ORIGINAL RESEARCH

Effectiveness of rb-bFGF Eye Drops for Post-Cataract Surgery Dry Eye and Observation of Changes in Tear Secretion and Corneal Damage in Patients

Xiaoying Zhao, BM; Qianwei Jia, BM; Juexiu Fu, MM

ABSTRACT

Objective • Dry eye syndrome after cataract surgery is a common complication that may affect the patient's visual comfort and quality of life. Because the surgery may affect the secretion and quality of tears in the eye, resulting in dry and uncomfortable eyes.This study aimed to investigate the therapeutic effects of recombinant bovine basic fibroblast growth factor (rb-bFGF) eye drops on dry eye syndrome after cataract surgery and to analyze its impact on tear secretion and corneal injury.

Methods • This is a retrospective study. A total of 126 patients (126 eyes) with dry eye syndrome after cataract surgery were treated between January 2021 and October 2022. patients were randomly divided into a study group (64 patients, 64 eyes) and a control group (62 patients, 62 eyes). Both groups were treated with sodium hyaluronate eye drops, while the study group received rb-bFGF eye drops for four weeks in addition to the sodium hyaluronate eye drops. The clinical efficacy, results of tear secretion test (SIT), tear film break-up time (BUT), corneal fluorescein staining, corneal topography examination, oxidative stress indicators, ocular surface disease index (OSDI) score, and drug adverse reactions were compared between the two groups.

Results • The study group exhibited a significantly higher total effective treatment rate (96.88%) compared to the control group (85.48%), suggesting the enhanced efficacy of rb-bFGF eye drops. Moreover, the study group demonstrated extended tear secretion length and tear film break-up time, indicating improved tear film stability and ocular surface health. Additionally, the study group showed reduced corneal fluorescein staining score and improved corneal surface regularity index, indicative of enhanced corneal integrity and smoothness. Notably, tear superoxide dismutase levels were elevated, while lipid peroxide levels were lowered in the study group, underscoring the potential antioxidative effects of rb-bFGF. The study group also exhibited a lower OSDI score, suggesting reduced ocular discomfort and improved quality of life. Although the study group had a slightly higher incidence of adverse reactions (9.38%) compared to the control group (8.06%), the difference was not statistically significant. Particularly significant is the statistical significance highlighting the heightened total effective treatment rate in the study group, indicating the potential of rb-bFGF eye drops in promoting favorable therapeutic outcomes.

Conclusion • rb-bFGF eye drops are safe and effective in treating dry eye syndrome after cataract surgery. They can help regulate tear secretion, repair corneal damage, and improve dry eye symptoms. Despite the retrospective design and relatively small sample size of this study, further randomized controlled trials and larger sample size may be needed to verify the robustness of the results, but this study is important for guiding the treatment strategy and optimizing patient care for dry eye after cataract surgery. (*Altern Ther Health Med.* 2023;29(8):489-495).

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INTRODUCTION

Dry eye syndrome is a common complication after cataract surgery, with an incidence rate of approximately 30%. Patients may experience postoperative dryness, foreign body sensation, burning pain, photophobia, and wind sensitivity. In severe cases, it may progress to redness, swelling, and corneal keratinization, and affect the patient's vision.[1,2] Dry eye syndrome after cataract surgery is a common complication, which may seriously affect the quality of life and postoperative recovery process of patients.

Postoperative dry eye can cause eye discomfort, burning sensation, blurred vision, and insufficient tear secretion, which can affect vision. In addition, dry eye may prolong postoperative recovery, since ocular discomfort may limit the patient's activities in daily life. This condition may be particularly evident with prolonged use of electronic devices, driving vehicles, and performing other tasks that require concentration. Therefore, finding an effective treatment to reduce the symptoms of dry eye syndrome after cataract surgery is of great significance to improve the quality of life of patients, promote postoperative recovery and protect vision.The pathological mechanism of dry eye syndrome after cataract surgery is mainly due to mechanical damage to the cornea during surgery, which causes damage and shedding of the corneal epithelium.[3,4] This damages the morphology of the tear film lipid layer and affects the stability of the tear film, resulting in reduced tear secretion. In addition, postoperative corneal incision healing and inflammation can also affect the corneal epithelium, disrupting the stability of the tear film.

Conventional anti-inflammatory eye drops can alleviate symptoms of dry eye syndrome to some extent, but long-term use has poor efficacy and may cause side effects such as conjunctival congestion and edema and decreased corneal sensation.[5] In recent years, in-depth studies on the mechanism of dry eye syndrome have found that oxidative stress is an important cause of the disease.[6] Exposure of the ocular surface to sunlight and UV radiation accelerates the aging and apoptosis of corneal epithelial cells. In addition to oxidative stress, dry eye syndrome after cataract surgery may be affected by other factors, such as inflammation, tear film instability, and hormonal changes, which may play an important role in tear secretion, ocular surface stability, and dry eye development. Therefore, regulating oxidative stress is beneficial for repairing damaged corneal epithelial cells. Antioxidant stress as a pathogenic treatment method for dry eye syndrome is gradually receiving clinical attention.[7]

Animal experiments conducted abroad have found that recombinant bovine-basic Fibroblast Growth Factor (rb-bFGF) promotes repair and regeneration of epithelial cells.[8,9] Rb-bFGF eye drops have been found to be effective in relieving dry eye syndrome in clinical applications. rb-bFGF has a broad prospect as a treatment for dry eye syndrome after cataract surgery. It can not only promote the repair and regeneration of epithelial cells, but also has potential anti-inflammatory and antioxidant properties. These properties fit with the focus of the study and further highlight the advantages of rb-bFGF as a therapeutic option. This study aims to fill the gaps in existing research, especially for the treatment of dry eye syndrome after cataract surgery. Despite the limitations of traditional anti-inflammatory eye drops to some extent, the potential benefits of rb-bFGF eye drops in the treatment of dry eye have not been fully explored, which provides ample justification and basis for our study.

The potential translational value of this study is that if rb-bFGF eye drops prove to be effective in treating dry eye syndrome after cataract surgery, it will be expected to provide a new and effective treatment for clinical practice. This will help to improve the quality of life of patients, alleviate their symptoms, and facilitate postoperative recovery, providing innovative solutions for the management of dry eye syndrome after cataract surgery.The aim of this study was to evaluate the clinical efficacy of rb-bFGF eye drops in patients with dry eye syndrome after cataract surgery. The specific objectives include: to evaluate the effect of rb-bFGF eye drops on tear secretion, to explore the improvement of corneal damage, and to investigate the regulatory effect of rb-bfgf eye drops on oxidative stress indicators. Through the comprehensive evaluation of these aspects, we aim to provide new clinical options and theoretical basis for the treatment of dry eye syndrome after cataract surgery. It was hypothesized that rb-bFGF eye drops would have the expected positive effect in the treatment of dry eye syndrome after cataract surgery, which could improve tear secretion, reduce corneal damage, and alleviate abnormal oxidative stress indicators.

PATIENTS AND METHODS

Patients

126 patients (126 eyes) with postoperative dry eye syndrome after cataract surgery from January 2021 (start treatment on this day) to October 2022 were selected for this study. Inclusion criteria were as follows: (1) onset of dry eye syndrome within 1 month after cataract surgery, with patients complaining of dryness and itching in the eyes, and meeting the diagnostic criteria for dry eye syndrome;[10] (2) tear secretion test <5 mm, tear film break-up time <10 s, and abnormality in the lipid layer of the tear film observed using a tear film interferometer; (3) complete medical records and follow-up data within 6 months after surgery. The theoretical basis for inclusion criteria is to ensure that the subjects have clear symptoms and examination indicators of dry eye syndrome and complete medical records and follow-up data to ensure the credibility and accuracy of the study results. Exclusion criteria were as follows: (1) concomitant ocular diseases, such as corneal inflammation, corneal ulcer, glaucoma, retinal detachment, macular pucker, and ocular trauma; (2) allergy to rb-bFGF eye drops; (3) poor treatment compliance (If treatment adherence is poor, patients may not be able to take their medication or perform their treatment on time, which can lead to data instability and biased results); (4) preexisting dry eye syndrome or a history of dry eye syndrome. The theoretical basis of the exclusion criteria is to exclude other eye diseases and factors that may affect the results of the study in order to ensure that the treatment effect of dry eye syndrome after cataract surgery is purely studied, avoiding intervention by other interfering factors. In conclusion, specific schirmer secretion, tear break-up time, and diagnostic criteria were selected as inclusion criteria to accurately assess the severity of dry eye syndromes and ensure that the subjects had obvious dry eye symptoms. Patients with comorbidities and specific medical histories were excluded to rule out confounding factors and ensure the

reliability of the study results. The selection of these criteria helped to ensure the clinical reliability of the study.According to the principle of randomization, patients were randomly allocated into the study group (64 cases and 64 eyes) and the control group (62 cases and 62 eyes) using the envelope method. This approach enables randomization by placing randomization information in closed envelopes and allowing the investigator to determine the patient's group by randomly selecting an envelope before enrollment.The study group consisted of 36 male patients (36 eyes) and 28 female patients (28 eyes) with an age range of 61-79 years and a mean age of (70.48 ± 3.42) years, a history of cataracts ranging from 2 to 7 years and a mean of (5.03±0.67) years, and postoperative corrected LogMAR visual acuity ranging from 0.0 to 0.2 and a mean of (0.08 ± 0.03). The control group consisted of 32 male patients (32 eyes) and 30 female patients (30 eyes) with an age range of 59-75 years and a mean age of (69.20 ± 3.11) years, a history of cataracts ranging from 1 to 7 years and a mean of (4.88 ± 0.63) years, and postoperative corrected LogMAR visual acuity ranging from 0.0 to 0.2 and a mean of (0.09 ± 0.03). There was no statistically significant difference in the general information between the two groups ($P > .05$), indicating comparability. The ethics committee of our hospital approved this study, and all patients provided informed consent, which ensured the ethical compliance of the study and the protection of patients' rights and interests.

Methods

Both groups of patients were treated with sodium hyaluronate eye drops (brand name "Hailu", Ursapharm Arzneimittel GmbH, Germany, with Chinese approval number H20150150) three times per day, one drop each time. The study group received rb-bFGF eye drops (brand name "Beifushu", Zhuhai Yisheng Biopharmaceutical Co., Ltd., with Chinese approval number S19991022) in addition to the control group, four times per day, one drop each time. Rb-bFGF eye drops are a protein drug that should be stored in a refrigerator at low temperatures. Each type of eye drops was used at a 10-minute interval. Both groups received continuous eye drop treatment for four weeks.

Outcome measures

Evaluation of therapeutic efficacy. Clinical efficacy was assessed 4 weeks after treatment. Cure was defined as the complete disappearance of dry eye-related symptoms in the affected eye, with a Schirmer test (SIT) >10 mm and a tear break-up time (BUT) >10 s. Significant improvement was defined as a 70% or more improvement in SIT and BUT results compared to before treatment, while effective treatment was defined as a 30% to 69% improvement. Ineffective treatment was defined as less than 30% improvement in SIT and BUT results, with no significant improvement in dry eye-related symptoms in the affected eye. The overall effective rate was calculated as (cure + significant improvement + effective treatment) / total number of cases × 100%.

SIT and BUT were chosen as measures of tear secretion because they directly reflect core features of dry eye syndromes, whereas corneal fluorescein staining and corneal topography were chosen to assess corneal damage to provide important insights regarding corneal health and treatment impact.Tear secretion indicators: The SIT and BUT tests were performed before and 4 weeks after treatment. For the SIT test, a 5 × 35 mm special examination filter paper was used. One end was folded 5 mm and placed in the lower third of the conjunctival sac of the affected eye. The remaining part of the filter paper was suspended on the skin surface. After 5 minutes, the length of the filter paper that was moistened was measured, which represents tear secretion length. For the BUT test, the patient was instructed to look upward, and 1% fluorescein sodium solution was instilled into the affected eye. The patient was then asked to blink and maintain an open eye while the physician observed the appearance of the first black spot on the tear film under a slit lamp, which indicates tear film break-up time. The time for tear film break-up was recorded with a stopwatch.Corneal Injury Indicators: Before and four weeks after treatment, corneal fluorescein staining score and corneal topography examination were performed. Corneal fluorescein staining score: 1% sodium fluorescein solution was dropped into the inferior conjunctival sac of the affected eye. The patient was instructed to keep the eye open after blinking. One to two minutes later, under the slit lamp from the temporal side with cobalt blue light, observe if the corneal epithelium is stained yellow-green. Staining indicates a corneal epithelial defect, and the intact corneal epithelium is not stained. When observing corneal fistulas, attention should be paid to whether the green tear film is displaced by aqueous humor. The cornea was divided into 4 quadrants, each with a score: no staining = 0 points, scattered punctate staining = 1 point, diffuse staining = 2 points, and large area patch staining = 3 points. Corneal topography examination: the patient was seated with the chin resting on a chin rest and the forehead leaning forward. The affected eye stared at the fixed light in the center of the corneal microscope, and the distribution frequency of the refractive power of 256 radii in the 4.5 mm pupil area of the cornea was measured. The refractive power of the 10 central rings of the cornea was selected to calculate the average value.

Tear Oxidative Stress Indicators. Before and 4 weeks after treatment, the patient's tears were collected by adding 100 μL sterile saline to the conjunctival sac of the affected eye. The tears were absorbed with a capillary glass tube after fusion with saline. Enzyme-linked immunosorbent assay was used to detect superoxide dismutase and lipid peroxide levels in tears. The detection instrument was the Beckman AU5800 automatic biochemical analyzer purchased from Sigma-Aldrich in the United States. Measurement of tear oxidative stress markers, such as superoxide dismutase and lipid peroxides, is essential to assess the effects of rb-bFGF eye drops on oxidative stress, as these can provide critical information about the oxidative status of the cells. rb-bFGF

is thought to have antioxidant properties and may help to mitigate the damage to ocular tissues caused by oxidative stress. By measuring these indicators, we can better understand whether rb-bFGF is able to influence oxidative stress levels during treatment and thus provide more insight into its therapeutic potential.Severity of Dry Eye Syndrome: Before and 4 weeks after treatment, the Ocular Surface Disease Index (OSDI)[11] was used to evaluate the subjective symptoms of dry eye syndrome and the degree of relief of dry eye symptoms before and after medication. The scale includes 12 items: photophobia, foreign body sensation, pain, blurred vision, impact on reading, writing, computer use, TV watching, night driving, wind sensitivity, discomfort in dry environments, and discomfort in air conditioning. Each item is scored: all the time = 5 points, most of the time = 4 points, sometimes = 3 points, rarely = 2 points, none = 1 point. The total score ranges from 12 to 60 points. OSDI can not only objectively measure the symptoms and pain degree of patients, but also deeply understand the subjective experience of patients, including dry eye, tingling, blurred vision, etc., so as to provide clinicians with comprehensive information about patients' feelings. These data not only help to determine the severity of the disease, but also reflect the patient's response to treatment, thus better guiding the development and adjustment of treatment regimens.

Adverse Drug Reactions. Observe adverse reactions such as eye irritation, eyelid itching, and conjunctival congestion during treatment. Adverse drug reactions were monitored daily during the study to ensure timely access to relevant information. This high frequency of monitoring helps to capture any possible adverse effects, thereby guaranteeing the safety and reliability of the study.

Statistical analysis

Statistical Product and Service Solutions (SPSS) 22.0 software (IBM, Armonk, NY, USA) was used. Normally distributed metric data were expressed as mean ± standard deviation. Independent sample *t* test was used for inter-group comparisons, and paired *t* test was used for intra-group comparisons before and after treatment. Count data were described in numbers and percentages (%), and chi-square test was used. $P < .05$ was considered statistically significant. Using statistical analysis, we were able to determine the efficacy of rb-bFGF eye drops in the treatment of dry eye after cataract surgery and whether significant improvements were present in indicators such as tear secretion, corneal damage, and oxidative stress. This contributes to a comprehensive understanding of treatment effects and provides a strong scientific basis for clinical practice.

RESULTS

Comparison of efficacy between the two groups

The overall response rate (ORR) in the study group was 96.88 significantly higher than 85.48 in the control group, and the difference was statistically significant ($P < .05$); see Table 1.

Table 1. Comparison of efficacy between the two groups [case (%)]

Group	Number of eyes	Recovered	Markedly effective	Effective	Invalid	Overall response rate
Study group	64	26 (40.62)	29 (45.31)	7 (10.94)	2 (3.12)	62 (96.88)
Control group	62	15 (24.19)	21 (33.87)	17 (27.42)	9 (14.52)	53 (85.48)
χ^2						5.128
P value						.024

Table 2. Comparison of tear secretion indicators before and after treatment between the two groups ($\bar{x} \pm s$)

Group	Number of cases	Length of tear secretion (mm)		Tear Break-up Time (s)	
		Before treatment	After treatment	Before treatment	After treatment
Study group	64	3.97 ± 1.10	12.53 ± 1.64[a]	6.33 ± 1.29	13.35 ± 2.26[a]
Control group	62	3.85 ± 1.05	10.76 ± 2.02	6.41 ± 1.30	12.15 ± 1.98
t		0.626	5.408	0.347	2.166
P value		.532	<.001	.729	.002

[a]$P < .05$ compared with the control group

Table 3. Comparison of corneal injury indicators before and after treatment between the two groups ($\bar{x} \pm s$)

Group	Number of cases	Fluorescein staining score (points)		Corneal Surface Rule Index	
		Before treatment	After treatment	Before treatment	After treatment
Study group	64	5.08 ± 1.20	1.19 ± 0.24[a]	0.68 ± 0.14	0.23 ± 0.05[a]
Control group	62	4.96 ± 1.05	2.68 ± 0.35	0.65 ± 0.15	0.31 ± 0.07
t		0.597	27.945	1.161	7.400
P value		.552	<.001	.248	<.001

[a]$P < .05$ compared with the control group

Comparison of Tear Secretion Length and Tear Break-Up Time After Treatment

After treatment, patients in both groups had significantly increased tear secretion length and significantly prolonged tear break-up time ($P < .05$); and tear secretion length was greater, and tear break-up time was longer in the study group than in the control group than in the control group, i.e. The difference was statistically significant ($P < .05$), as shown in Table 2.

Comparison of corneal injury indexes before and after treatment

Before treatment, the two groups had no significant difference in fluorescein staining score and corneal surface regularity index ($P = .552$). After treatment, the fluorescein staining score and corneal surface regularity index decreased significantly in both groups ($P < .05$); and the fluorescein staining score and corneal surface regularity index in the study group were less than those in the control group, and the differences were statistically significant ($P < .05$), as shown in Table 3.

Comparison of oxidative stress indexes of tears before and after treatment

Before treatment between the two groups, there was no significant difference in superoxide dismutase and lipid peroxide levels of tears between the two groups ($P > .05$). After treatment, there was a significant increase in superoxide dismutase levels in tears and a significant decrease in lipid peroxide levels in both

groups ($P < .05$); and superoxide dismutase levels in tears were higher and lipid peroxide levels were lower in the study group than in the control group, i.e. The difference was statistically significant ($P < .05$), as shown in Table 4.

Comparison of OSDI scale scores before and after treatment between the two groups

Before treatment, there was no significant difference in OSDI scale scores and the two groups ($P = .295$). At one week, two weeks, and four weeks of treatment, patients in both groups had significantly lower OSDI scale scores ($P < .05$); and the OSDI scale scores in the study group were lower than those in the control group; the difference was statistically significant ($P < .05$), as shown in Table 5, Figure 1.

These results suggest that rb-bFGF eye drops have potential benefits in the treatment of dry eye syndrome, which may improve the clinical symptoms and quality of life of patients by promoting corneal epithelial cell repair and regeneration, as well as having anti-inflammatory and antioxidant properties. These findings highlight the promise of this treatment in the management of dry eye syndromes, especially in patients after cataract surgery.

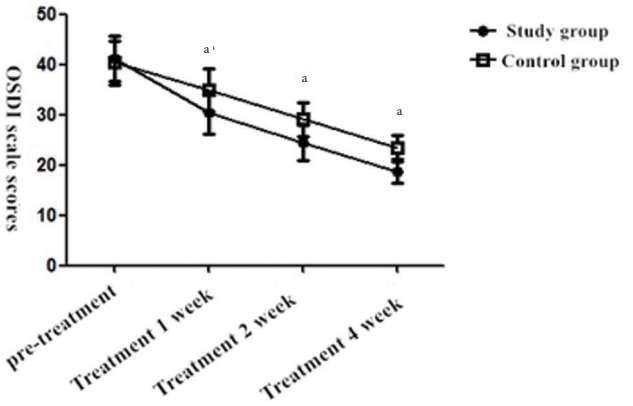
Adverse reactions

The incidence of adverse reactions was 9.38% in the study group and 8.06% in the control group, and the difference was not statistically significant ($P > .05$). See Table 6. We noted that the incidence of adverse effects was similar and mild between the study and control groups. Adverse effects in the study group included ocular irritation, mild foreign body sensation, and increased tear production, whereas ocular irritation and mild foreign body sensation occurred in the control group. It should be noted that there were no significant differences in these adverse reactions between the two groups, indicating that rb-bFGF eye drops have a good safety profile in the treatment of dry eye syndrome. This result further supports the plausibility of rb-bFGF eye drops as a treatment option.

DISCUSSION

With the continuous improvement of cataract surgery techniques, an increasing number of cataract patients have achieved good visual recovery. However, a large number of surveys have found that some cataract patients are prone to develop postoperative complications of dry eye, causing severe eye discomfort.[12,13] The causes of dry eye caused by cataract surgery are complex.[14] cataract surgery often uses surface anesthesia such as lidocaine, which is slightly irritating to the corneal epithelium and can cause scattered punctate epithelial cell loss. Secondly, the corneal incision caused by the surgery can lead to damage of the corneal reflex arc conduction nerve, reduced corneal sensation, decreased blink frequency, and inhibition of tear secretion conveyed by the brain reflex arc to the lacrimal gland, resulting in decreased tear production and dry eye. Thirdly, during the corneal incision healing process, inflammatory reactions and tissue edema occur, directly affecting the stability of the tear film mucous layer above the cornea, leading to decreased tear film stability. Fourthly, after cataract surgery, antibiotics and corticosteroid eye drops are commonly used, which can change the osmotic pressure of the corneal epithelial cells and destroy the stability of the tear film. Fifthly, cataract patients often have diabetes, and the corneal epithelial basement membrane is malnourished, leading to slower corneal healing after surgery and poorer tear film stability on the corneal surface.

Figure 1. Line graph of OSDI scale score before and after treatment in the two groups



[a]$P < .05$ compared with the control group

Table 4. Comparison of tear oxidative stress indicators before and after treatment between the two groups ($\bar{x} \pm s$, μmol/L)

Group	Number of cases	Superoxide dismutase		Lipid peroxide	
Study group	64	0.12 ± 0.04	0.18 ± 0.05[a]	2.41 ± 0.52	1.26 ± 0.21[a]
Control group	62	0.11 ± 0.03	0.14 ± 0.02	2.45 ± 0.58	1.59 ± 0.25
t		1.584	5.861	0.408	8.033
P value		.116	<.001	.684	<.001

[a]$P < .05$ compared with the control group

Table 5. Comparison of OSDI scale scores before and after treatment between the two groups ($\bar{x} \pm s$, points)

Group	Number of cases	Before treatment	1 week treatment	2 weeks of treatment	4 weeks of treatment
Study group	64	41.22 ± 5.45	30.36 ± 4.10[a]	24.48 ± 3.56[a]	18.63 ± 2.15[a]
Control group	62	40.30 ± 4.28	34.85 ± 4.22	29.08 ± 3.37	23.47 ± 2.36
t		1.052	6.058	7.444	12.041
P value		.295	<.001	<.001	<.001

[a]$P < .05$ compared with the control group

Table 6. Comparison of adverse drug reactions between the two groups

Group	Number of cases	Eye irritation	Itching eyelid	Conjunctival hyperaemia	Total
Study group	64	3 (4.69)	2 (3.13)	1 (1.56)	6 (9.38)
Control group	62	2 (3.23)	1 (1.61)	2 (3.23)	5 (8.06)
χ^2					0.068
P value					.794

In the in-depth exploration of the mechanism and pathogenesis of dry eye syndrome after cataract surgery, we refer to a number of relevant studies to strengthen our discourse. Specifically, previous studies have deeply explored the inflammatory factors in the pathogenesis of dry eye syndromes and focused on the association between dry eye syndromes and tear film instability. In addition, studies have highlighted the role of hormonal changes in the development of dry eye syndromes. Taking these findings together, our discussion concludes that the pathogenesis of dry eye syndrome after cataract surgery is a complex multifactorial process involving multiple mechanisms such as inflammation, tear film instability, and hormonal changes. This literature supports our in-depth elaboration of the mechanism of dry eye syndrome in this study, while also providing a scientifically credible basis for our study conclusions.Artificial tears, anti-inflammatory and other eye drops are mainly used for treatment for dry eye.[15] Sodium hyaluronate eye drops are a clinically commonly used artificial tear, which can promote corneal surface water retention, delay tear film water evaporation, and maintain tear film stability. The mechanism of action is that sodium hyaluronate has many negatively charged anions, which have excellent water retention properties, thereby maintaining tear film stability. At the same time, sodium hyaluronate can bind to corneal fibers and promote corneal cell repair. Previous studies have shown that sodium hyaluronate eye drops have good efficacy in treating dry eye, which can improve dry eye to some extent.[16,17] Based on sodium hyaluronate eye drops, this study applied rb-bFGF eye drops for treatment. The results showed that the total effective rate of the study group was 96.88%, which was higher than that of the control group (85.48%). The length of tear secretion in the study group was longer than in the control group, and the tear film rupture time was longer than in the control group. The OSDI score in the study group was lower than that in the control group. The above indicates that rb-bFGF eye drops can help regulate tear secretion and improve dry eye symptoms, which is consistent with the study reported by Xiao et al.[18]

Previous research has found that the pathogenesis of dry eye disease includes factors such as unstable tear film, inflammation, oxidative stress, and corneal epithelial damage.[19] In this study, we analyzed the effects of rb-bFGF eye drops from the perspective of corneal damage. Patients treated with rb-bFGF eye drops showed lower corneal fluorescein staining scores and lower corneal surface irregularity indices compared to the control group, indicating the reparative effect of rb-bFGF eye drops on corneal damage. The active ingredient in rb-bFGF is fibroblast growth factor, which promotes the proliferation and growth of endothelial cells, repairs damaged endothelial cells, promotes epithelial regeneration, and is widely used in skin repair and beauty [20,21] Wang et al.[22] analyzed the mechanism and found that in an in vitro cultured mouse dry eye corneal epithelial cell model, the expression of microtubule-associated protein 1 light chain 3 (LC3-II), sequestosome 1 (SQSTM1), and DNA damage-inducible transcript 4 (DDIT4) proteins increased. Electron microscopy revealed numerous autophagic vacuoles in the corneal epithelial cells under high osmotic stress, which disrupted mitochondrial function in corneal epithelial cells and led to corneal damage. An animal experiment showed that the use of rb-bFGF in a rabbit corneal alkali burn model resulted in a significant restoration of the stromal and endothelial layers of the burned cornea, promoted corneal epithelialization and transition, effectively treated corneal damage, and did not cause corneal neovascularization complications.[23] In addition, oxidative stress induces lipid peroxidation, depletion of glutathione, and accumulation of ferrous ions in corneal epithelial cells, inducing apoptosis.[24] Our study found that the level of superoxide dismutase in the tears of patients treated with rb-bFGF eye drops was higher than that of the control group, while the level of lipid peroxidation was lower than that of the control group, indicating the antioxidative stress effect of rb-bFGF eye drops. The mechanism may be related to promoting corneal tissue metabolism and nutrition by antioxidation.[25] An animal experiment[26] indicated that rb-bFGF inhibits inflammation and oxidative stress, enhances glycosylated phosphoproteins in rats, and improves dry eye disease. The mechanism may be that rb-bFGF can reduce tear oxidative stress indicators such as glycerol and lipid peroxide, thereby reducing the levels of interleukin-1β and interleukin-8 in tears, inhibiting inflammatory factors, improving oxidative stress status, and countering the peroxidation of free radicals, thereby improving tear film stability in patients.

Our findings highlight the potential clinical relevance of the use of rb-bFGF eye drops in the treatment of dry eye syndrome after cataract surgery. This finding may significantly change the therapeutic landscape for dry eye syndrome after cataract surgery. Firstly, rb-bFGF eye drops have been shown to significantly increase tear secretion, improve tear film instability, and reduce corneal damage index, which is important for improving the visual condition of patients and alleviating symptoms. Secondly, the antioxidant and anti-inflammatory properties of rb-bFGF eye drops may help to reduce the severity of dry eye syndrome, thereby reducing the incidence of postoperative complications. In addition, improved dry eye symptoms and visual status may significantly improve patient quality of life and reduce reliance on other treatments, thereby positively impacting cost-effectiveness for patients and healthcare systems. Therefore, our study not only reveals the potential efficacy of rb-bFGF eye drops in the treatment of dry eye syndromes, but also provides important clinical prospects for improving patients' quality of life, reducing treatment costs, and reducing the risk of postoperative complications.

This study also had some limitations, including small sample size, short follow-up time, and a lack of further analysis of different patient subgroups. Due to the small sample size, the stability and generalization ability of the results may be affected. In addition, the follow-up time was

only six months, which failed to fully evaluate the long-term treatment effect. In addition, this study did not further analyze subgroups with different age, gender, and severity of disease and may not be able to fully understand the effect and safety of rb-bFGF eye fluid in different patient populations. Therefore, future studies could increase the sample size, extend follow-up time, and conduct more detailed subgroup analyses to further validate the results of this study. In view of the above limitations, we suggest that future studies could take a larger sample size and use a more rigorous randomized controlled trial design to further verify the efficacy and safety of rb-bFGF eye drops. In addition, long-term follow-up studies are helpful to reveal its long-term treatment efficacy and continued safety. At the same time, exploring the effects of different doses and treatment durations, as well as combined application with other treatments for dry eye syndromes, are interesting directions for future research. Taken together, our study provides useful suggestions and directions for future in-depth research on rb-bFGF eye drops in the treatment of dry eye syndrome after cataract surgery.

CONCLUSION

In conclusion, rb-bFGF eye drops are safe and effective in treating dry eye disease after cataract surgery. They help regulate tear secretion, repair corneal damage, and improve dry eye symptoms and are worthy of clinical application.

CONFLICT OF INTERESTS

The authors declared no conflict of interest.

AUTHOR CONTRIBUTIONS

XZ and QJ designed the study and performed the experiments, QJ collected the data, JF analyzed the data, XZ prepared the manuscript. All authors read and approved the final manuscript.

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