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Clinical science

Outcomes of low-level light therapy before and after cataract surgery for the prophylaxis of postoperative dry eye: a prospective randomised double-masked controlled clinical trial

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ABSTRACT

Background Despite increasing evidence shows that optimising ocular surface before cataract surgery is fundamental in patients with pre-existing dry eye disease (DED) to achieve the desired postoperative outcomes, the prophylactic treatment of healthy patients undergoing surgery aiming at preventing iatrogenic DED is worth investigating.

Methods This was a prospective, interventional, randomised, controlled, double-masked clinical trial. Patients were randomly assigned 1:1 to receive either low-level light therapy (LLLT) or sham treatment (LLLT with a power output <30%). Patients underwent two treatment sessions: 7±2 days before cataract surgery (T0) and 7±2 days after (T1). Outcome measures evaluated 30±4 days after surgery (T2) included Ocular Surface Disease Index (OSDI) questionnaire, non-invasive break-up time (NIBUT), tear meniscus height, meibomian gland loss (MGL) and redness score.

Results Out of 153 patients randomised to receive LLLT (n=73) or sham treatment (n=80), 131 (70 men, 61 women, mean age 73.53±7.29 years) completed regularly the study. Patients treated with LLLT had significantly lower OSDI scores compared with controls at T1 and T2 (respectively, 7.2±8.8 vs 14.8±13.0 and 9.0±9.0 vs 18.2±17.9; both p<0.001), higher NIBUT values at T2 (12.5±6.6 vs 9.0±7.8; p=0.007) and lower MGL Meiboscore values at T1 (1.59±0.70 vs 1.26±0.69; p=0.008). Unlike controls, patients treated with LLLT had significantly lower OSDI scores and higher NIBUT values at T2 compared with T0 (respectively, 9.0±9.0 vs 21.2±16.1; p<0.001 and 12.5±6.6 vs 9.7±7.2; p=0.007).

Conclusion Two sessions of LLLT performed before and after cataract surgery were effective in ameliorating tear film stability and ocular discomfort symptoms.

Trial registration number NCT05754437.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Signs and symptoms of dry eye disease (DED) are highly prevalent in the postoperative course of patients undergoing cataract surgery, significantly impairing patients' satisfaction with surgery and quality of life and vision. Although optimising ocular surface before cataract surgery in patients with pre-existing DED is an established strategy to achieve the desired postoperative outcomes, less is known about the prophylactic treatment of healthy patients.

WHAT THIS STUDY ADDS

⇒ In this randomised controlled trial, two sessions of low-level light therapy performed 1 week before and after cataract surgery were effective in ameliorating tear film stability and ocular discomfort symptoms.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Prophylactic treatment using low-level light therapy could be easily incorporated in the workflow of otherwise healthy patients undergoing senile cataract surgery in order to avoid iatrogenic DED.

INTRODUCTION

Despite cataract surgery is widely recognised as one of the safest and most successful surgical procedures in modern medicine, it represents one of the main causes of iatrogenic dry eye disease (DED).[1 2] DED tends to manifest in the first postoperative week and may often last 3–6 months after surgery.[3] Moreover, dry eye symptoms such as pain, foreign body sensation, photophobia, visual fatigue, epiphora and fluctuating or blurry vision significantly impact patient satisfaction and impair quality of vision postoperatively.[4]

Despite increasing evidence showing that the optimisation of the ocular surface before cataract surgery represents a crucial step to achieve the desired postoperative outcomes,[5–7] the prophylactic treatment of otherwise asymptomatic patients undergoing cataract surgery with the aim of preventing or mitigating iatrogenic DED is less studied and is worth investigating.[8–10]

Low-level light therapy (LLLT) is a particular form of photobiomodulation based on light-emitting

diodes. Sending low incident levels of photon energy, which is transferred directly to the absorbing cell or chromophore, LLLT determines photoactivation of the target cells thus repairing cellular damage and improving function and proliferation thanks to the increase ATP production.[11] Several studies have demonstrated the safety and efficacy of in-office LLLT in the setting of DED secondary to different aetiologies.[12–15]

Herein, we investigated the outcomes of LLLT performed before and after cataract surgery in healthy patients as a prophylactic treatment of iatrogenic DED.

MATERIALS AND METHODS

Study and patients

This prospective, interventional, randomised, controlled, double-masked clinical trial involved patients who had been scheduled for routine cataract surgery. The trial was conducted at the Department of Ophthalmology of the University Magna Graecia of Catanzaro (Italy), according to the guidelines of the Declaration of Helsinki. The study was registered in the United States trial register as the 'Efficacy of Low-Level Light Therapy in Reducing Dry Eye in Patients Undergoing Cataract Surgery' (ClinicalTrials.gov identifier, NCT05754437). Patients were recruited between September 2022 and March 2023, and written informed consent was obtained from all participants. Exclusion criteria were previous diagnosis of ocular surface disease (OSD) or DED, ocular comorbidities, previous ocular surgery in both eyes, chronic and regular use of therapies for OSD or DED (topical, instrumental or oral), use of systemic drugs with a known or suspected link to DED (eg, diuretics, antidepressants, antihistamines, hormone replacement therapy)[16] and autoimmune diseases (eg, Sjögren syndrome). Only one eye per patient was enrolled in the study.

Ocular surface workup

In all eligible patients, medical history was recorded and a comprehensive ophthalmic examination including slit lamp examination was performed. Non-invasive ocular surface examination was carried out in the eye undergoing cataract surgery by means of Oculus Keratograph 5 M (K5 M; Oculus GmbH, Wetzlar, Germany) by a trained operator (CR) three times over the study period: 7±2 days prior to surgery (before the first LLLT/sham session—T0), 7±2 days after surgery (before the second LLLT/sham session—T1) and 30±4 days after surgery (T2) (figure 1). All the measurements were taken between 09:00 and 11:00 in a dimly lit room with controlled temperature (21–24°C) and humidity (30%–60%). The device was used for the evaluation of: (1) tear meniscus height (TMH); (2) non-invasive break-up time (NIBUT); (3) infrared meibography of the lower eyelid and (4) redness score. In detail, images of the central inferior lid margin were captured with infrared illumination and TMH was measured in millimetres (mm) using the device's built-in caliper. NIBUT was measured using Placido rings as the interval time in seconds (s) between the last complete blinking and the first distortion of the 22 concentric rings reflected on the corneal surface. Infrared transillumination of the lower eyelid was used to evaluate meibomian gland loss (MGL) that was graded using the Meiboscore: grade 0=no gland loss; grade 1=area of gland loss up to 33% of the total gland area; grade 2=area of gland loss between 33% and 66% and grade 3=area of gland loss of 67% or more.[17] MGL grading was performed by two masked investigators, and a third one was involved in case of disagreement to calculate the definite grade. Five redness scores (global, nasal bulbar, temporal bulbar, nasal limbal and temporal limbal) obtained from an anterior segment photograph were graded based on ratio between blood vessels and the rest of the analysed bulbar conjunctiva; the global redness score was used for the statistical analysis. Ocular discomfort symptoms were investigated by means of Ocular Surface Disease Index (OSDI) questionnaire.

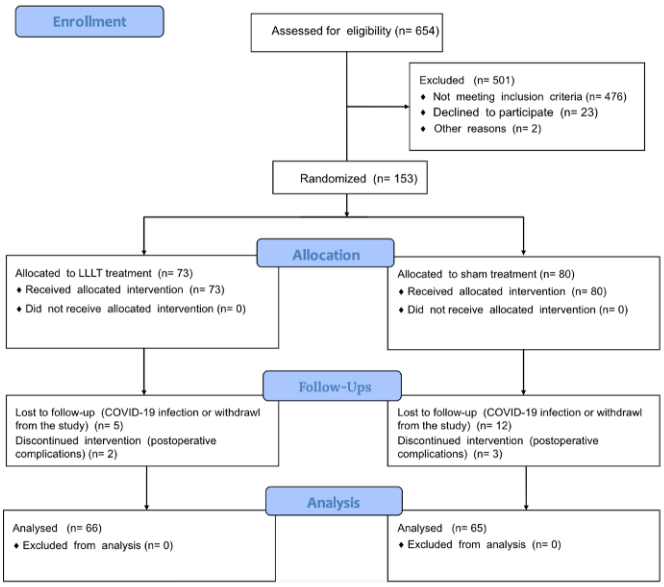

Figure 1 CONSORT flow diagram for the randomised controlled study. Number of patients screened for eligibility, randomised and then followed-up for the entire study duration. CONSORT, Consolidated Standards of Reporting Trials; LLLT, low-level light therapy.

Treatment

LLLT or sham treatments were performed using different modules available on the device EYE-LIGHT ® (Espansione Group S.p.A., Bologna, Italy). Both treatments had a duration of 15 min and differed for power output: 100% for treatment group versus <30% for sham. The latter protocol (demo light) has been shown to have no effects on target tissue(s) in experimental tests (data provided by Espansione Group S.p.A., Bologna, Italy); at the same time, the sham modality looks like a normal treatment for both the operator and the patient. No eye shields were required for this procedure and patients were instructed to keep their eye closed to ensure a complete treatment of the upper and lower eyelids. Treatments were performed 7±2 days before (T0) and after surgery (T1).

All patients underwent conventional phacoemulsification by two surgeons (GG, VS). All surgeries were performed using the same technique ('phaco chop') under topical anaesthesia through a 2.4 mm clear corneal incision with implantation of a foldable intraocular lens within the capsular bag. Only eyes with no relevant intra or postoperative complications were included in the analysis. The postoperative drug regimen consisted of the following eye drops: dexamethasone sodium phosphate 1 mg/mL+levofloxacin hemihydrate 5 mg/mL (Ducressa, Santen, Osaka, Japan) four times daily for 7 days switched to dexamethasone sodium phosphate 1 mg/1 mL (Dexamono, Théa Pharma, Clermont Ferrand, France) four times daily for the subsequent 7 days; bromfenac sodium 0.9 mg/mL (Yellox, Bausch & Lomb, New York, USA) two times daily for 14 days; 0.2% hyaluronic acid (Hyalistil, Catania, Italy) three times daily for 30 days.

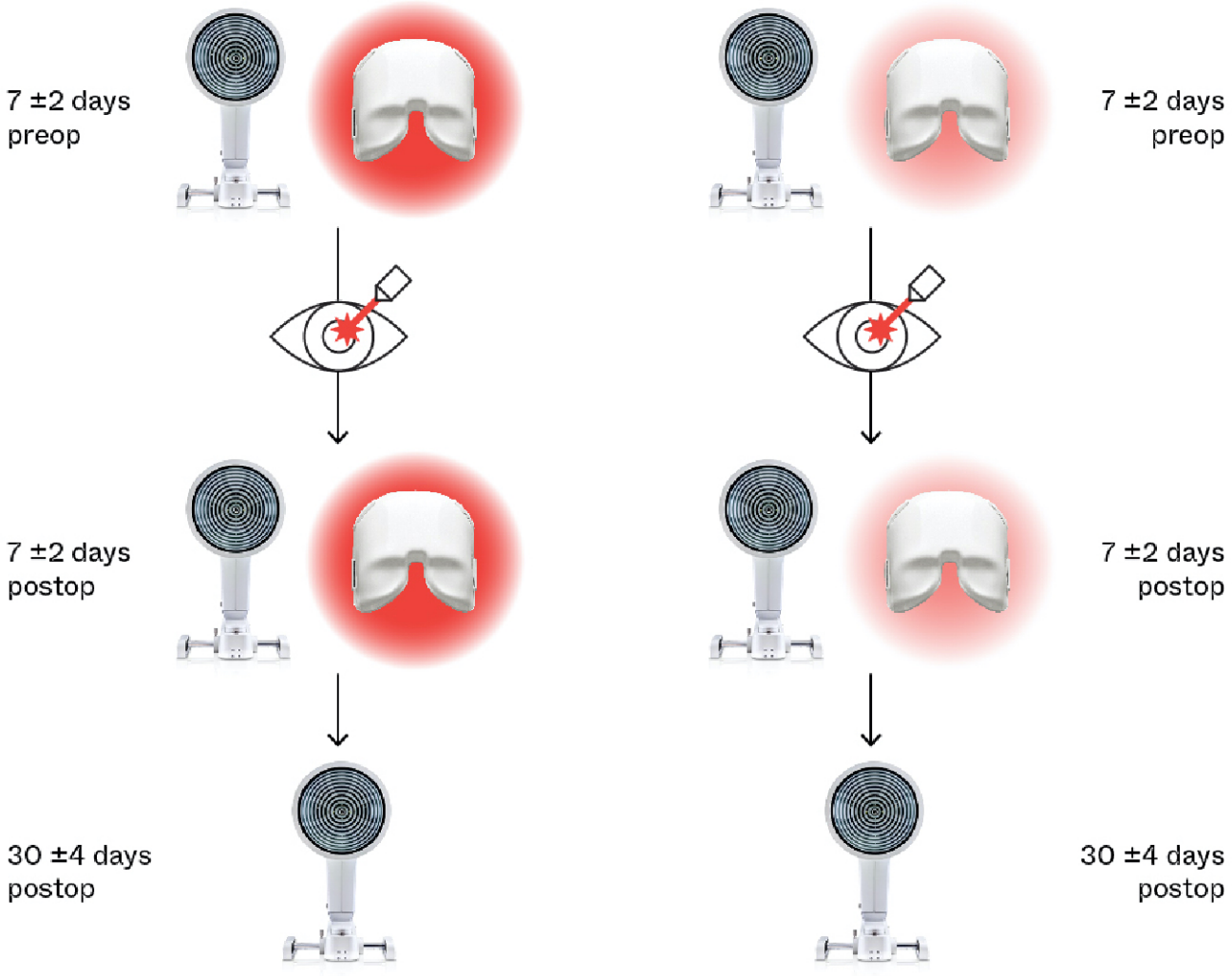

Figure 2 Schematic representation of the timing of ocular surface workup and treatments. One week before and after cataract surgery, patients underwent ocular surface workup by means of Keratograph followed by low-level light therapy (left) or sham (right). One month postoperatively, both groups underwent final ocular surface examination.

Outcomes

The primary endpoint with respect to the effect of LLLT performed before and after cataract surgery was the change in NIBUT from T0 to T2. The secondary endpoints were the changes in ocular discomfort symptoms, TMH, MGL and redness from T0 to T2.

Sample size

Sample size calculation was based on the difference in break-up time 1 months after cataract surgery reported in a previous study that compared patients treated preoperatively with vector thermal pulsation therapy and control subjects.[6] On this basis, a minimum sample size of 65 patients per group was required to achieve a power of 0.80 and a p value of 0.05 using the Mann-Whitney U test.

Randomisation and blinding

Patients were randomised 1:1 to receive LLLT or sham treatment using the device EYE-LIGHT ® (Espansione Group S.p.A., Bologna, Italy). In order to ensure double-blinding, demo light mode delivering <30% of the power output of a full treatment, simulating for both patient and operator a normal LLLT session, was used in patients belonging to control arm.

Statistical analysis

Statistical analysis was performed using R (V.4.0.0) and RStudio (V.1.2.5042) software. The Shapiro-Wilk test was used to determine the normality of data. Two-way mixed model analysis of variance (ANOVA) was used to determine the interaction between treatment and time on dry eye symptoms and ocular surface parameters. Post hoc analysis for the significance of treatment effects at each time point was conducted using one-way ANOVA. Post hoc analysis for the significance of time effect in each group was conducted using repeated-measures ANOVA. The χ^2 test was used to compare the percentage of patients in which ocular surface parameters worsened at T2 compared with T0 in the two groups. A p value of <0.05 was considered statistically significant.

RESULTS

Overall, 654 patients were screened for eligibility during the study period. Of these, 153 patients fulfilled the study criteria and were included. These patients were randomised to receive LLLT (n=73) or sham treatment (n=80). No significant differences in age and gender distribution were observed between the two groups (respectively, p=0.153 and p=0.434). One hundred and thirty-one patients (70 men, 61 women, mean age

Table 1 Ocular surface parameters measured during each time point in patients undergoing cataract surgery and randomised to receive low-level light therapy or sham treatment

Parameter	Group	T0 (1 week before)	T1 (1 week after)	T2 (1 month after)	P value*
OSDI	LLLT	21.2±16.1	7.2±8.8	9.0±9.0	<0.001
	Control	19.7±14.0	14.8±13.0	18.2±17.9	0.088
	P value†	0.573	<0.001	<0.001	
NIBUT (s)	LLLT	9.7±7.2	11.1±7.1	12.5±6.6	0.044
	Control	10.4±7.1	9.1±7.5	9.0±7.8	0.373
	P value†	0.570	0.126	0.007	
MGL (Meiboscore)	LLLT	1.56±0.75	1.59±0.70	1.42±0.82	0.308
	Control	1.45±0.71	1.26±0.69	1.32±0.71	0.165
	P value†	0.329	0.008	0.536	
TMH (mm)	LLLT	0.40±0.23	0.38±0.17	0.39±0.16	0.806
	Control	0.39±0.24	0.38±0.21	0.39±0.21	0.949
	P value†	0.768	0.960	0.795	
Redness	LLLT	1.57±0.47	1.58±0.46	1.55±0.46	0.829
	Control	1.54±0.38	1.62±0.55	1.56±0.51	0.360
	P value†	0.603	0.706	0.892	

*Time effect in each group; repeated-measures ANOVA.
†Treatment effects at each time point; one-way ANOVA.
ANOVA, analysis of variance; LLLT, low-level light therapy; MGL, Meibomian Gland Loss; NIBUT, non-invasive break-up time; OSDI, Ocular Surface Disease Index; TMH, tear meniscus height.

73.53±7.29 years) regularly completed the study and their data were used for the statistical analysis (figure 2).

Two-way ANOVA demonstrated a significant effect of treatment on the change in OSDI (p<0.001) and NIBUT (p=0.027) across T0, T1 and T2. Conversely, no significant effect of treatment on the change in MGL (p=0.242), TMH (p=0.957) and redness (p=0.624) was observed. Post hoc testing showed that patients who were treated with LLLT had significantly lower OSDI scores compared with those undergoing sham treatment at T1 and T2 (both p<0.001, table 1). Patients treated with LLLT showed significantly higher NIBUT values than control patients at T2 (p=0.007). MGL Meiboscore was significantly higher in patients treated with LLLT at T1 (p=0.008), but not at T2 (p=0.536). Conversely, no differences between the two groups were detected at each time point for TMH and redness (all p>0.706).

In the LLLT and sham groups, the percentage of patients in whom OSDI, NIBUT, MGL, TMH and redness worsened at T2 compared with T0 were respectively 27.3% vs 40.0% (p=0.175), 40.9% vs 55.4% (p=0.138), 25.8% vs 16.9% (p=0.308), 40.9% vs 46.2% (p=0.668) and 43.4% vs 33.8% (p=0.315).

No unanticipated or serious device-related adverse events during treatment or follow-up were reported.

DISCUSSION

This is the first study evaluating the outcomes of LLLT used as prophylaxis of DED in otherwise asymptomatic patients undergoing routine cataract surgery. The study demonstrated that the prophylactic treatment with LLLT of patients 1 week before and after surgery is able to allow a significant improvement of ocular discomfort symptoms and tear stability even in patients undergoing cataract surgery, a well-known cause of iatrogenic dry eye.

TMH did not change significantly after treatment but its mean value was within the normal range before surgery and remained approximately unchanged postoperatively. Infrared meibography detected fluctuations of MGL over time in the LLLT group that were neither statistically significant nor clinically meaningful at the last follow-up visit. This is not surprisingly since it is already known that after a such short follow-up device-based therapies can determine changes of the vagueness of the meibomian glands rather than of their area.[18] Objective evaluation of redness score did not change significantly after therapy; however, it has been already demonstrated that this value is not sensitive to diagnose or grade DED.[19] On the contrary, no ocular surface parameters improved after surgery in control patients who experienced a postoperative worsening, although not statistically significant, of NIBUT values compared with baseline status. The regular use of hyaluronic-based tear substitute in the postoperative month might have counteracted, at least partially, the detrimental effects of surgery, avoiding a frank postoperative decline of ocular surface parameters in this group of patients.

Improving outcomes of cataract surgery in terms of ocular comfort in the postoperative course represents a primary concern for both patients and clinicians. A large number of studies have shown that cataract surgery can induce or aggravate DED, resulting in patients reporting poor satisfaction with the surgical results.[20] However, an educational gap still exists between the awareness of DED impact on cataract surgery outcomes and the efforts made by ophthalmologists to address this issue in routine clinical practice.

In the last years, increasing evidence has shown that optimising ocular surface status before cataract surgery in patients with pre-existing DED/OSD is a crucial step to achieve the desired postoperative outcomes while avoiding the occurrence of complications. Recent works by Mencucci *et al* and Zhao *et al* included patients with meibomian gland dysfunction (MGD) undergoing cataract surgery, and evaluated the efficacy of vector thermal pulsation therapy performed 5 weeks and 1 day preoperatively, respectively.[6 21] Both studies showed that the device-based treatment was able to ameliorate eyelid margin parameters and ocular discomfort symptoms. Another study from Park *et al* included and treated with the same device patients with either healthy ocular surface or MGD.[7] The most outstanding finding was that patients without preoperative MGD benefited from receiving vector thermal pulsation therapy before surgery, in terms of meibomian quality, tear film stability, corneal staining and DED symptoms. This preliminary evidence opened up the interesting scenario of treating prophylactically patients with healthy ocular surface in order to prevent or mitigate iatrogenic DED postoperatively. However, to date contrasting results have been provided by the few attempts of using topical therapies for this task. On one hand, the preoperative use of a short-term course of betamethasone 0.1% had no significant effect on postoperative dry eye indices[8]; on the other hand, two studies reported that the prolonged instillation of a tear substitute (respectively, 1 week and 2 weeks before surgery) reduced postoperative DED-related signs and symptoms to almost normal values.[9 10]

Unlike medical therapy, employing device-based treatments before cataract surgery with prophylactic purposes raises some concerns. Ideally, a technology employed for disease prophylaxis should be fast, easy to use, non-invasive, painless and safe, without any contraindications or influences on surgery. All these characteristics are incorporated in LLLT,[22] thus making this technology suitable for improving patients' comfort after surgery. On the contrary, vector thermal pulsation therapy employed in previous studies is invasive, requiring the use of a topical anaesthetic (0.5% proparacaine hydrochloride) to make painless the insertion and removal of the device treatment.[6 7 21] Furthermore,

our protocol consisting of two LLLT sessions performed 1 week apart from surgery can be easily incorporated in the workflow of patients undergoing cataract surgery thus helping the potential widespread adoption of the protocol in the routine clinical practice. In fact, the first LLLT session coincides with preoperative evaluation and counselling, while the second session with one of the scheduled postoperative control visits. This protocol also guarantees a time interval of 1 week from treatment to surgery and vice versa, thus avoiding any issue related to the safety.

Despite the robust design and the original investigation, we are aware that our study suffers from some limitations. First, using OSDI score in the population of patients with cataract may represent a bias since this questionnaire has a high correlation with visual acuity being composed of a subsection of vision-related functions.[23] Second, a follow-up assessment longer than 1 month might provide additional information about the persistence over time of the benefits of LLLT in the setting of cataract surgery.

In conclusion, this randomised controlled clinical study showed that, unlike sham treatment, two sessions of LLLT performed 1 week before and after surgery were effective in significantly ameliorating tear film stability and ocular discomfort symptoms in otherwise healthy patients undergoing senile cataract surgery.

Contributors GG, CR, MB, GCS, RP and VS had substantial contribution to the conception and design of the study. GG, CR, MB, GS, GCS and BF had substantial contribution to the acquisition and collection of data. RP, MP, BF, GS and ACY contributed to the analysis and interpretation of data. GG, CR, MB, GS, MP, VS and ACY contributed to the drafting of the manuscript. GG, MP, VS, RP, GCS, BF and ACY contributed to the approval of the version of the manuscript to be published. GG is guarantor of this work.

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Competing interests None declared.

Patient consent for publication Not applicable.

Ethics approval This study involves human participants and was approved by the Ethics Committee 'Comitato Etico Regione Calabria—Sezione Area Centro' (approval number: 159-2022). It adheres to the tenets of Declaration of Helsinki and is registered in the United States trial register (ClinicalTrials.gov identifier, NCT05754437). Patients provided written informed consent prior to participation.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available upon reasonable request. The dataset used and analysed during the current study is available from the corresponding author on reasonable request.

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REFERENCES

1 Gomes JAP, Azar DT, Baudouin C, *et al*. TFOS lifestyle: impact of elective medications and procedures on the ocular surface. *Ocul Surf* 2023;29:331–85.
2 Mencucci R, Vignapiano R, Rubino P, *et al*. Iatrogenic dry eye disease: dealing with the conundrum of post-cataract discomfort. A P.I.C.A.S.S.O. *Ophthalmol Ther* 2021;10:211–23.
3 Naderi K, Gormley J, O'Brart D. Cataract surgery and dry eye disease: A review. *Eur J Ophthalmol* 2020;30:840–55.
4 Gupta PK, Drinkwater OJ, VanDusen KW, *et al*. Prevalence of ocular surface dysfunction in patients presenting for cataract surgery evaluation. *J Cataract Refract Surg* 2018;44:1090–6.
5 He X, Huang AS, Jeng BH. Optimizing the ocular surface prior to cataract surgery. *Curr Opin Ophthalmol* 2022;33:9–14.
6 Zhao Y, Li J, Xue K, *et al*. Preoperative management of MGD with Vectored thermal pulsation before cataract surgery: a prospective, controlled clinical trial. *Semin Ophthalmol* 2021;36:2–8.
7 Park J, Yoo Y-S, Shin K, *et al*. Effects of Lipiflow treatment prior to cataract surgery: A prospective, randomized, controlled study. *Am J Ophthalmol* 2021;230:264–75.
8 Shokoohi-Rad S, Javaheri SZH, Malekabad FZ, *et al*. Effects of preoperative doses of Betamethasone acetate 0.1% on dry eye control after cataract surgery. *Indian J Ophthalmol* 2020;68:450–4.
9 Fogagnolo P, Favuzza E, Marchina D, *et al*. New therapeutic strategy and innovative lubricating ophthalmic solution in minimizing dry eye disease associated with cataract surgery: A randomized, prospective study. *Adv Ther* 2020;37:1664–74.
10 Favuzza E, Cennamo M, Vicchio L, *et al*. Protecting the ocular surface in cataract surgery: the efficacy of the perioperative use of a Hydroxypropyl Guar and Hyaluronic acid ophthalmic solution. *Clin Ophthalmol* 2020;14:1769–75.
11 Lipko NB. Photobiomodulation: evolution and adaptation. *Photobiomodul Photomed Laser Surg* 2022;40:213–33.
12 Giannaccare G, Pellegrini M, Carnovale Scalzo G, *et al*. Low-level light therapy versus intense pulsed light for the treatment of Meibomian gland dysfunction: preliminary results from a prospective randomized comparative study. *Cornea* 2023;42:141–4.
13 Giannaccare G, Vaccaro S, Pellegrini M, *et al*. Serial sessions of a novel low-level light therapy device for home treatment of dry eye disease. *Ophthalmol Ther* 2023;12:459–68.
14 D'Souza S, Padmanabhan Nair A, Iyappan G, *et al*. Clinical and molecular outcomes after combined intense pulsed light therapy with low-level light therapy in recalcitrant evaporative dry eye disease with Meibomian gland dysfunction. *Cornea* 2022;41:1080–7.
15 Park Y, Kim H, Kim S, *et al*. Effect of low-level light therapy in patients with dry eye: a prospective, randomized, observer-masked trial. *Sci Rep* 2022;12:3575.
16 Gomes JAP, Azar DT, Baudouin C, *et al*. TFOS DEWS II iatrogenic report. *Ocul Surf* 2017;15:511–38.
17 Arita R, Itoh K, Inoue K, *et al*. Noncontact infrared Meibography to document age-related changes of the Meibomian glands in a normal population. *Ophthalmology* 2008;115:911–5.
18 Yin Y, Gong L. The quantitative measuring method of Meibomian gland vagueness and diagnostic efficacy of Meibomian gland index combination. *Acta Ophthalmol* 2019;97:e403–9.
19 Schulze MM, Ng A, Yang M, *et al*. Bulbar redness and dry eye disease: comparison of a validated subjective grading scale and an objective automated method. *Optom Vis Sci* 2021;98:113–20.
20 Han KE, Yoon SC, Ahn JM, *et al*. Evaluation of dry eye and Meibomian gland dysfunction after cataract surgery. *Am J Ophthalmol* 2014;157:1144–50.
21 Mencucci R, Mercuri S, Cennamo M, *et al*. Efficacy of vector thermal pulsation treatment in reducing post-cataract surgery dry eye disease in patients affected by Meibomian gland dysfunction. *J Cataract Refract Surg* 2023;49:423–9.
22 Caccianiga P, Carminati I, Caccianiga G. Photobiomodulation with laser technology to reduce pain perception during fixed orthodontic treatment: literature review and new perspectives with LED devices. *Inventions* 2023;8:46. 10.3390/inventions8010046 Available: https://doi.org/10.3390/inventions801004
23 Fydanaki O, Chalkiadaki E, Tsiogka A, *et al*. Preoperative dry eyes disease in cataract patients with deficient tear break up time: evaluation of OSDI questionnaire, its Subcategories and Keratograph 5m device results. *Int Ophthalmol* 2022;42:3017–25.