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ORIGINAL ARTICLE

The Effects of Topical Cyclosporine 0.05% on Dry Eye Symptoms of Postcataract Surgery

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Background: Dry eye disease is a common complication after cataract surgery, often impairing visual recovery and patient satisfaction. Conventional management includes artificial tears and mild corticosteroids, but their efficacy is limited. **Aim:** This study evaluated the effect of topical cyclosporine 0.05% on post-cataract surgery–related dry eye symptoms compared with artificial tears plus fluorometholone and no additional treatment. **Methods:** Sixty eyes of 60 patients who had undergone cataract surgery within the past 3 months were enrolled. After standard postoperative therapy with econopred and cravit for 1 week, patients were assigned to three groups: artificial tears + fluorometholone 0.1% (20 eyes), topical cyclosporine 0.05% starting 2 weeks preoperatively and continuing for 6 weeks postoperatively (19 eyes), and control with no additional treatment (21 eyes). Ocular surface disease index (OSDI), tear meniscus height (TMH), noninvasive keratograph tear breakup time (NIKBUT), and redness score (RS) were assessed preoperatively and at 1 week and 1 month postoperatively. **Results:** The cyclosporine group showed significant improvements in OSDI and TMH over time, with better outcomes at 1 month compared with the other groups. NIKBUT and RS declined postoperatively in all groups, but the decrease was more pronounced in the artificial tears + fluorometholone and control groups. Cyclosporine did not improve NIKBUT or RS. **Conclusion:** Topical cyclosporine 0.05% demonstrated superior benefits in relieving post-cataract surgery dry eye symptoms compared with artificial tears + fluorometholone or no treatment, though larger studies are needed to confirm its efficacy.

Key words: Cataract surgery, cyclosporine, dry eye disease

INTRODUCTION

Cataract surgery is a common procedure aimed at removing cataracts to restore vision and improve visual quality. However, some patients often experience postoperative dry eye, which leads to discomfort such as eye pain, burning sensation, and blurred vision. This can cause patients to feel that the outcomes of the cataract surgery are less satisfactory.[1] The main causes of postoperative dry eye include improper use of eye drops, damage to corneal nerves, and irregularities on the ocular surface.[2,3]

Topical cyclosporine 0.05% is an immunomodulatory agent with anti-inflammatory effects that has been proven beneficial for treating dry eye. Numerous clinical studies have shown positive outcomes with cyclosporine 0.05% for dry eye syndrome by reducing inflammation on the ocular surface.[4-6]

Many studies have focused on the anti-inflammatory effects of topical cyclosporine in treating dry eye syndrome.[5,7] However, relatively few studies have examined its use in treating dry eye in patients after cataract surgery. Therefore, this study aimed to evaluate the effect of topical cyclosporine 0.05% on dry eye symptoms associated with cataract surgery.

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MATERIALS AND METHODS

Ethical approval statement

The study was conducted in accordance with the Declaration of Helsinki and approved by the Institutional Review Board (IRB) of Tri-Service General Hospital (B202205197) and approved on 12/19/2022. The informed consent was waived by the IRB.

Settings and design

The patients' basic personal and medical data were recorded. All patients underwent dry eye assessments before cataract surgery as well as 1 week and 1 month after surgery. The ocular surface disease index (OSDI) questionnaire was administered before the ocular examination. OSDI scores range from 0 to 100, and the patients were categorized into normal (0–12 points), mild (13–22 points), moderate (23–32 points), and severe (33–100 points) groups according to previously published guidelines.[8] Furthermore, all patients underwent dry eye examinations using Oculus Keratograph (K5 M; Oculus GmbH, Wetzlar, Germany) for the evaluation of tear meniscus height (TMH), noninvasive keratograph tear break-up time (NIKBUT), and redness scores (RS).

Participants

All participants were aged 55 or older and had visited this tertiary medical center in Taiwan for unilateral cataract surgery between September 2022 and March 2023. The surgical procedure involved phacoemulsification with posterior chamber intraocular lens implantation. Patients were excluded if they had active ocular inflammation; recent ocular surface or eyelid surgery within the past 3 months; a history of ocular trauma, pinguecula, or pterygium; a prior history of dry eye; or any use of eye drops within the past week. All patients received routine postoperative treatment, including econopred and cravit eye drops for 1 week. Subsequently, patients in the cyclosporine 0.05% group began using 0.05% cyclosporine eye drops twice daily, 2 weeks before cataract surgery, and continued for 6 weeks after surgery. Patients in the artificial tear group received artificial tears and 0.1% fluorometholone eye drops four times daily for 6 weeks. In addition, patients in the control group did not receive artificial tears or cyclosporine 0.05% eye drops postoperatively.

Statistical analysis

Data were expressed as means ± standard deviation and were analyzed using SPSS version 23 (SPSS Inc., Chicago, USA). The paired *t*-test was used to compare pre- and postoperative dry eye parameters. One-way analysis of variance and the Kruskal–Wallis test were used to evaluate the outcomes in different groups. Statistical significance was defined as a $P < 0.05$.

RESULTS

Demographics and baseline parameters

This study included 60 eyes of 60 patients: 19 eyes of 19 patients in the cyclosporine 0.05% group, 20 eyes of 20 patients in the artificial tear group, and 21 eyes of 21 patients in the control group. This study included 28 women (47%) and 32 men (53%). Table 1 compares the demographic characteristics and baseline dry eye parameters between the cyclosporine 0.05%, artificial tears + fluorometholone 0.1%, and control groups. The mean age and sex distributions were similar across the three groups, with no statistically significant differences ($P = 0.1$). The baseline OSDI scores were significantly lower in the cyclosporine group than in the artificial tears + fluorometholone 0.1% and control groups ($P = 0.001$). The NIKBUT was also significantly higher in the cyclosporine group than in the artificial

Table 1: Comparison of demographic characteristics and dry eye parameters before surgery among the cyclosporine 0.05%, artificial tears, and control groups

	Cyclosporine 0.05% group (*n*=19 eyes), mean±SD	Artificial tears + fluorometholone 0.1% (*n*=20 eyes), mean±SD	Control group (*n*=21 eyes), mean±SD	*P*
Age (years)	64.42±7.97	65.45±6.28	69.05±6.9	0.1
Sex				
Male/female	12/7	11/9	9/12	
OSDI	16.25±15.49	28.39±12.26	29.17±3.02	0.001**
TMH	0.27±0.14	0.19±0.14	0.26±0.15	0.173
NIKBUT	14.06±6.82	12.26±5.04	7.69±6.14	0.004**
RS	1.31±0.67	1.59±0.41	2.35±1.13	<0.001**

SD=Standard deviation; OSDI=Ocular surface disease index; TMH=Tear meniscus height; NIKBUT=Noninvasive keratograph tear break-up time; RS=Redness score, *P<0.05; **P<0.01; ***P<0.001

tears + fluorometholone 0.1% and control groups ($P = 0.004$). RS were the lowest in the cyclosporine group and were significantly different from those in the artificial tears + fluorometholone 0.1% and control groups ($P < 0.001$). However, no significant differences were observed in baseline TMH among the groups ($P = 0.173$).

Changes in ocular surface disease index scores

The changes in OSDI scores over time are presented in Table 2 and Figure 1a. One week postoperatively, all groups showed a reduction in OSDI scores, with the cyclosporine group demonstrating the greatest improvement. At 1 month, the OSDI scores in the cyclosporine group were significantly lower than those in the artificial tears + fluorometholone 0.1% and control groups ($P < 0.001$). Within-group comparisons revealed that the improvement in OSDI from baseline was significant in the artificial tears + fluorometholone 0.1% ($P < 0.001$) and control groups ($P < 0.001$), but was most pronounced in the cyclosporine group.

Changes in tear meniscus height

As shown in Table 3 and Figure 1b, TMH decreased in all groups 1 week after surgery, with the most substantial decline observed in the control group. At 1 month, the TMH in the cyclosporine group recovered to near preoperative levels, which was significantly higher than that in the control group ($P = 0.001$). The artificial tears + fluorometholone 0.1% group also demonstrated partial recovery, but the recovery remained lower than that in the cyclosporine group.

Changes in NIKBUT

The changes in NIKBUT over time are presented in Table 4 and Figure 1c. One week postoperatively, NIKBUT increased in both the cyclosporine and control groups, whereas it decreased in the artificial tears + fluorometholone 0.1% group, with a statistically significant difference ($P = 0.004$). One month postoperatively, NIKBUT decreased in all three groups, with a statistically significant difference ($P < 0.001$). One month after surgery, the NIKBUT in all three groups was lower than the preoperative levels. However, a statistically significant decrease was observed only in the artificial tears + fluorometholone 0.1% and control groups, with $P = 0.016$ and <0.001, respectively.

Changes in RS

As shown in Table 5 and Figure 1d, RS decreased in all groups 1 week after surgery, with the most substantial decline observed in the control group. One month after surgery, the RS in both the cyclosporine and control groups increased compared with 1 week postoperatively. In addition, the cyclosporine group showed a slight increase in RS compared with the preoperative value, but the difference was not statistically significant ($P = 0.26$). Further percentage change analyses and clinical interpretations of TMH, NIKBUT, and RS are provided in Appendix 1 and 2 for supplementary reference.

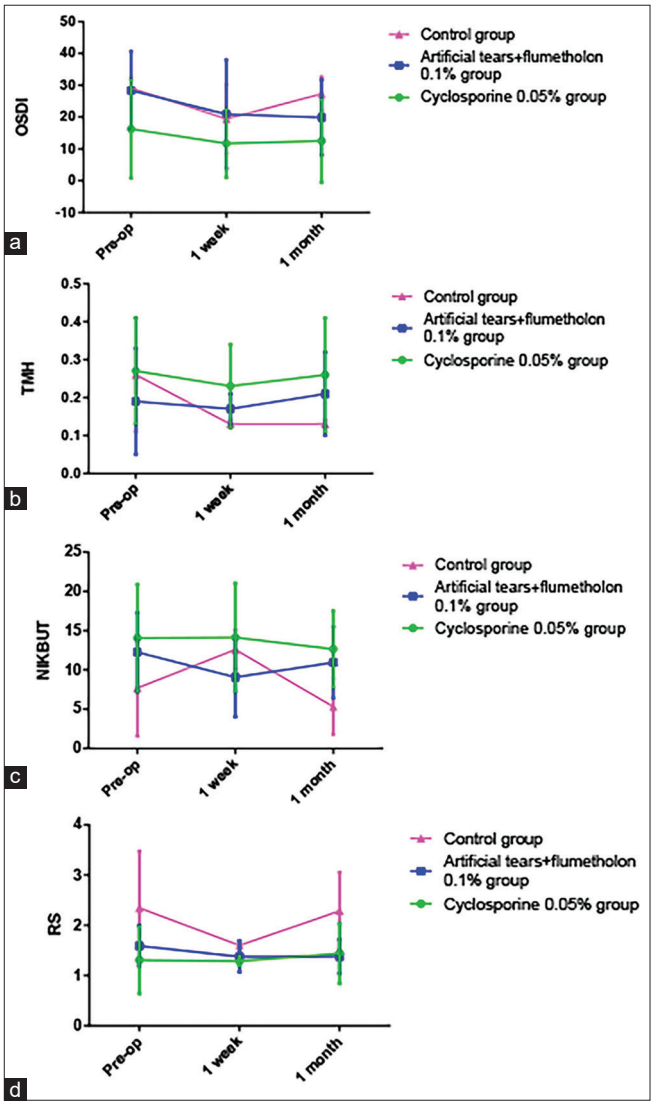

Figure 1: (a) Changes in the ocular surface disease index scores over time among the three groups (b) Changes in the tear meniscus height over time among the three groups (c) Changes in the noninvasive keratograph tear break-up time, among the three groups (d) Changes in the redness score over time among the three groups. OSDI = Ocular surface disease index, TMH = Tear meniscus height, NIKBUT = Noninvasive keratograph tear break-up time,, RS = Redness score

DISCUSSION

This study focused on the efficacy of topical cyclosporine 0.05% in patients with dry eye symptoms after cataract

Table 2: Changes in ocular surface disease index scores among the cyclosporine 0.05%, artificial tears, and control groups at different visits

	Cyclosporine 0.05% (*n*=19 eyes), mean±SD	Artificial tears + fluorometholone 0.1% (*n*=20 eyes), mean±SD	Control (*n*=21 eyes), mean±SD	*P*
Preoperative	16.25±15.49	28.39±12.26	29.17±3.02	0.001**
1 week	11.74±10.71	20.94±17.07	19.42±10.78	0.075
1 month	12.5±13.01	19.9±11.86	27.33±5.38	<0.001***
P	0.379	<0.001***	<0.001***	

*P<0.05; **P<0.01; ***P<0.001. SD=Standard deviation

Table 3: Changes in tear meniscus height among the cyclosporine 0.05%, artificial tears, and control groups at different visits

	Cyclosporine 0.05% (*n*=19 eyes), mean±SD	Artificial tears + fluorometholone 0.1% (*n*=20 eyes), mean±SD	Control (*n*=21 eyes), mean±SD	*P*
Preoperative	0.27±0.14	0.19±0.14	0.26±0.15	0.173
1 week	0.23±0.11	0.17±0.04	0.13±0.01	<0.001***
1 month	0.26±0.15	0.21±0.11	0.13±0.01	0.001**
P	0.41	0.005**	0.001**	

**P<0.01; ***P<0.001. SD=Standard deviation

Table 4: Changes in Noninvasive keratograph tear break-up time among the cyclosporine 0.05%, artificial tears, and control groups at different visits

	Cyclosporine 0.05% (*n*=19 eyes), mean±SD	Artificial tears + fluorometholone 0.1% (*n*=20 eyes), mean±SD	Control (*n*=21 eyes), mean±SD	*P*
Preoperative	14.06±6.82	12.26±5.04	7.69±6.14	0.004**
1 week	14.14±6.92	9.08±5.06	12.59±2.53	0.009**
1 month	12.66±4.87	10.94±4.54	5.33±3.58	<0.001***
P	0.71	0.016*	<0.001***	

*P<0.05; **P<0.01; ***P<0.001. SD=Standard deviation

Table 5: Changes in redness scores among the cyclosporine 0.05%, artificial tears, and control groups at different visits

	Cyclosporine 0.05% (*n*=19 eyes), mean±SD	Artificial tears + fluorometholone 0.1% (*n*=20 eyes), mean±SD	Control (*n*=21 eyes), mean±SD	*P*
Preoperative	1.31±0.67	1.59±0.41	2.35±1.13	<0.001***
1 week	1.29±0.10	1.38±0.31	1.6±0.1	0.015*
1 month	1.44±0.6	1.38±0.34	2.29±0.77	<0.001***
P	0.26	<0.001***	<0.001***	

*P<0.05; ***P<0.001. SD=Standard deviation

surgery. Dry eye symptoms are commonly observed after cataract surgery.[1,3] Li *et al*. reported that some patients who did not experience dry eye before cataract surgery developed symptoms. In addition, in some cases, preexisting dry eye symptoms worsen following surgery. These symptoms were most noticeable 1 month after the procedure. [1] Furthermore, Cho and Kim investigated changes in dry eye symptoms and diagnostic test values after cataract surgery in dry eye and nondry eye groups. All dry eye test values were significantly worse after cataract surgery in the nondry eye group.[3] The dry eye condition results from various factors, such as improper use of eye drops, damage to corneal nerves at the incision site that reduces the blink reflex, disruption of the ocular surface caused by the incision impacting tear film stability, and injury to conjunctival goblet cells during surgery, which decreases mucin production in the tear film.[2,3]

Li *et al*.[1] conducted impression cytology in patients after cataract surgery and found similar results to those observed in patients with keratoconjunctivitis sicca, suggesting a possible shared pathology between dry eye following cataract surgery

and keratoconjunctivitis sicca. Their study also showed a reduction in tear film breakup time and Schirmer test I scores in the postoperative phase, along with squamous metaplasia in the conjunctival epithelium and a decrease in goblet cell density. In contrast, although impression cytology was not performed in this study, TMH levels were decreased in all groups 1 week after surgery, with the most substantial decline observed in the control group. At 1 month, the TMH in the cyclosporine group recovered to near preoperative levels, which were significantly higher than those in the artificial tears + fluorometholone 0.1% and control groups. These findings suggest that cyclosporine enhances tear volume stabilization postoperatively compared with artificial tears + fluorometholone 0.1% or no treatment.

Dry eye disease is a multifactorial disease of the ocular surface characterized by a loss of homeostasis of the tear film and is accompanied by ocular symptoms, in which tear film instability and hyperosmolarity, ocular surface inflammation and damage, and neurosensory abnormalities play etiological roles.[9] Topical cyclosporine 0.05% is an anti-inflammatory medication used to treat dry eye disease, which was introduced to the market in 2002. A Cochrane Review in 2019 indicated that the treatment outcomes of topical cyclosporine on dry eye parameters and subjective questionnaires in patients with dry eye were inconsistent. In some cases, no significant differences were observed between the effects of topical cyclosporine and those of artificial tears or the control group.[10] This result is similar to the findings of the present study. The topical cyclosporine 0.05% and artificial tears + fluorometholone 0.1% groups showed a trend of improvement in OSDI and TMH 1 month after surgery compared to the control group in this study. Furthermore, the artificial tears + fluorometholone 0.1% group showed a significant improvement in RS 1 month postoperatively compared to preoperative levels, whereas the topical cyclosporine 0.05% group showed no significant difference.

The review considered that topical cyclosporine may experience a higher incidence of nonserious, treatment-related adverse effects, particularly burning sensations.[10] In this study, although an improvement was observed in the OSDI scores in the topical cyclosporine 0.05% group, statistical significance was not reached. This lack of significance may also be related to the side effects of burning sensations, which could have impacted the patients' perception of symptom improvement. Furthermore, although NIKBUT in the cyclosporine group did not show a significant increase 1 month after surgery, and the control group exhibited an increasing trend at the 1-month postoperative mark, this may be due to the fact that the therapeutic effects of cyclosporine require a longer duration to manifest. In addition, it could be related to the natural variations in tear film stability among patients.

One study also found that topical cyclosporine may increase the number of conjunctival goblet cells, which are responsible for mucus production in the eye.[11] It remains unclear whether an increase in goblet cells can directly correlate with an increase in the mucin component of the tear film, thus directly improving dry eye symptoms. Because it is currently not possible to directly quantify mucin secretion, this relationship cannot be definitively established.

This study has some limitations. First, the small sample size may have affected the validity of the results. Second, the follow-up period was relatively short, which may have limited our understanding of the long-term therapeutic effects of topical cyclosporine. A longer observation period may be necessary to fully evaluate its effectiveness in treating dry eye symptoms. Third, this study is a retrospective study, and therefore, the random nature of patient recruitment in retrospective studies may result in variations in baseline characteristics, including gender distribution. Fourth, some patients may experience mild transient irritation upon initiation of cyclosporine treatment, which could momentarily affect their subjective symptom scores, including OSDI. This could partially explain why OSDI improvement might not be as pronounced as expected in the early phase of treatment. Finally, because the study design was retrospective, the causal relationship between topical cyclosporine and its therapeutic effect on dry eye disease may not have been fully established.

CONCLUSION

Topical cyclosporine 0.05% may be more effective in improving certain dry eye parameters than artificial tears + fluorometholone 0.1% or no treatment. Specifically, the cyclosporine group showed significant improvements in OSDI and TMH over time, with better outcomes at 1 month postoperatively than the artificial tears + fluorometholone 0.1% and control groups. Although all groups experienced a decline in NIKBUT and RS postoperatively, the artificial tears + fluorometholone 0.1% and control groups showed a more pronounced decrease. The stability of these parameters in the cyclosporine group suggests the potential benefit of cyclosporine in the management of dry eye symptoms following surgery. However, further long-term studies are warranted to confirm these findings and better understand the role of cyclosporine in postoperative dry eye management.

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Data availability statement

The corresponding author (YMC) had full access to all the data in the study and was responsible for the integrity and accuracy of the data analysis.

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Nil.

Conflicts of interest
There are no conflicts of interest.

REFERENCES

1. Li XM, Hu L, Hu J, Wang W. Investigation of dry eye disease and analysis of the pathogenic factors in patients after cataract surgery. Cornea 2007;26:S16-20.
2. Jensen P, Nilsen C, Gundersen M, Gundersen KG, Potvin R, Gazerani P, *et al*. A preservative-free approach – Effects on dry eye signs and symptoms after cataract surgery. Clin Ophthalmol 2024;18:591-604.
3. Cho YK, Kim MS. Dry eye after cataract surgery and associated intraoperative risk factors. Korean J Ophthalmol 2009;23:65-73.
4. Chung YW, Oh TH, Chung SK. The effect of topical cyclosporine 0.05% on dry eye after cataract surgery. Korean J Ophthalmol 2013;27:167-71.
5. Wilson SE, Perry HD. Long-term resolution of chronic dry eye symptoms and signs after topical cyclosporine treatment. Ophthalmology 2007;114:76-9.
6. Donnenfeld E, Pflugfelder SC. Topical ophthalmic cyclosporine: Pharmacology and clinical uses. Surv Ophthalmol 2009;54:321-38.
7. Akpek EK, Wirta DL, Downing JE, Tauber J, Sheppard JD, Ciolino JB, *et al.* Efficacy and safety of a water-free topical cyclosporine, 0.1%, solution for the treatment of moderate to severe dry eye disease: The ESSENCE-2 randomized clinical trial. JAMA Ophthalmol 2023;141:459-66.
8. Walt J. Ocular Surface Disease Index (OSDI) Administration and Scoring Manual. Irvine, California: Allergan Inc; 2004.
9. Craig JP, Nichols KK, Akpek EK, Caffery B, Dua HS, Joo CK, *et al.* TFOS DEWS II definition and classification report. Ocul Surf 2017;15:276-83.
10. de Paiva CS, Pflugfelder SC, Ng SM, Akpek EK. Topical cyclosporine A therapy for dry eye syndrome. Cochrane Database Syst Rev 2019;9:CD010051.
11. Kunert KS, Tisdale AS, Gipson IK. Goblet cell numbers and epithelial proliferation in the conjunctiva of patients with dry eye syndrome treated with cyclosporine. Arch Ophthalmol 2002;120:330-7.

SUPPLEMENTARY FILE

Appendix 1

(1) TMH Percentage Change among the cyclosporine 0.05%, artificial tears, and control groups at different visits

	Cyclosporine 0.05%, mean±SD	Artificial tears + fluorometholone 0.1%, mean±SD	Control, mean±SD
1-week change	0.85±0.09	0.89±0.04	0.5±0.01
1-month change	0.96±0.56	1.11±0.12	0.5±0.01

SD=Standard deviation

*Short-term (1 week)

1. Control group (50%): TMH decreased significantly, indicating severe tear deficiency in the short term after surgery.
2. Artificial tears + fluorometholone group (89%): Slight improvement in TMH, but not fully recovered.
3. Cyclosporine group (85%): Similar to the artificial tears group, with limited improvement in the short term.

*Long-term (1 month)

1. Cyclosporine group (96%): TMH returned close to preoperative levels, suggesting a possible delayed effect.
2. Artificial tears + fluorometholone group (111%): TMH exceeded the preoperative value, indicating a potential role in promoting tear production.
3. Control group (50%): TMH remained below the preoperative level, suggesting that without treatment, tear volume does not recover naturally.

*Clinical Significance

1. Artificial tears + fluorometholone can protect TMH in the short term and even exceed baseline levels after 1 month, demonstrating good moisturizing and anti-inflammatory effects.
2. Cyclosporine has little short-term impact but restores TMH close to preoperative levels after 1 month, suggesting a slower therapeutic effect.
3. Control group patients showed no spontaneous recovery of TMH, indicating that without treatment, dry eye symptoms may persist after surgery.

(2) NIKBUT Percentage Change among the cyclosporine 0.05%, artificial tears + fluorometholone 0.1%, and control groups at different visits

	Cyclosporine 0.05%, mean±SD	Artificial tears + fluorometholone 0.1, mean±SD	Control, mean±SD
1-week change	1.01±6.96	0.74±3.75	1.64±4.14
1-month change	0.9±4.39	0.89±4.05	0.69±2.48

SD=Standard deviation

*Short-term (1 week)

1. Control group (164%): NIKBUT unexpectedly increased in the short term, possibly due to a physiological compensatory effect after surgery.
2. Artificial tears + fluorometholone group (74%): NIKBUT decreased in the short term, indicating poor short-term effectiveness.
3. Cyclosporine group (101%): Minimal change in NIKBUT in the short term, showing limited impact on tear film stability.

*Long-term (1 month)

1. Cyclosporine group (90%): NIKBUT decreased by 10%, suggesting poor long-term effectiveness.
2. Artificial tears + fluorometholone group (89%): NIKBUT decreased by 11%, indicating limited long-term impact on tear film stability.
3. Control group (69%): NIKBUT decreased by 31%, showing that without treatment, tear film stability significantly deteriorates.

*Clinical Significance

1. Cyclosporine has little short-term impact on NIKBUT and does not show significant improvement in the long term, suggesting a limited effect on tear film stability.
2. Artificial tears + fluorometholone not only failed to improve NIKBUT in the short term but also did not restore it after one month, indicating limited benefits for tear film stability.
3. Control group patients showed a significant 31% decrease in NIKBUT after one month, suggesting that without treatment, tear breakup time will continue to decline, potentially worsening dry eye symptoms.

(3) RS Percentage Change among the cyclosporine 0.05%, artificial tears + fluorometholone 0.1%, and control groups at different visits

	Cyclosporine 0.05%, mean±SD	Artificial tears + fluorometholone 0.1%, mean±SD	Control, mean±SD
1-week change	0.98±0.1	0.87±0.27	0.68±0.07
1-month change	1.1±0.66	0.87±0.3	0.97±0.75

SD=Standard deviation

*Short-term (1 week):

1. The control group showed the most significant natural reduction in redness (32% decrease).
2. The artificial tears + fluorometholone group had some redness reduction (13% decrease) but with considerable individual variability.
3. The cyclosporine group had little impact on redness in the short term (98%).

*Long-term (1 month):

1. The cyclosporine group showed a slight increase in redness (110%), with large individual differences.
2. The artificial tears + fluorometholone group remained at 87%, with no further improvement.
3. The control group returned to near preoperative levels (97%), but with high variability.

*Clinical significance:

1. These results suggest that redness may naturally subside over time, and specific drug interventions may not be necessary.
2. Artificial tears + fluorometholone may help in the short term, but the effect is not significant.
3. Cyclosporine may have little impact on redness, and in some cases, redness may even worsen after one month.

Appendix 2

*Cyclosporine group

	OSDI	*P*	TMH	*P*	NIKBUT	*P*	Red value	*P*
Pre	16.25±15.49	-	0.27±0.14	-	14.06±6.82	-	1.31±0.67	-
1 week	11.74±10.71	0.26 (pre-1 week)	0.23±0.11	0.18 (pre-1 week)	14.14±6.92	0.97 (pre-1 week)	1.29±0.50	0.91 (pre-1 week)
1 month	12.5±13.01	0.27 (pre-1 month)	0.26±0.15	0.64 (pre-1 month)	12.66±4.87	0.51 (pre-1 month)	1.44±0.60	0.24 (pre-1 month)
-	-	0.81 (1 week–1 month)	-	0.43 (1 week–1 month)	-	0.42 (1 week–1 month)	-	0.09 (1 week–1 month)

OSDI=Ocular surface disease index; TMH=Tear meniscus height; NIKBUT=Noninvasive keratograph tear break-up time

*AT + FML group

	OSDI	*P*	TMH	*P*	NIKBUT	*P*	Red value	*P*
Pre	28.39±12.26	-	0.19±0.14	-	12.26±5.04	-	1.59±0.41	-
1 week	20.94±17.07	0.01* (pre-1 week)	0.17±0.04	0.43 (pre-1 week)	9.08±5.06	0.02* (pre-1 week)	1.38±0.31	0.001* (pre-1 week)
1 month	19.9±11.86	< 0.001*** (pre-1 month)	0.20±0.11	0.69 (pre-1 month)	10.94±4.54	0.06 (pre-1 month)	1.38±0.34	< 0.001*** (pre-1 month)
-	-	0.41 (1 week–1 month)	-	0.56 (1 week–1 month)	-	0.01* (1 week–1 month)	-	1 (1 week–1 month)

OSDI=Ocular surface disease index; TMH=Tear meniscus height; NIKBUT=Noninvasive keratograph tear break-up time

*Control group

	OSDI	*P*	TMH	*P*	NIKBUT	*P*	Red value	*P*
Pre	29.17±3.02	-	0.26±0.15	-	7.69±6.14	-	2.35±1.13	-
1 week	19.42±10.78	< 0.001*** (pre-1 week)	0.13±0.01	< 0.001*** (pre-1 week)	12.59±2.53	0.02* (pre-1 week)	1.60±0.10	0.003* (pre-1 week)
1 month	27.33±5.38	0.25 (pre-1 month)	0.13±0.01	< 0.001*** (pre-1 month)	5.33±3.58	0.001** (pre-1 month)	2.29±0.77	0.40 (pre-1 month)
-	-	< 0.01** (1 week–1 month)	-	N/A (1 week–1 month)	-	< 0.001*** (1 week–1 month)	-	< 0.001*** (1 week–1 month)

OSDI=Ocular surface disease index; TMH=Tear meniscus height; NIKBUT=Noninvasive keratograph tear break-up time; N/A=Not available