research.

Participants A total of 368 patients (387 eyes) with RRD who underwent SB surgery at our institution between August 2013 and July 2023 were included. The surgeries were performed by 2 surgeons experienced in vitreoretinal surgery.

Inclusion and Exclusion Criteria The inclusion criteria were as follows: 1) Patients had not undergone prior SB or vitreoretinal surgery; 2) Patients demonstrated excellent compliance and completed at least one month of postoperative follow-up. The exclusion criteria included: 1) Tractional or exudative retinal detachment; 2) Retinal holes located posterior to equator; 3) Conditions affecting fundus examination, such as corneal leukoplakia, severe cataracts, vitreous hemorrhage, or refractive media opacities; 4) Coexisting ocular or systemic diseases that could affect retinal reattachment, such as diabetic retinopathy or ocular trauma; 5) Postoperative follow-up of less than 6 mo.

Methods This study was a single-center, retrospective, descriptive study. The collected data included patient demographics, gender, age, follow-up duration, postoperative retinal reattachment status, and reoperation rates for recurrent cases. In total, 368 patients (387 eyes) were enrolled in the study, comprising 222 males (60.3%, 222/368) and 146 females (39.7%, 146/368). The mean age was 30.26±14.18 years, ranging from 5 to 71 years.

Effectiveness evaluation: slit-lamp examination, anterior segment imaging, fundus photography, and optical coherence tomography (OCT) were employed to evaluate the affected eye, with retinal repositioning status documented. Anatomical retinal reattachment was used as the primary criterion for surgical success. The reasons for SB surgery failure were analyzed based on surgical records, with surgical missed holes defined as the presence of unpressurized retinal holes in addition to the original suprachoroidal hole.

Statistical Analysis Results are presented as mean ± standard deviation for continuous variables and as percentage for categorical variables. Differences in continuous variables were tested for statistical significance using Student's t-test, and statistical significance was defined as $P<0.05$. Data were analyzed using IBM SPSS ver. 22.0 (IBM Co., Armonk, NY, USA).

RESULTS

A total of 387 patients (368 eyes) underwent SB for RRD over a 10-year period. The follow-up duration ranged from 6 to 106 mo, with a mean follow-up duration of 48.33±20.39 mo. The success rate of the surgery at the final follow-up was 90.2%. Recurrence occurred in 38 eyes (9.8%), with an average recurrence time of 6.04±5.88 mo postoperatively. Among these, 22 eyes (57.9%, 22/38) recurred within 3 mo post-surgery, leading to a success rate of 94.3% at 3 mo post-surgery. Additionally, 16 eyes (42.1%, 16/38) experienced recurrence more than 3 mo after surgery.

The recurrence causes included abnormal compression ridge position (position, height, or width) in 14 eyes (36.8%, 14/38), hole omission in 11 eyes (29.0%, 11/38), proliferative vitreoretinopathy (PVR) in 10 eyes (26.3%, 10/38), and new holes in 3 eyes (7.9%, 3/38; Table 1).

Table 1 Recurrence of retinal detachment after scleral buckling surgery

Recurrent retinal detachment	Eyes (%)
Numbers	38(9.8%)
Recurrence time	
≤3 months postoperative	22 (57.9%)
>3 months postoperative	16 (42.1%)
Reasons	
Abnormal compression ridge position	14 (36.8%)
Retinal hole omission	11 (29.0%)
Proliferative vitreoretinopathy	10 (26.3%)
New retinal holes	3 (7.9%)

For patients who experienced recurrence following the initial SB surgery, 8 eyes (21.1%, 8/38) underwent repeat SB surgery. Specifically, 5 eyes were due to missed retinal holes during the first SB surgery and received segmental SB surgery again; 2 eyes were due to improper positioning of the scleral buckle, where the original buckle was removed and external SB surgery was repeated; and 1 eye was due to postoperative vitreoretinal proliferation and underwent encircling buckling again. The remaining 30 eyes (78.9%, 30/38) underwent PPV. Regarding tamponade agent selection, 11 eyes (36.7%, 11/30) used silicone oil, among which 8 eyes experienced recurrence due to postoperative vitreoretinal proliferation, 2 eyes due to incorrect positioning or height of the scleral buckle, and 1 eye due to missed retinal holes. In contrast, 12 cases (40.0%, 12/30) used inert gas C_3F_8 as the tamponade agent, while 7 eyes (23.3%, 7/30) used sterile air. At the final follow-up, all affected eyes demonstrated complete reattachment of the retina. No serious complications were observed during or after the surgical procedures in any of the affected eyes.

DISCUSSION

SB is a commonly used procedure for treating RRD. It is characterized by its simplicity and effectiveness. Key advantages include minimal intraoperative trauma, superior postoperative recovery of visual function, and fewer complications. Specifically, vitreoretinal surgery poses significant challenges in adolescents due to the rarity of vitreoretinal tissue detachment, combined with strong tissue regeneration capabilities in this population. Additionally, PVR following vitreoretinal surgery can lead to a high likelihood of surgical failure, as well as complications such as disruption of the blood-retinal barrier, iatrogenic holes, and complicated cataracts[8-10]. Consequently, the choice of surgical methods for retinal detachment in adolescents must be approached with great caution, and indications should be strictly defined. SB surgery can be considered the preferred surgical option for adolescent patients with a retinal hole located at or near the equator and without obvious vitreous proliferation, unless vitrectomy is required for complex retinal detachment cases where SB surgery may fail to effectively close the hole. In this study, we utilized a binocular indirect ophthalmoscope to locate and freeze all retinal holes, with or without subretinal fluid drainage, and with or without encircling buckling, achieving excellent therapeutic outcomes. Following an average follow-up period of 48.33±20.39 mo, the final surgery anatomical success rate was 90.2%, which is consistent with the success rates reported in previous studies[4-7]. Common complications following SB include refractive changes, displacement of the external pressure device, infection, anterior segment ischemia, and choroidal detachment[8,11-12]. With advancements in scleral buckling techniques, severe postoperative complications have become rare. Notably, no serious complications were observed in any of the patients in this study.

The results of this study demonstrated that 36.8% (14/38) of eyes undergoing their first SB surgery experienced incorrect positioning of the pressurized ridge, as well as insufficient width and height of the ridge. These factors were identified as the most common causes of postoperative SB failure. The primary reason for these issues may stem from inadequate proficiency in using the ophthalmoscope, leading to inaccurate positioning. With the advent of PPV, particularly the recent advancements in minimally invasive PPV techniques, PPV has gained widespread acceptance and application in clinical practice. However, SB remains a valuable treatment option for RRD, offering unique advantages that should not be overlooked. The second potential cause of failure is inappropriate suture placement. During SB surgery, the positioning and marking of the ridge must be reconfirmed after suturing is completed. For irregular or large retinal holes, oblique degeneration areas, *etc.*, it is essential to accurately locate the three or both ends of the hole based on its position. Furthermore, suture placement after positioning is critical in determining the final location of the pressurized ridge. Suture placement should take into account both intraocular pressure and the height of retinal detachment in the affected eye. Lower intraocular pressure increases the likelihood of scleral collapse; therefore, over-tightening of the suture should be avoided to prevent excessive pressure ridges. Typically, after subretinal fluid drainage during SB surgery, the actual location of the hole tends to shift backward due to subretinal fluid reduction. As such, the anchor point is usually placed forward to the compression ridge. In myopic patients or cases where the suture location is near the muscle insertion, the thin sclera makes it challenging to control needle penetration depth. Deep needle penetration risks perforating the sclera, potentially causing complications such as eye depression, iatrogenic retinal holes, or choroidal hemorrhage. Conversely, shallow needle insertion may lead to scleral dehiscence and insufficient ridge height. Re-suturing carries the risk of ridge displacement. Third, the correct choice of cushion material is crucial. Silicone bands are suitable for horizontal or radial ridges, while silicon sponges with steep edges are more appropriate for radial ridges. In summary, the fundamental principle of SB surgery is to ensure that the entire retinal hole, particularly the posterior edge of the hole, is fully positioned on the ridge. Placing the posterior edge of a large retinal hole on the posterior slope of the ridge can result in leakage and subsequent surgical failure.

The second reason for the failure of SB surgery was the presence of undetected retinal holes during surgery, which accounted for 29.0% (11/38). According to literature reports, 22.5% to 40.0% of patients with RRD have multiple retinal holes, particularly in myopic patients[13-14]. Some cases may arise due to insufficiently thorough preoperative examinations, poor patient cooperation, small or obscured retinal holes, opacities in the refractive media, or retinal folds concealing undetected holes. Therefore, a comprehensive preoperative fundus examination is critical for all affected eyes. This should include indirect ophthalmoscopy, three-mirror contact lens examination, B-ultrasound, OCT, and other ancillary tests to identify all potential retinal holes. Preoperative measures such as appropriate postural rest, systemic medications to promote subretinal fluid absorption, and even repeated examinations (including positional changes) can help minimize the risk of missing retinal holes. For children with poor cooperation, it is recommended to perform a detailed fundus examination under general anesthesia *via* inhalation. Intraoperative peri-retinal examination during the localization of retinal holes, as well as re-examination after fluid drainage and cushion placement, can further reduce the likelihood of missed retinal holes. When the exact location of the hole is unclear, Lincoff's rule[15-16] or additional clinical details, such as the patient's chief complaint, retinal detachment morphology, and subretinal proliferation patterns, can assist in determining the probable location of the retinal hole.

PVR of varying degrees was identified as the third common cause of postoperative recurrence of SB in this study, accounting for 26.3% (10/38). PVR is a major contributor to retinal reattachment failure and recurrence[17-19], typically manifesting 4 to 6 wk postoperatively[20]. During SB, freezing may facilitate the diffusion or dissociation of retinal pigment epithelial cells from the subretinal space into the vitreous cavity, potentially leading to preretinal or subretinal membrane formation. These membranes can contract, causing recurrent retinal detachment. Additionally, freezing disrupts the blood-retinal barrier, promoting the leakage of plasma components and inflammatory factors into the vitreous cavity, thereby accelerating PVR progression. To minimize PVR occurrence, excessive freezing and freezing of pigmented areas should be avoided during SB, thus preventing hole reopening or new hole formation due to increased traction. For large retinal holes or extensive degenerative areas, judicious intraoperative cryotherapy combined with supplemental retinal laser photocoagulation can effectively reduce postoperative PVR incidence. Furthermore, surgical indications must be carefully evaluated preoperatively. In cases of severe pre-existing PVR, particularly grade D, PPV is preferred. Successful surgery hinges on thorough vitreous removal, complete peeling of epiretinal membranes, adequate subretinal fluid drainage, and laser closure of retinal holes.

In this study, 3 eyes (7.9%, 3/38) of SB surgery failure were attributed to the formation of new retinal holes. Possible causes for the formation of new holes include inadequate treatment of retinal degeneration areas during and after surgery, insufficient cryotherapy or laser photocoagulation, lack of appropriate SB during the procedure, and failure to perform postoperative supplementary retinal laser photocoagulation. This can lead to new retinal holes due to persistent vitreous traction. Following retinal detachment, vitreous traction on the retina is temporarily reduced. However, upon reattachment, the tightly adherent vitreous fibers become taut again, resulting in new retinal holes in areas of pre-existing degeneration and thinning. In this study, one case was attributed to fall-related injury, which may have caused sharp vitreoretinal traction, resulting in the formation of new holes and subsequent postoperative recurrence. Therefore, regular postoperative follow-up is essential, and preventive photocoagulation should be promptly performed for suspicious holes to prevent the emergence of new holes.

For the management of recurrent retinal detachment after SB, different surgical approaches can be selected based on the location and size of the retinal hole and the degree of vitreoretinal proliferation[21-23]. In young patients with recurrent retinal detachment, due to the high risk of PVR recurrence after vitrectomy, re-SB should be considered as much as possible in those with good vitreous conditions. For patients with posteriorly located holes or significant PVR proliferation, PPV is recommended, with inert gas or silicone oil tamponade performed as appropriate. As an excellent vitreous cavity filler, silicone oil is widely used in treating complex retinal detachment, PVR, giant retinal tears, diabetic retinopathy, and severe ocular trauma[24-25]. For patients with recurrent retinal detachment after SB accompanied by significant retinal proliferation, silicone oil tamponade is preferred whenever possible, allowing for a relatively free and appropriate postoperative positioning. Nevertheless, specific clinical analysis remains necessary. For recurrent cases unsuitable for repeat SB, PPV should still be selected to ensure surgical success rates.

By reviewing and analyzing the patients with simple RRD who underwent SB surgery in our hospital in the last decade, we concluded that SB surgery demonstrates reliable efficacy for treating uncomplicated RRD, achieving a high postoperative reattachment rate. The most common reasons for failure in SB were incorrect position of the buckling ridge, insufficient width and height of the compression ridge. Intraoperative missing hole, PVR and new hole were also the main factors leading to surgical failure. However, the treatment of SB operation failure is not the same for different reasons. For young people with good vitreous condition, re-SB can be used, and for recurrent cases where SB is no longer suitable, PPV should still be selected to ensure the success rate of surgery. However, there are still some limitations in this study: First, the operations were performed by 2 different physicians, which may have different effects on the success rate of the operation; As a retrospective analysis, and we expect that more prospective studies will be conducted to analyze and improve the success rate of SB surgery. Particularly mastering fundoscopic evaluation and comprehensive understanding of SB principles remains the keys to improving the success rate.

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Authors' contributions: Hu C and Liu Y conceptualized the manuscript; Du F, Xiang N and Huang ZJ collected the clinical data; Zhu L and Chen X performed the surgery; Chen X, Liu Y and Zeng B helped in drafting the manuscript. All authors have read and agreed to the published version of the manuscript.

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