THERAPEUTIC ADVANCES in
Ophthalmology

Review

Factors influencing aqueous flare after cataract surgery and its evaluation with laser flare photometry

Ther Adv Ophthalmol
2023, Vol. 15: 1–15
DOI: 10.1177/25158414231204111

Christopher Way, Andrew J. Swampillai, Kin Sheng Lim and Mayank A. Nanavaty

***Abstract*:** Despite the refinement of modern cataract surgery, postoperative inflammation still constitutes a substantial amount of visual morbidity worldwide. A surrogate for intraocular inflammation and blood–aqueous barrier breakdown can be objectively quantified by Laser flare photometry (LFP). This review outlines the utility of LFP in assessing the assessment of post-cataract surgery inflammation. It highlights the impact of preoperative pathological states such as uveitis and diabetes, intraoperative techniques, including efficient phacoemulsification and direct comparisons between postoperative anti-inflammatory regimes. There is a large interobserver variation in the subjective flare measurement after cataract surgery and the continued use of LFP amongst other objective, noninvasive measurements of intraocular inflammation, particularly in the further development of cataract surgery, is recommended.

Keywords: cataract, flare, inflammation, phacoemulsification

Received: 27 March 2023; revised manuscript accepted: 11 September 2023.

Introduction

Senile cataracts are the leading cause of visual impairment worldwide.[1] Cataract surgery is one of the most commonly performed surgical procedures, with over 4.7 million operations performed across European Union member states in 2017[2] and over 400,000 carried out by the National Health Service in the United Kingdom alone.[3] Surgical techniques have advanced dramatically over the last 60 years since the advent of modern small-incision phacoemulsification cataract extraction, first described by Kellman in 1967.[4] Its high safety profile and excellent visual outcomes allow cataract surgery to treat glaucoma[5,6] and refractive errors using premium intraocular lenses (IOLs).[7]

Intraocular surgery causes a breakdown in the blood–aqueous barrier and leakage of inflammatory material to the anterior chamber (AC).[8] Consequently, cataract surgery produces distinctive alterations in aqueous concentrations of proteins.[9] Increased aqueous protein concentrations result in an aqueous humour haze called AC flare.[8] This is assessed during slit lamp biomicroscopy and is the subject of various clinical grading systems,[10,11] the most popular of which is the Standardization of Uveitis Nomenclature (SUN) grading system.[12] While this classification is widely accepted in quantifying AC inflammation to guide treatment, limitations include inherent subjectivity and marked interobserver variability, especially at low levels, primarily seen in clinical practice. It is, therefore, imperative to develop objective and noninvasive measurements of AC inflammation.

Laser flare photometry (LFP), described as early as 1988,[13] has been commercialized since its emergence in 1989 and is currently marketed by KOWA (Kowa Company, Tokyo, Japan). It measures the level of scattered light from a laser beam directed through a measurement window at the AC[14] (Figure 1). Successive models of laser flare meters (Kowa Co. Ltd, Tokyo, Japan) are differentiated by the laser medium (e.g. Helium-Neon 632.8 nm laser for FC-1000 and diode 670 nm for FM-500), the area of AC studied as

Correspondence to:
Mayank A. Nanavaty
University Hospitals Sussex NHS Foundation Trust, Sussex Eye Hospital, Eastern Road, Brighton, BN2 5BF, UK
Brighton & Sussex Medical School, University of Sussex, Falmer, Brighton, UK
mayank.nanavaty@nhs.net

Christopher Way
University Hospitals Sussex NHS Foundation Trust, Brighton, UK

Andrew J. Swampillai
Kin Sheng Lim
Department of Ophthalmology, St. Thomas' Hospital, London, UK
School of Life Course & Population Sciences, King's College London, London, UK

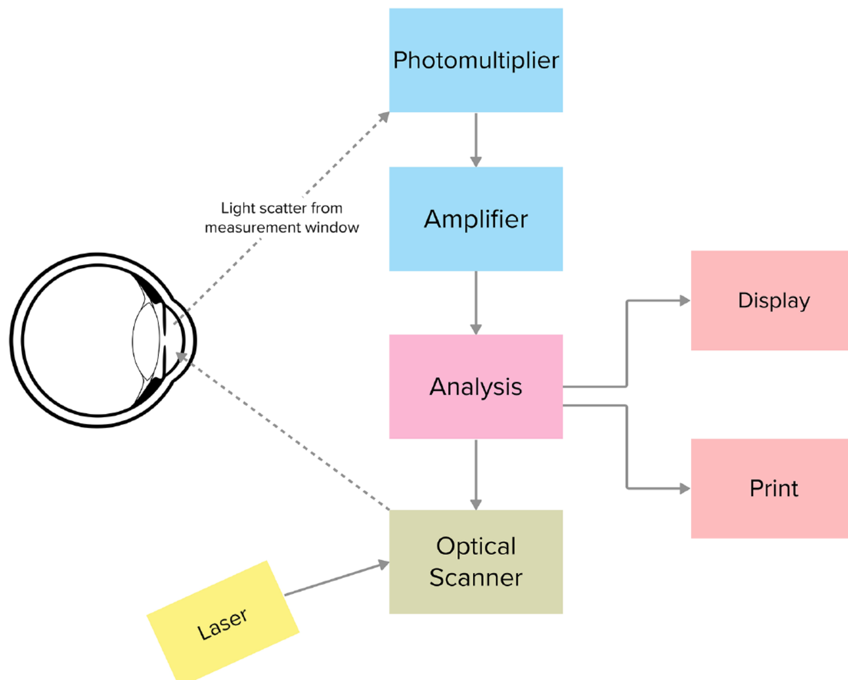

Figure 1. Schematic of laser flare photometry.

well as the ability to quantify cell as well as flare. Published comparisons are rare but show reproducibility and comparability.[15]

Measurements cannot be recorded in eyes with opaque media (e.g. corneal scarring) or in shallow ACs. Reliable measurements may also not be obtained in eyes with mature cataracts or extensive posterior synechiae due to increased background light scatter. LFP measurements are expressed in photons per millisecond (ph/ms), and the grading ranges from 3 to 1000 ph/ms.[16] Because of its ability to be a more precise tool for aqueous flare quantification, LFP has been utilized in measuring postsurgical inflammation in ophthalmic surgical procedures such as trabeculectomy[17] and pars plana vitrectomy,[18] as well as laser procedures such as argon laser panretinal photocoagulation[19] and laser capsulotomy.[20] Background flare (2.9–3.9 ph/ms between 20 and 40 years of age, increasing to 5.0–6.5 ph/ms between 70 and 80) is present in physiological eyes,[21,22] but is undetectable at the slit lamp. Studies have shown a high correlation between LFP values and protein concentrations in plasma and aqueous humour samples obtained in patients undergoing intraocular surgery.[23] LFP values also appear not to be significantly affected by mydriatic agents such as tropicamide and phenylephrine.[24]

This review aims to identify and summarize the studies of LFP quantifying AC inflammation (*via* aqueous flare measurements) in the use of materials and surgical procedures used in cataract extraction as well as regimens to control postoperative inflammation.

Methods

We conducted a search using the following databases: PubMed (all years), the Web of Science (all years), Ovid MEDLINE (R) (1980–31 December 2021), Ovid MEDLINE (R) Daily Update 31 December 2021, MEDLINE and MEDLINE non-indexed items, Embase (1980–2021, week 52), Ovid MEDLINE (R) and Epub Ahead of Print, in-Process & Other Non-Indexed Citations and Daily (1980–31 December 2021), CENTRAL (including Cochrane Eyes and Vision Trials Register; Cochrane Library: Issue 12 of 14 December 2021), *meta*Register of Controlled Trials (*m*RCT) (https://www.controlled-trials.com), ClinicalTrials.gov (www.clinicaltrial.gov) and the WHO International Clinical Trials Registry Platform (www.who.int/ictrp/search/en). Search terms included 'aqueous flare', 'anterior chamber inflammation', 'tyndallometry', 'laser flare photometry' combined with 'cataract surgery', 'extra capsular', 'phacoemulsification', 'laser' and 'femtosecond'. Published articles in English were preferentially selected for consideration in the review. Articles selected for eligibility were screened and deemed eligible if the aqueous flare was measured with LFP both before and after cataract surgery. All the articles were screened by two authors (CW and AS) for eligibility in this narrative review. The data were collected in a spreadsheet (MicroSoft Excel, MicroSoft Corp, USA). The flare data in relation to the preoperative patient's factors/comorbidities, intraoperative steps (incision, method of cataract removal, ophthalmic viscosurgical device, irrigating solutions and intraocular lenses) and postoperative regime for control of inflammation were collected.

Results

Articles from 1990 to June 2022 were accessed, identifying 155 articles for further analysis. Of these, 24 articles were excluded for the following reasons: 15 were duplicate studies, 1 did not involve cataract surgery and 8 measured flare using either clinical grading systems such as the SUN or an enzyme-linked immunosorbent assay instead of LFP (Figure 2).

All studies showed an increase in flare after cataract surgery, which is at its highest and most variable in the immediate postoperative hours.[25] No study recorded flare with more than one model of flare meter, with the most popular meters used being the FC-1000, FM-500 and FM-600. The influence of pre-, intra- (including incision, nucleus dissassembly, ophthalmic viscosurgical devices, irrigating solutions and intraocular lenses) and postoperative variables are discussed below.

Preoperative

Patient factors and comorbidities are associated with the increased postoperative flare. Non-pathological states include older age[26] and pathological states include pseudoexfoliation syndrome,[27–29] chronic uveitis[17,30] and diabetes both with and without retinopathy.[31–34] The density of the nucleus, according to the LOCS III grading system, did not correlate with higher flare preoperatively.[26] However, it was associated with a higher postoperative flare,[26] possibly due to a higher phacoemulsification energy requirement.[34] Though iris colour does not affect preoperative values,[26,35] darker irises have a greater postoperative flare response at 2 weeks than lighter colours.[36]

Intraoperative

Incision. The introduction of phacoemulsification techniques and foldable intraocular lenses in the early 1990s allowed for smaller primary incisions into the AC. This was shown in 1991 by Gills and Sanders to reduce flare as well as surgically induced astigmatism at postoperative day 1.[37] Though this is confounded by the different lenses that each group received, it is later discussed that foldable lenses do not adversely affect flare outcomes. The clear corneal incision is the preferred choice among cataract surgeons compared with scleral tunnels.[38] There is contrasting evidence regarding the impact of incision on postoperative flare; Dick *et al.*[39]

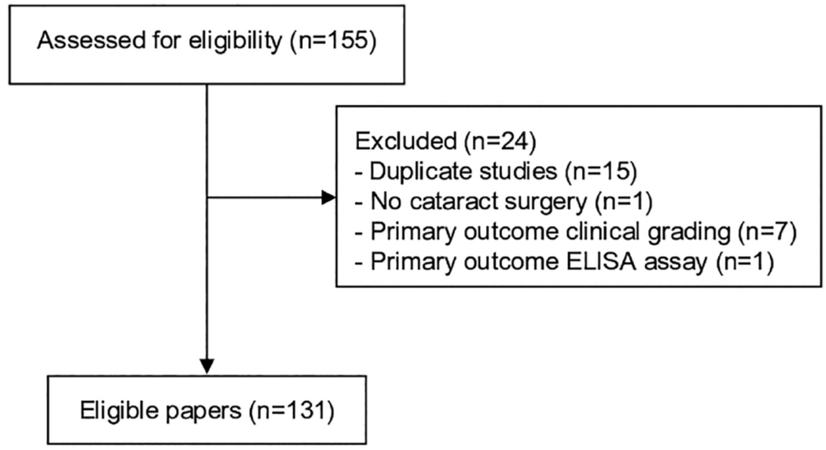

Figure 2. Flow diagram outlining eligible studies.

found significantly lower flare in those who underwent clear corneal incisions in the first three postoperative days, but Kruger *et al.*[40] found similar flare levels at almost all time points to 90 days postoperatively. Nguyen *et al.*[41] also found no postoperative difference between the incisions, however this was a secondary outcome measure No studies have found clear corneal incisions to worsen flare levels compared with scleral tunnels.

Nucleus disassembly. Phacoemulsification is the dominant method of nucleus disassembly in modern cataract surgery. Several studies comparing phacoemulsification with extracapsular surgery in the mid-1990s demonstrated that phacoemulsification resulted in a statistically significant reduction in peak flare values and a shorter postoperative recovery to normal flare values.[42–44] Kruger *et al.*[40] showed higher flare levels in patients subjected to longer phacoemulsification times (over 80 s) at postoperative week one. These differences had disappeared by 1 month. A similar influence of phacoemulsification time on postoperative flare was seen by Kaur *et al.*,[45] who found phacoemulsification time is affected by different femtosecond laser pretreatment patterns. Though the aim of phacoemulsification and irrigation/aspiration is to fully remove both nucleus and cortex, retained cataract fragments are often seen in the postoperative setting. Though retained fibres were not found to increase postoperative flare in a small study,[46] Nishi *et al.* found a prolonged postoperative flare in eyes with retained lens epithelial cells at days 6–14.

An observational study on femtosecond laser cataract surgery showed elevated flare levels for 1 month postoperative,[47] which returned to preoperative levels by 3 months. Comparative studies of flare measurements between femtosecond laser fragmentations of the lens compared to manual phacoemulsification shows mixed results. Femtosecond use was associated with a statistically significant decrease in flare at all time points up to 1 month by Abell *et al.*[48] and Chen *et al.*,[49] however it was not associated with a statistically significant difference in aqueous flare in a study of 110 patients by Pahlitzch *et al.*[50] or Favuzza *et al.*[51] in their case series of 40 eyes undergoing femtosecond laser pretreatment. A matrix lens fragmentation pattern was associated with reduced postoperative flare values compared with a phacoemulsification 'chop' method. Proponents of femtosecond suggest that it can facilitate more efficient lens removal and less phacoemulsification time, which is known to decrease postoperative flare.[45] Femtosecond laser-assisted posterior capsulotomy at the end of surgery (to avoid posterior capsule opacification) did not increase flare compared to controls.[52]

Ophthalmic viscosurgical devices. Ophthalmic viscosurgical devices (OVDs) are essential in modern cataract surgery in protecting structures, compartmentalizing key areas and maintaining pressure gradients.[53] Complete removal of OVD at the end of the case is important to avoid postoperative intraocular pressure (IOP) spikes.[54] In the early 1990s, studies investigated flare in postoperative patients with retained OVD, assumed by the absence of the physiological 'warm current' detected at the slit lamp. It identified that those with loss of the warm current had higher flare levels for up to 1 week postoperatively compared to those with a normal warm current.[55,56] Use of the viscoadaptive OVD Healon 5 (Johnson & Johnson, New Jersey, USA) in cataract surgery was associated with lower flare values than the dispersive OVD Viscoat (Alcon laboratories, Fort Worth, Texas, USA) up to 8 h postoperatively.[57]

Irrigating solutions and antibiotics. Irrigation solutions are used during phacoemulsification to facilitate cataract removal and maintain AC stability. Roberts found that adding the miotic carbachol at the end of surgery increased postoperative flare, probably due to a delayed reestablishment of the blood–aqueous barrier, while acetylcholine reduced flare compared to administration of a balanced salt solution control.[58] However, this was likely due to increased iris manipulation of the unconstructed pupil at the end of surgery. Kohnen *et al.*[59] also found the addition of heparin to the irrigation solution reduced postoperative flare on days 1 and 3, a difference that disappeared after 1 year. Unfortunately there are no studies that investigate the influence of intracameral antibiotic prophylaxis on aqueous flare as measured by LFP.

Intraocular lenses. LFP found similar flare rates across the previous generation of rigid poly (methyl methacrylate) (PMMA) IOLs inserted during extracapsular cataract extraction.[60] Modern IOL technology encounters materials that include silicone and acrylic with hydrophobic or hydrophilic properties. Foldable silicone and acrylic lenses which could be inserted through a smaller corneal incision than the rigid PMMA lens was not associated with a statistically significant difference in flare in patients with no medical history,[61–63] diabetes[64] and diabetic retinopathy.[65] Initially, it was thought that more postoperative flare was seen in hydrophobic than hydrophilic IOLs,[66] however the results of this short follow-up study (3 months) have not been replicated. No differences in postoperative flare have been seen among three different IOL models by Monnet *et al.*[67] and four types of foldable lenses from Schauersberger *et al.*[68] Similar flare values were seen in the 1CU (HumanOptics Ag, Erlangen, Germany) accommodative IOL.[69] Abela-Formanek *et al.*[70] studied six different IOLs in 2002 and found the hydrophobic acrylic AR40 lens (Allergan) to have statistically less flare than hydrophilic acrylic or hydrophobic silicone counterparts at 1 year postoperative. However, the authors could not identify an explanation for this. In addition, there were no correlations with other inflammatory parameters and these results were not replicated. There were no differences in postoperative flare in patients with uveitis who were given hydrophobic acrylic, hydrophilic acrylic or silicone IOLs.[70,71] Early evidence showed that IOLs with Heparin Surface Modification (HSM) were thought to reduce the inflammatory response, particularly in eyes at higher risk of postoperative inflammation such as uveitis.[72] Indeed, HSM of hydrophobic IOLs was associated with less flare on postoperative day 1 in two studies,[73,74] but both of these results were not statistically significant in subsequent visits. By contrast, there were no differences in flare in patients with diabetes receiving a HSM PMMA IOL *versus* an uncoated hydrophobic acrylic IOL[64] or in patients with either diabetes and/or pseudoexfoliation syndrome receiving either a coated or uncoated IOL.[75] In 1997 Alió *et al.* investigated the flare associated with haptic placement post extracapsular cataract surgery. They found that on day 1, the highest flare was in the eyes with IOL implantation in the sulcus, and the lowest flare was when IOL implantation was in-the-bag implantation.[62] In patients without capsular support, Cellini *et al.* found higher postoperative flare in scleral-fixated IOLs compared with iris fixation or control in-the-bag placement.[76] Amino and Yamakawa found that sulcus-to-sulcus fixation resulted in higher flare values than the sulcus-to-ciliary body or in-the-bag fixation.[77]

Postoperative regimen

The postoperative regime after cataract surgery aims to minimize infection, inflammation and the development of pseudophakic cystoid macular edema (CME), which often impedes visual recovery.

Aqueous flare is often seen alongside CME as both result from a compromised blood–aqueous barrier.[78–81] Therefore, flare assessment is important to those investigating methods of reducing the incidence of postoperative CME. The major therapeutic classes are corticosteroids and nonsteroidal anti-inflammatory drugs (NSAIDs), which have been shown either alone or combined to decrease postoperative flare compared with vehicle controls.[82,83] They are particularly important for patients at higher risk of postoperative inflammation, such as uveitis, pseudoexfoliation syndrome, or diabetes.[84] A summary of relevant studies is found in Table 1.

Corticosteroids are well-known anti-inflammatory molecules and topical use has been a historical mainstay of ocular anti-inflammatories. Several steroid injections administered at the end of surgery do not appear to reduce flare compared with topical steroid controls, including subconjunctival betamethasone[111,112] or methylprednisolone[113] and a single perioperative subtenon dose of triamcinolone (either 20 or 30 mg)[114] in uncomplicated cataract surgery, subconjunctival dexamethasone in normal eyes and those with diabetes[115,116] or the intracameral dexamethasone delivery system IBI-10090 (Dexycu®, Massachusetts, USA).[117] There were no statistically significant differences in postoperative flare between postoperative prednisolone 1% drops and a dexamethasone 0.1% gel (Dexagel®, Bausch & Lomb, Ireland).[118] The AC dexamethasone delivery system Surodex® (Oculex, California, USA) did reduce postoperative flare compared with a 4-week course of dexamethasone eye drops in patients undergoing extracapsular extraction.[119,120]

The side effects of steroids are well recognized,[121] and LFP has allowed for investigating alternative NSAIDs in the postoperative period. As a sole treatment, Indomethacin appears to reduce flare over flurbiprofen[85,86] and when combined with prednisolone, reduces flare more than combination diclofenac and prednisolone for the first three postoperative days.[87] Indomethacin also appears non-inferior to ketorolac.[88] Diclofenac 0.1% is associated with less flare than flurbiprofen[86,90] or bromfenac[92] and is similarly effective as ketorolac 0.5%.[91] Ketorolac has an equivalent effect on flare as the now discontinued rimexolone.[95] Nepafenac 0.1% reduces aqueous flare more than ketorolac

Table 1. Selected studies comparing the effect of two different postoperative medications on post-cataract surgery aqueous flare. Comparisons are between the medication in question in the vertical rows and comparator medication in the columns. Upward arrows indicate an increase in flare compared to the comparator medication and downward arrows indicate a decrease. Sideways arrows indicate no statistically significant difference between the medications.

	Comparator medication									
	Effects on flare	**Flurbiprofen 0.03% drop**	**Diclofenac 0.1% drop**	**Ketorolac 0.5% drop**	**Bromfenac 0.09% drop**	**Rimexolone 1% drop**	**Betamethasone 0.1% drop**	**Fluorometholone 0.1% drop**	**Subtenon dexamethasone**	**Dexamethasone 0.1% drop**
Medication	Indomethacin 0.1% drop	↓ 85, 86	↓ 87	↔ 88						↑ 89
	Diclofenac 0.1% drop	↓ 86, 90		↔ 91	↓ 92			↓ 93		↓ 29, 94
	Ketorolac 0.5% drop					↔ 95			↓ 96	
	Nepafenac 0.1% drop		↔ 97, ↓ (combined with steroid)[98]	↓ 99	↓ 99			↓ 100		
	Dexamethasone 0.1% drop	↔ 101	↔ 102–104, ↑ 29, 94		↔ 105, ↑ 106			↔ 107		
	Bromfenac 0.09% drop						↔ 108	↔ 109		
							↓ (compared to betamethasone then fluorometholone wean)[110]			↓ 106

0.4% and bromfenac 0.09% at the 4-week interval[99] and reduces flare more than diclofenac 0.1% when both are combined with steroids at days 15 and 30.[98] It appears comparable to preservative-free diclofenac 0.1% in diabetic and nondiabetic patients.[97] Twice daily bromfenac 0.09% does not improve postoperative flare compared to once daily dosing.[122] Flare comparisons between topical corticosteroids and NSAIDs have yielded no statistically significant differences between the following: dexamethasone *versus* flurbiprofen,[101] dexamethasone *versus* diclofenac,[102–104] dexamethasone *versus* bromfenac[105]; bromfenac *versus* betamethasone[108] or bromfenac *versus* fluorometholone 0.1%[109]; diclofenac *versus* 1% prednisolone,[123] fluorometholone/levofloxacin *versus* tobramycin/dexamethasone.[107] Erichsen *et al.* found no difference in postoperative flare between those taking combination prednisolone 1%/ketorolac 0.5% *versus* ketorolac 0.5% alone,[96] as did Ylinen *et al.* with diclofenac 0.1%/dexamethasone 0.1% *versus* diclofenac 0.1%.[97] Intraoperative administration of subtenon dexamethasone depot does not reduce flare as effectively as a topical regime of ketorolac 0.5% with or without prednisolone 1%.[96]

Several NSAIDs have been shown to reduce flare more effectively than topical steroids. Bromfenac was shown to reduce flare more than a course of betamethasone followed by a fluorometholone wean in both patients with diabetes and their healthy controls; a difference was seen in the control arm at 2 weeks and the diabetes arm at 4 and 6 weeks.[110] Nepafenac 0.1% appears to reduce flare more strongly than fluorometholone resulting in reduced fluorescein angiographic evidence of CME and hastened visual recovery.[100] Bromfenac 0.09% is associated with lower flare levels at 3 and 6 months postoperatively compared with dexamethasone 0.1%.[106] Diclofenac reduced postoperative flare compared to fluorometholone up to 8 weeks postoperatively.[93] It also reduces flare significantly compared to dexamethasone in both normal eyes and those with pseudoexfoliation.[29,94] By contrast, Zhang *et al.*[89] identified that dexamethasone reduced postoperative aqueous flare more than indomethacin. The intravitreal dexamethasone drug delivery system Ozurdex® (Allergan, Dublin, Ireland) reduced postoperative flare for weeks 1–4. However, the standard of care comparison group received no anti-inflammatory therapies.[124]

Postoperative antibiotic prophylaxis are frequently used to reduce the risk of endophthalmitis. Though this is a well-studied area, the authors cannot find studies that investigate the influence of postoperative antibiotic medication on aqueous flare, nor are there comparisons between different postoperative antibiotic regimes that utilize LFP to assess anterior segment inflammation after cataract surgery. Some studies as described in this review investigate combination antibiotic/anti-inflammatory medication but no meaningful conclusions about the contribution of the antibiotic component can be drawn.

Ophthalmic solution preservatives contribute to conjunctival inflammation and disrupt the corneal epithelium, but these effects are primarily seen in their long-term use.[125] Hessemer *et al.*[126] found no statistically significant difference in aqueous flare between groups given preservative-free diclofenac 0.1% postoperatively compared to preserved diclofenac 0.1%. The addition of preservative-free diclofenac, when given both pre- and postoperatively, appeared to reduce flare compared to when given postoperatively alone. However, the study arms were limited to 30 patients only and follow-up extended to 7 days postoperatively. In patients with diabetic retinopathy, Yasuda *et al.*[127] found patients treated with preservative-free diclofenac postoperatively showed a faster return to preoperative flare values than preserved formulations.

Traditional Chinese and Sino-Japanese herbal remedies have shown statistically significant reductions in the postoperative flare on days 1, 3 and 5 with Orengedoku-to in uncomplicated eyes and Kakkon-to in both uncomplicated and uveitic eyes.[128,129] However, these results have since not been replicated, follow-up was limited to 7 days postoperatively and the control group in one of these studies received no therapies.[128] Topical miotics given postoperatively do not appear to affect flare.[130]

Discussion

LFP is an established technology in assessing intraocular inflammation after cataract surgery. It identifies those at risk of postoperative inflammation, including older age and the presence of diabetes or uveitis. Ursell *et al.* showed that postoperative flare is also related to preoperative flare ($p = 0.001$, $r^2 = 9.0\%$) as well as the preoperative colour of the cataract ($p = 0.038$, $r^2 = 3.3\%$).[26] However, the properties of the cataract may falsely change the flare due to increased background light scatter.[131] Cataract surgery technique influences postoperative flare and can be minimized with small incisions, efficient phacoemulsification and in-the-bag IOL placement. The majority of IOLs used today do not affect flare differently from one another. Finally, laser flare measurements are critical in the ongoing pursuit of the optimum postoperative anti-inflammatory regime. A recent phase III, multicentre, randomized trial has demonstrated the non-inferiority of a new topical antibiotic/anti-inflammatory agent levofloxacin 5 mg/mL + dexamethasone 1 mg/mL for 1 week in comparison to tobramycin 3 mg/mL + dexamethasone 1 mg/mL (Tobradex®, Novartis Pharmaceuticals, UK) for 2 weeks after cataract surgery but still relied on subjective aqueous flare measurements.[132] Many other studies investigating topical medications postoperatively rely on the clinical grading of flare. These studies find little to no flare postoperatively but this is probably more due to the low sensitivity of the clinical grading system as opposed to representing a true absence of flare.[133,134]

Levels of aqueous flare negatively correlate with visual function in other conditions such as uveitic macular edema[135] and retinitis pigmentosa.[136] Aqueous flare levels mostly seen after cataract surgery are unlikely to be of visual significance to most patients. However, as a marker of intraocular inflammation, flare is strongly associated with visually significant outcome measures such as cystoid macular edema.[81] In patients with pseudophakic cystoid macular edema, LFP did not correlate with retinal thickness but did correlate significantly with reduced visual acuity.[79] LFP was analysed in 42% of 187 studies investigating both AC inflammation and macular changes after cataract surgery in a review by De Maria *et al.*[81] It was found to correlate with the frequency of CME postoperatively better than other methods, including clinical grading and aqueous humour sampling. This is probably because of its superior ability to quantify the low levels of inflammation often seen after uncomplicated cataract surgery. Its routine use post-cataract surgery may help predict those at risk of inflammatory decompensation and allow treatment before significant morbidity occurs. Its validation as a sensitive, objective marker of postoperative inflammation has allowed for new associations with intraocular inflammation. For example, it is now shown that cases with raised LFP values at day 1 postoperative tended to also demonstrate increased flicker electroretinogram (ERG) responses at week 1.[137] Increased flare is also seen in eyes with anterior capsular contraction[138] and is interestingly detected in the fellow non-operated eye on day 1 postoperatively.[139]

This review consists mainly of well-designed prospective, randomized studies with clear outcome measures and statistically significant results. However many studies did not include a flare measurement protocol. Pupillary dilatation prior to flare measurement may influence values[14,23,140] and it is unknown in many whether this was performed. Many followed a similar protocol to that of Ursell *et al.*[26] whereby seven dilated readings with <15% between background readings were taken, the two extreme values were discarded and the mean and standard deviation were taken from the remaining five. However, many studies included different approaches to background readings and extreme values before calculating mean and standard deviation and a number did not include a protocol at all. Methods for flare measurement must be included in each study and a standardized protocol in this area is welcome. Longer patient follow-up is also required, with very few studies having follow-up of greater than 12 months; despite evidence that aqueous flare in the eyes post-cataract surgery can persist for up to 36 months.[141] Though the majority of research has been in the assessment of topical postoperative anti-inflammatory agents, little has been done to investigate the influence of antibiotic prophylaxis on anterior segment inflammation, either through intracameral antibiotics at the end of surgery or through postoperative drop regimes. Future studies should utilize LFP to measure the influence of cataract surgery antibiotics on blood–aqueous breakdown.

Conclusion

Despite its success, the worldwide frequency of cataract surgery creates substantial morbidity associated with blood–aqueous breakdown and inflammatory sequelae. The optimization of an already refined operation with modest postoperative changes cannot rely on clinical grading, which is qualitative and fraught with interobserver variability, particularly at the lower levels seen after an uncomplicated cataract surgery. In this review we highlight the influence of preoperative pathological states such as uveitis and diabetes where the blood–aqueous barrier is compromised prior to surgery. Various intraoperative strategies can minimize postoperative flare, including clear corneal incisions, efficient phacoemulsification and in-the-bag IOL placement. The optimum postoperative anti-inflammatory regimen is subject to ongoing study and care must be taken to include the influence of antibiotic prophylaxis. Aqueous flare is far from the only consideration in the assessment of cataract surgery strategies but it is only with objective and sensitive outcome measures of intraocular inflammation that the refinement of modern cataract surgery can continue.

Declarations

Ethics approval and consent to participate

Ethical approval/consent to participate are not required for this study as this is a review article evaluating previously published literature.

Consent for publication

Not applicable.

Author contributions

Christopher Way: Investigation; Project administration; Supervision; Validation; Writing – original draft; Writing – review & editing.

Andrew J. Swampillai: Conceptualization; Methodology; Resources; Software; Writing – original draft; Writing – review & editing.

Kin Sheng Lim: Conceptualization; Methodology; Writing – original draft; Writing – review & editing.

Mayank A. Nanavaty: Methodology; Project administration; Resources; Supervision; Writing – original draft; Writing – review & editing.

Acknowledgements

None.

Funding

The authors received no financial support for the research, authorship, and/or publication of this article.

Competing interests

The authors declare that there is no conflict of interest.

Availability of data and materials

Not applicable.

ORCID iD

Mayank A. Nanavaty https://orcid.org/0000-0003-0667-3700

References

1. Lee CM and Afshari NA. The global state of cataract blindness. *Curr Opin Ophthalmol* 2017; 28: 98–103.
2. Eurostat, https://ec.europa.eu/eurostat/web/products-eurostat-news/-/ddn-20191204-1 (2019, accessed 6 January 2023).
3. NHS Digitial, https://digital.nhs.uk/data-and-information/publications/statistical/hospital-admitted-patient-care-activity/2019-20#highlights (2020, accessed 25 January 2023).
4. Kelman CD. Phaco-emulsification and aspiration. A new technique of cataract removal. A preliminary report. *Am J Ophthalmol* 1967; 64: 23–35.
5. Friedman DS and Vedula SS. Lens extraction for chronic angle-closure glaucoma. *Cochrane Database Syst Rev* 2006; 3: CD005555.
6. Mansberger SL, Gordon MO, Jampel H, *et al*. Reduction in intraocular pressure after cataract extraction: the ocular hypertension treatment study. *Ophthalmology* 2012; 119: 1826–1831.
7. Wang SY, Stem MS, Oren G, *et al*. Patient-centered and visual quality outcomes of premium cataract surgery: a systematic review. *Eur J Ophthalmol* 2017; 27: 387–401.
8. Hogan MJ, Kimura SJ and Thygeson P. Signs and symptoms of uveitis. I. Anterior uveitis. *Am J Ophthalmol* 1959; 47: 155–170.
9. Kondo T, Yamauchi T and Nakatsu A. Effect of cataract surgery on aqueous turnover and blood-aqueous barrier. *J Cataract Refract Surg* 1995; 21: 706–709.
10. Ben Ezra D, Forrester JV, Nussenblatt RB, *et al*. *Uveitis scoring system*. Berlin: Spriger Verlag, 1991, pp. 1–13.
11. Schlaegel TF Jr. *Essentials of uveitis*. Boston: Little, Brown and Company, 1969, p. 27.
12. Jabs DA, Nussenblatt RB, Rosenbaum JT, *et al*. Standardization of uveitis nomenclature for reporting clinical data. Results of the first international workshop. Am J Ophthalmol 2005; 140: 509–516.
13. Sawa M, Tsurimaki Y, Tsuru T, *et al*. New quantitative method to determine protein concentration and cell number in aqueous in vivo. *Jpn J Ophthalmol* 1988; 32: 132–142.
14. Tugal-Tutkun I, Yalçındağ FN and Herbort CP. Laser flare photometry and its use in uveitis. *Expert Rev Ophthalmol* 2012; 7: 449–457.

15. Nguyen NX, Martus P and Küchle M. [A clinical comparative study of tyndallometry using 2 laser flare meters]. *Klin Monbl Augenheilkd* 1996; 209: 89–93.

16. Tugal-Tutkun I and Herbort CP. Laser flare photometry: a noninvasive, objective, and quantitative method to measure intraocular inflammation. *Int Ophthalmol* 2010; 30: 453–464.

17. Nguyen NX, Küchle M, Martus P, *et al*. Quantification of blood–aqueous barrier breakdown after trabeculectomy: pseudoexfoliation versus primary open-angle glaucoma. *J Glaucoma* 1999; 8: 18–23.

18. Agarwal A, Joshi D, Katoch D, *et al*. Application of laser flare photometry in the quantification of blood-aqueous barrier breakdown after micro-incision vitrectomy. *Ocul Immunol Inflamm* 2019; 27: 651–657.

19. Moriarty AP, Spalton DJ, Shilling JS, *et al*. Breakdown of the blood-aqueous barrier after argon laser panretinal photocoagulation for proliferative diabetic retinopathy. *Ophthalmology* 1996; 103: 833–838.

20. Altamirano D, Mermoud A, Pittet N, *et al*. Aqueous humor analysis after Nd:YAG laser capsulotomy with the laser flare-cell meter. *J Cataract Refract Surg* 1992; 18: 554–558.

21. Onodera T, Gimbel HV and DeBroff BM. Aqueous flare and cell number in healthy eyes of Caucasians. *Jpn J Ophthalmol* 1993; 37: 445–451.

22. Guillén-Monterrubío OM, Hartikainen J, Taskinen K, *et al*. Quantitative determination of aqueous flare and cells in healthy eyes. *Acta Ophthalmol Scand* 1997; 75: 58–62.

23. Shah SM, Spalton DJ and Smith SE. Measurement of aqueous cells and flare in normal eyes. *Br J Ophthalmol* 1991; 75: 348–352.

24. Chin PK, Cuzzani OE, Gimbel HV, *et al*. Effect of commercial dilating agents on laser flare-cell measurements. *Can J Ophthalmol* 1996; 31: 362–365.

25. Findl O, Amon M, Petternel V, *et al*. Early objective assessment of intraocular inflammation after phacoemulsification cataract surgery. *J Cataract Refract Surg* 2003; 29: 2143–2147.

26. Ursell PG, Spalton DJ and Tilling K. Relation between postoperative blood-aqueous barrier damage and LOCS III cataract gradings following routine phacoemulsification surgery. *Br J Ophthalmol* 1997; 81: 544–547.

27. Schumacher S, Nguyen NX, Küchle M, *et al*. Quantification of aqueous flare after phacoemulsification with intraocular lens implantation in eyes with pseudoexfoliation syndrome. *Arch Ophthalmol* 1999; 117: 733–735.

28. Shastri L and Vasavada A. Phacoemulsification in Indian eyes with pseudoexfoliation syndrome. *J Cataract Refract Surg* 2001; 27: 1629–1637.

29. Ilveskoski L, Taipale C, Holmström EJ, *et al*. Macular edema after cataract surgery in eyes with and without pseudoexfoliation syndrome. *Eur J Ophthalmol* 2019; 29: 504–509.

30. Takeda A, Hasegawa E, Notomi S, *et al*. Surgical outcomes of contrast sensitivity and visual acuity in uveitis-associated cataract. *Clin Ophthalmol* 2021; 15: 2665–2673.

31. Liu Y, Luo L, He M, *et al*. Disorders of the blood-aqueous barrier after phacoemulsification in diabetic patients. *Eye* 2004; 18: 900–904.

32. Takamura Y, Tomomatsu T, Arimura S, *et al*. Anterior capsule contraction and flare intensity in the early stages after cataract surgery in eyes with diabetic retinopathy. *J Cataract Refract Surg* 2013; 39: 716–721.

33. Zaczek A and Zetterström C. Aqueous flare intensity after phacoemulsification in patients with diabetes mellitus. *J Cataract Refract Surg* 1998; 24: 1099–1104.

34. Ikegami Y, Takahashi M and Amino K. Evaluation of choroidal thickness, macular thickness, and aqueous flare after cataract surgery in patients with and without diabetes: a prospective randomized study. *BMC Ophthalmol* 2020; 20: 102.

35. Kruger AJ, Schauersberger J, Abela-Formanek C, *et al*. [Effect of duration of phacoemulsification on postoperative inflammation–a retrospective study]. *Klin Monbl Augenheilkd* 2001; 218: 204–208.

36. Onodera T, Gimbel HV and DeBroff BM. Effects of cycloplegia and iris pigmentation on postoperative intraocular inflammation. *Ophthalmic Surg* 1993; 24: 746–752.

37. Gills JP and Sanders DR. Use of small incisions to control induced astigmatism and inflammation following cataract surgery. *J Cataract Refract Surg* 1991; 17: 740–744.

38. Leaming DV. Practice styles and preferences of ASCRS members–2003 survey. *J Cataract Refract Surg* 2004; 30: 892–900.

39. Dick HB, Schwenn O, Krummenauer F, *et al*. Inflammation after sclerocorneal versus clear corneal tunnel phacoemulsification. *Ophthalmology* 2000; 107: 241–247.

40. Kruger A, Schauersberger J, Findl O, *et al*. Postoperative inflammation after clear corneal

and sclerocorneal incisions. *J Cataract Refract Surg* 1998; 24: 524–528.

41. Nguyen NX, Tomida I and Kuchle M. [Blood-aqueous barrier after phacoemulsification with posterior chamber lens implantation; foldable acrylate lens vs PMMA lens– a clinical study on 46 eyes]. *Klin Monbl Augenheilkd* 2000; 217: 215–218.

42. Pande MV, Spalton DJ, Kerr-Muir MG, *et al*. Postoperative inflammatory response to phacoemulsification and extracapsular cataract surgery: aqueous flare and cells. *J Cataract Refract Surg* 1996; 22: 770–774.

43. Laurell CG, Zetterström C, Philipson B, *et al*. Randomized study of the blood-aqueous barrier reaction after phacoemulsification and extracapsular cataract extraction. *Acta Ophthalmol Scand* 1998; 76: 573–578.

44. Chee SP, Ti SE, Sivakumar M, *et al*. Postoperative inflammation: extracapsular cataract extraction versus phacoemulsification. *J Cataract Refract Surg* 1999; 25: 1280–1285.

45. Kaur M, Titiyal JS, Surve A, *et al*. Effect of lens fragmentation patterns on phacoemulsification parameters and postoperative inflammation in femtosecond laser-assisted cataract surgery. *Curr Eye Res* 2018; 43: 1228–1232.

46. Nishi O and Nishi K. Disruption of the blood-aqueous barrier by residual lens epithelial cells after intraocular lens implantation. *Ophthalmic Surg* 1992; 23: 325–329.

47. Mariacher S, Ebner M, Seuthe AM, *et al*. Femtosecond laser–assisted cataract surgery: first clinical results with special regard to central corneal thickness, endothelial cell count, and aqueous flare levels. *J Cataract Refract Surg* 2016; 42: 1151–1156.

48. Abell RG, Allen PL and Vote BJ. Anterior chamber flare after femtosecond laser-assisted cataract surgery. *J Cataract Refract Surg* 2013; 39: 1321–1326.

49. Chen H, Lin H, Zheng D, *et al*. Expression of cytokines, chmokines and growth factors in patients undergoing cataract surgery with Femtosecond Laser Pretreatment. *PLoS One* 2015; 10(9): e0137227.

50. Pahlitzsch M, Torun N, Pahlitzsch ML, *et al*. Impact of the femtosecond laser in line with the femtosecond laser-assisted cataract surgery (FLACS) on the anterior chamber characteristics in comparison to the manual phacoemulsification. *Semin Ophthalmol* 2017; 32: 456–461.

51. Favuzza E, Becatti M, Gori AM, *et al*. Cytokines, chemokines, and flare in the anterior chamber after femtosecond laser-assisted cataract surgery. *J Cataract Refract Surg* 2019; 45: 910–914.

52. Schojai M, Schultz T, Haeussler-Sinangin Y, *et al*. Safety of femtosecond laser-assisted primary posterior capsulotomy immediately after cataract surgery. *J Cataract Refract Surg* 2017; 43: 1171–1176.

53. Malvankar-Mehta MS, Fu A, Subramanian Y, *et al*. Impact of ophthalmic viscosurgical devices in cataract surgery. *J Ophthalmol* 2020; 2020: 7801093.

54. Tognetto D, Cecchini P and Ravalico G. Survey of ophthalmic viscosurgical devices. *Curr Opin Ophthalmol* 2004; 15: 29–32.

55. Tsurimaki Y and Shimizu H. Effects of residual sodium hyaluronate on postsurgical blood-aqueous barrier. *Jpn J Ophthalmol* 1991; 35: 446–452.

56. Tsurimaki Y and Shimizu H. [The effect of viscoelastic substances on postsurgical blood aqueous barrier]. *Nippon Ganka Gakkai Zasshi* 1991; 95: 570–574.

57. Schwenn O, Dick HB, Krummenauer F, *et al*. Healon5 versus Viscoat during cataract surgery: intraocular pressure, laser flare and corneal changes. *Graefes Arch Clin Exp Ophthalmol* 2000; 238: 861–867.

58. Roberts CW. Intraocular miotics and postoperative inflammation. *J Cataract Refract Surg* 1993; 19: 731–734.

59. Kohnen T, Dick B, Hessemer V, *et al*. Effect of heparin in irrigating solution on inflammation following small incision cataract surgery. *J Cataract Refract Surg* 1998; 24: 237–243.

60. Alió JL, Sayans JA and Chipont E. Laser flare-cell measurement of inflammation after uneventful extracapsular cataract extraction and intraocular lens implantation. *J Cataract Refract Surg* 1996; 22: 775–779.

61. Krepler K, Ries E, Derbolav A, *et al*. Inflammation after phacoemulsification in diabetic retinopathy. Foldable acrylic versus heparin-surface-modified poly(methyl methacrylate) intraocular lenses. *J Cataract Refract Surg* 2001; 27: 233–238.

62. Alió JL, Sayans JA and Chipont E. Flare-cell meter measurement of inflammation after uneventful cataract surgery with intraocular lens implantation. *J Cataract Refract Surg* 1997; 23: 935–939.

63. Martin RG, Sanders DR, Van Der Karr MA, *et al*. Effect of small incision intraocular lens surgery on postoperative inflammation and

astigmatism. *J Cataract Refract Surg* 1992; 18: 51–57.

64. Gatinel D, Lebrun T, Le Toumelin P, *et al*. Aqueous flare induced by heparin-surface-modified poly(methyl methacrylate) and acrylic lenses implanted through the same-size incision in patients with diabetes. *J Cataract Refract Surg* 2001; 27: 855–860.

65. Oshika T, Suzuki Y, Kizaki H, *et al*. Two year clinical study of a soft acrylic intraocular lens. *J Cataract Refract Surg* 1996; 22: 104–109.

66. Miyake K, Ota I, Miyake S, *et al*. Correlation between intraocular lens hydrophilicity and anterior capsule opacification and aqueous flare. *J Cataract Refract Surg* 1996; 22(Suppl. 1): 764–769.

67. Monnet D, Tépenier L and Brézin AP. Objective assessment of inflammation after cataract surgery: comparison of 3 similar intraocular lens models. *J Cataract Refract Surg* 2009; 35: 677–681.

68. Schauersberger J, Kruger A, Abela C, *et al*. Course of postoperative inflammation after implantation of 4 types of foldable intraocular lenses. *J Cataract Refract Surg* 1999; 25: 1116–1120.

69. Nguyen NX, Langenbucher A, Huber S, *et al*. Short-term blood-aqueous barrier breakdown after implantation of the 1CU accommodative posterior chamber intraocular lens. *J Cataract Refract Surg* 2002; 28: 1189–1194.

70. Abela-Formanek C, Amon M, Schild G, *et al*. Uveal and capsular biocompatibility of hydrophilic acrylic, hydrophobic acrylic, and silicone intraocular lenses. *J Cataract Refract Surg* 2002; 28: 50–61.

71. Abela-Formanek C, Amon M, Kahraman G, *et al*. Biocompatibility of hydrophilic acrylic, hydrophobic acrylic, and silicone intraocular lenses in eyes with uveitis having cataract surgery: long-term follow-up. *J Cataract Refract Surg* 2011; 37: 104–112.

72. Tran VT, Guex-Crosier Y and Herbort CP. Effect of cataract surgery with intraocular lens implantation on inflammation in chronic uveitis: a longitudinal laser flare photometry study. *Can J Ophthalmol* 1998; 33: 264–269.

73. Krall EM, Arlt EM, Jell G, *et al*. Intraindividual aqueous flare comparison after implantation of hydrophobic intraocular lenses with or without a heparin-coated surface. *J Cataract Refract Surg* 2014; 40: 1363–1370.

74. Shah SM and Spalton DJ. Comparison of the postoperative inflammatory response in the normal eye with heparin-surface-modified and poly(methyl methacrylate) intraocular lenses. *J Cataract Refract Surg* 1995; 21: 579–585.

75. Maedel S, Hirnschall N, Chen YA, *et al*. Effect of heparin coating of a foldable intraocular lens on inflammation and capsular bag performance after cataract surgery. *J Cataract Refract Surg* 2013; 39: 1810–1817.

76. Cellini M, Strobbe E, Toschi PG, *et al*. Secondary IOL implantation without capsular support: a laser flare cell meter study. *ISRN Ophthalmol* 2011; 2011: 653246.

77. Amino K and Yamakawa R. Long-term results of out-of-the-bag intraocular lens implantation. *J Cataract Refract Surg* 2000; 26: 266–270.

78. Ursell PG, Spalton DJ, Whitcup SM, *et al*. Cystoid macular edema after phacoemulsification: relationship to blood-aqueous barrier damage and visual acuity. *J Cataract Refract Surg* 1999; 25: 1492–1497.

79. Ersoy L, Caramoy A, Ristau T, *et al*. Aqueous flare is increased in patients with clinically significant cystoid macular oedema after cataract surgery. *Br J Ophthalmol* 2013; 97: 862–865.

80. Aaronson A, Taipale C, Achiron A, *et al*. Relationship between prolonged intraocular inflammation and macular edema after cataract surgery. *Transl Vis Sci Technol* 2021; 10: 15.

81. De Maria M, Coassin M, Iannetta D, *et al*. Laser flare and cell photometry to measure inflammation after cataract surgery: a tool to predict the risk of cystoid macular edema. *Int Ophthalmol* 2021; 41: 2293–2300.

82. Blaydes EJ, Kelley EP, Walt JG, *et al*. Flurbiprofen 0.03% for the control of inflammation following cataract extraction by phacoemulsification. *J Cataract Refract Surg* 1993; 19: 481–487.

83. Lorenz K, Dick B, Jehkul A, *et al*. Inflammatory response after phacoemulsification treated with 0.5% prednisolone acetate or vehicle. *Graefes Arch Clin Exp Ophthalmol* 2008; 246: 1617–1622.

84. Coassin M, Iovieno A, Soldani A, *et al*. Bromfenac ophthalmic solution 0.09% as an adjunctive therapy to topical steroids after cataract surgery in pseudoexfoliation syndrome. *J Cataract Refract Surg* 2016; 42: 1119–1125.

85. Strobel J, Seitz W and Tietze K. [Quantitative studies of protein and cell concentrations in the anterior chamber in cataract surgery with therapy using steroidal and non-steroidal antiphlogistic drugs]. *Ophthalmologica* 1991; 202: 86–93.

86. Diestelhorst M, Schmidl B, Konen W, *et al*. Efficacy and tolerance of diclofenac sodium 0.1%, flurbiprofen 0.03%, and indomethacin 1.0% in controlling postoperative inflammation. *J Cataract Refract Surg* 1996; 22(Suppl. 1): 788–793.
87. Hessemer V and Schmitt K. [Anti-inflammatory effect of a local combination therapy with diclofenac and prednisolone vs. indomethacin and prednisolone. A laser flare cell photometry study]. *Ophthalmologe* 1994; 91: 224–228.
88. Weber M, Kodjikian L, Kruse FE, *et al*. Efficacy and safety of indomethacin 0.1% eye drops compared with ketorolac 0.5% eye drops in the management of ocular inflammation after cataract surgery. *Acta Ophthalmol* 2013; 91: e15–e21.
89. Zhang G, Liu S, Yang L, *et al*. The role of dexamethasone in clinical pharmaceutical treatment for patients with cataract surgery. *Exp Ther Med* 2018; 15: 2177–2181.
90. Schmidl B, Mester U, Diestelhorst M, *et al*. [Laser flare measurement with 3 different nonsteroidal anti-inflammatory drugs after phacoemulsification with posterior chamber lens implantation]. *Ophthalmologe* 1997; 94: 33–37.
91. Flach AJ, Dolan BJ, Donahue ME, *et al*. Comparative effects of ketorolac 0.5% or diclofenac 0.1% ophthalmic solutions on inflammation after cataract surgery. *Ophthalmology* 1998; 105: 1775–1779.
92. Giannaccare G, Finzi A, Sebastiani S, *et al*. The comparative efficacy and tolerability of diclofenac 0.1% and bromfenac 0.09% ophthalmic solutions after cataract surgery. *Curr Eye Res* 2018; 43: 1445–1453.
93. Miyake K, Masuda K, Shirato S, *et al*. Comparison of diclofenac and fluorometholone in preventing cystoid macular edema after small incision cataract surgery: a multicentered prospective trial. *Jpn J Ophthalmol* 2000; 44: 58–67.
94. Ylinen P, Holmström E, Laine I, *et al*. Anti-inflammatory medication following cataract surgery: a randomized trial between preservative-free dexamethasone, diclofenac and their combination. *Acta Ophthalmol* 2018; 96: 486–493.
95. Solomon KD, Vroman DT, Barker D, *et al*. Comparison of ketorolac tromethamine 0.5% and rimexolone 1% to control inflammation after cataract extraction. Prospective randomized double-masked study. *J Cataract Refract Surg* 2001; 27: 1232–1237.
96. Erichsen JH, Forman JL, Holm LM, *et al*. Effect of anti-inflammatory regimen on early postoperative inflammation after cataract surgery. *J Cataract Refract Surg* 2021; 47: 323–330.
97. Ylinen P, Taipale C, Lindholm JM, *et al*. Postoperative management in cataract surgery: nepafenac and preservative-free diclofenac compared. *Acta Ophthalmol* 2018; 96: 853–859.
98. Cagini C, Pellegrino A, Cerquaglia A, *et al*. Comparison of the effect of diclofenac 0.1% and nepafenac 0.1% on aqueous flare in patients undergoing cataract surgery: a prospective randomized study. *Curr Eye Res* 2020; 45: 1089–1093.
99. Sahu S, Ram J, Bansal R, *et al*. Effect of topical ketorolac 0.4%, nepafenac 0.1%, and bromfenac 0.09% on postoperative inflammation using laser flare photometry in patients having phacoemulsification. *J Cataract Refract Surg* 2015; 41: 2043–2048.
100. Miyake K, Ota I, Miyake G, *et al*. Nepafenac 0.1% versus fluorometholone 0.1% for preventing cystoid macular edema after cataract surgery. *J Cataract Refract Surg* 2011; 37: 1581–1588.
101. Drews RC. Management of postoperative inflammation: dexamethasone versus flurbiprofen, a quantitative study using the new flare cell meter. *Ophthalmic Surg* 1990; 21: 560–562.
102. Othenin-Girard P, Tritten JJ, Pittet N, *et al*. Dexamethasone versus diclofenac sodium eyedrops to treat inflammation after cataract surgery. *J Cataract Refract Surg* 1994; 20: 9–12.
103. Roberts CW and Brennan KM. A comparison of topical diclofenac with prednisolone for postcataract inflammation. *Arch Ophthalmol* 1995; 113: 725–727.
104. Laurell CG and Zetterström C. Effects of dexamethasone, diclofenac, or placebo on the inflammatory response after cataract surgery. *Br J Ophthalmol* 2002; 86: 1380–1384.
105. Coassin M, De Maria M, Mastrofilippo V, *et al*. Anterior chamber inflammation after cataract surgery: a randomized clinical trial comparing bromfenac 0.09% to dexamethasone 0.1. *Adv Ther* 2019; 36: 2712–2722.
106. De Maria M, Coassin M, Mastrofilippo V, *et al*. Persistence of inflammation after uncomplicated cataract surgery: a 6-month laser flare photometry analysis. *Adv Ther* 2020; 37: 3223–3233.

107. Chen PQ, Han XM, Zhu YN, *et al*. Comparison of the anti-inflammatory effects of fluorometholone 0.1% combined with levofloxacin 0.5% and tobramycin/dexamethasone eye drops after cataract surgery. *Int J Ophthalmol* 2016; 9: 1619–1623.

108. Miyanaga M, Miyai T, Nejima R, *et al*. Effect of bromfenac ophthalmic solution on ocular inflammation following cataract surgery. *Acta Ophthalmol* 2009; 87: 300–305.

109. Nishino M, Eguchi H, Iwata A, *et al*. Are topical steroids essential after an uneventful cataract surgery? *J Med Invest* 2009; 56: 11–15.

110. Endo N, Kato S, Haruyama K, *et al*. Efficacy of bromfenac sodium ophthalmic solution in preventing cystoid macular oedema after cataract surgery in patients with diabetes. *Acta Ophthalmol* 2010; 88: 896–900.

111. Shah SM, McHugh JD and Spalton DJ. The effects of subconjunctival betamethasone on the blood aqueous barrier following cataract surgery: a double-blind randomised prospective study. *Br J Ophthalmol* 1992; 76: 475–478.

112. Dieleman M, Wubbels RJ, van Kooten-Noordzij M, *et al*. Single perioperative subconjunctival steroid depot versus postoperative steroid eyedrops to prevent intraocular inflammation and macular edema after cataract surgery. *J Cataract Refract Surg* 2011; 37: 1589–1597.

113. Nicolás T, Benítez del Castillo JM, Díaz D, *et al*. Effects of subconjunctival methylprednisolone on the blood aqueous barrier following cataract surgery. *Int Ophthalmol* 1995–1996; 19: 235–238.

114. Negi AK, Browning AC and Vernon SA. Single perioperative triamcinolone injection versus standard postoperative steroid drops after uneventful phacoemulsification surgery: randomized controlled trial. *J Cataract Refract Surg* 2006; 32: 468–474.

115. Schmitt K and Hessemer V. [Is subconjunctival steroid administration in addition to local therapy after cataract operations necessary? a laser tyndallometric study]. *Ophthalmologe* 1995; 92: 303–306.

116. Fukushima H, Kato S, Kaiya T, *et al*. Effect of subconjunctival steroid injection on intraocular inflammation and blood glucose level after cataract surgery in diabetic patients. *J Cataract Refract Surg* 2001; 27: 1386–1391.

117. Donnenfeld ED, Solomon KD and Matossian C. Safety of IBI-10090 for inflammation associated with cataract surgery: phase 3 multicenter study. *J Cataract Refract Surg* 2018; 44: 1236–1246.

118. Struck HG and Bariszlovich A. Comparison of 0.1% dexamethasone phosphate eye gel (Dexagel) and 1% prednisolone acetate eye suspension in the treatment of post-operative inflammation after cataract surgery. *Graefes Arch Clin Exp Ophthalmol* 2001; 239: 737–742.

119. Tan DT, Chee SP, Lim L, *et al*. Randomized clinical trial of a new dexamethasone delivery system (Surodex) for treatment of post-cataract surgery inflammation. *Ophthalmology* 1999; 106: 223–231.

120. Tan DT, Chee SP, Lim L, *et al*. Randomized clinical trial of Surodex steroid drug delivery system for cataract surgery: anterior versus posterior placement of two Surodex in the eye. *Ophthalmology* 2001; 108: 2172–2181.

121. Dinning WJ. Steroids and the eye–indications and complications. *Postgrad Med J* 1976; 52: 634–638.

122. Titiyal JS, Thangavel R, Kaur M, *et al*. Comparative evaluation of once-daily and twice-daily dosing of topical bromfenac 0.09%: aqueous pharmacokinetics and clinical efficacy study. *J Cataract Refract Surg* 2021; 47: 1115–1121.

123. Brennan KM, Brown RM and Roberts CW. A comparison of topical non-steroidal anti-inflammatory drugs to steroids for control of post cataract inflammation. *Insight* 1993; 18: 8–9, 11.

124. Gupta PC, Ram J, Kumar MP, *et al*. Effect of sustained-release long-acting intravitreal dexamethasone implant in patients of non-proliferative diabetic retinopathy undergoing phacoemulsification: a randomized controlled trial. *Indian J Ophthalmol* 2021; 69: 3263–3272.

125. Baudouin C, Labbé A, Liang H, *et al*. Preservatives in eyedrops: the good, the bad and the ugly. *Prog Retin Eye Res* 2010; 29: 312–334.

126. Hessemer V, Schmidt KG and Schartner H. [Minimally inflammatory cataract surgery]. *Klin Monbl Augenheilkd* 1996; 209: 331–339.

127. Yasuda K, Miyazawa A and Shimura M. A comparison of preservative-free diclofenac and preserved diclofenac eye drops after cataract surgery in patients with diabetic retinopathy. *J Ocul Pharmacol Ther* 2012; 28: 283–289.

128. Ikeda N, Hayasaka S, Nagaki Y, *et al*. Effects of traditional Sino-Japanese herbal medicines on aqueous flare elevation after small-incision cataract surgery. *J Ocul Pharmacol Ther* 2001; 17: 59–65.

129. Ikeda N, Hayasaka S, Nagaki Y, *et al*. Effects of kakkon-to and sairei-to on aqueous flare elevation after complicated cataract surgery. *Am J Chin Med* 2002; 30: 347–353.

130. Tomida I, Martus P and Küchle M. [Influence of postoperative topical application of miotics after cataract extraction on intraocular pressure and the blood-aqueous barrier]. *Ophthalmologe* 1999; 96: 583–586.

131. Hasanreisoglu M, Kesim C, Yalinbas D, *et al*. Effect of light backscattering from anterior segment structures on automated flare meter measurements. *Eur J Ophthalmol* 2022; 32: 2291–2297.

132. Bandello F, Coassin M, Di Zazzo A, *et al*. Correction: one week of levofloxacin plus dexamethasone eye drops for cataract surgery: an innovative and rational therapeutic strategy. *Eye (London, England)* 2020; 34: 2150–2122.

133. Kim S, Ko BY, Koh JW, *et al*. Comparison of a preservative-free nonsteroidal anti-inflammatory drug and preservative-free corticosteroid after uneventful cataract surgery: multicenter, randomized, evaluator-blinded clinical trial. *J Cataract Refract Surg* 2022; 48: 710–716.

134. Kuriakose RK, Cho S, Nassiri S, *et al*. Comparative outcomes of standard perioperative eye drops, intravitreal triamcinolone acetonide-moxifloxacin, and intracameral dexamethasone-moxifloxacin-ketorolac in cataract surgery. *J Ophthalmol* 2022; 2022: 4857696.

135. Gonzales CA, Ladas JG, Davis JL, *et al*. Relationships between laser flare photometry values and complications of uveitis. *Arch Ophthalmol* 2001; 119: 1763–1769.

136. Murakami Y, Yoshida N, Ikeda Y, *et al*. Relationship between aqueous flare and visual function in retinitis pigmentosa. *Am J Ophthalmol* 2015; 159: 958-63.e1.

137. Kato K, Nagashima R, Matsubara H, *et al*. Transient increase of flicker electroretinography amplitudes after cataract surgery: association with postoperative inflammation. *Ophthalmol Sci* 2023; 3: 100243.

138. Kato S, Suzuki T, Hayashi Y, *et al*. Risk factors for contraction of the anterior capsule opening after cataract surgery. *J Cataract Refract Surg* 2002; 28: 109–112.

139. El-Harazi SM, Feldman RM, Ruiz RS, *et al*. Consensual inflammation following ocular surgery. *Ophthalmic Surg Lasers* 1999; 30: 254–259.

140. Oshika T and Kato S. Changes in aqueous flare and cells after mydriasis. *Jpn J Ophthalmol* 1989; 33: 271–278.

141. Schauersberger J, Kruger A, Müllner-Eidenböck A, *et al*. Long-term disorders of the blood-aqueous barrier after small-incision cataract surgery. *Eye (Lond)* 2000; 14 (Pt 1): 61–63.