EXTENDED REPORT

Objective assessment of intraocular flare after cataract surgery with combined primary posterior capsulorhexis and posterior optic buttonholing in adults

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Combining primary posterior continuous curvilinear capsulorhexis (PPC) with posterior optic buttonholing (POBH) of the intraocular lens (IOL) has recently been investigated as a standard cataract procedure that could completely prevent after-cataract formation in age-related cataract patients.¹ A PPC 4.5 to 5.0 mm in diameter is performed with this surgical method after standard cataract removal by phacoemulsification.¹ Then, the optic of a 3-piece IOL is buttonholed posteriorly. Extensive anterior capsule polishing could be performed additionally to fully prevent anterior capsule opacification.² The surgical manoeuvres can all be safely performed under topical anaesthesia, and this is recommended.

However, all additional surgical manoeuvres (eg, performing a PPC combined with POBH), and particularly the accidental puncturing of the anterior vitreous surface might possibly increase the postoperative anterior chamber reaction.

Previous studies on postoperative inflammation after cataract surgery with PPC without POBH evaluated that postoperative flare intensity after phacoemulsification cataract surgery with PPC and implantation of a foldable silicone IOL was not significantly different to postoperative flare measurements in a control group that underwent conventional cataract surgery with IOL in-the-bag implantation.³

The exclusive performance of a PPC creates an aperture between the anterior and posterior department. In contrast, the combined performance of a PPC with posterior buttonholing of the optic results in a hermetically sealed IOL–capsule diaphragm. This should primarily prevent the possibility of a

Aim: Combining primary posterior capsulorhexis (PPC) and posterior optic buttonholing (POBH) in cataract surgery is an innovative approach to prevent after-cataract formation effectively and to increase postoperative stability of the intraocular lens (IOL). The present study was designed to compare the postoperative intraocular flare after cataract surgery with combined PPC and POBH to conventional in-the-bag implantation of the IOL.

Methods: Fifty consecutive age-related cataract patients with cataract surgery under topical anaesthesia in both eyes were enrolled prospectively into a prospective, randomised clinical trial. In randomised order, cataract surgery with combined PPC and POBH was performed in one eye; in the other eye cataract surgery was performed conventionally with in-the-bag IOL implantation keeping the posterior lens capsule intact. Intraocular flare was measured 1, 2, 4, 6, 12 and 24 h postoperatively, as well as 1 week and 1 month postoperatively, using a KOWA FC-1000 laser flare cell meter.

Results: The peak of intraocular flare was observed in POBH eyes and eyes with in-the-bag IOL implantation 1 h postoperatively. In both groups, the response was steadily decreasing thereafter. During measurements at day 1, small though statistically significant higher flare measurements were observed in eyes with in-the-bag IOL implantation ($p < 0.05$). At 1 week and 1 month postoperatively, intraocular flare measurements were comparable again ($p > 0.05$).

Conclusion: Cataract surgery with combined PPC/POBH showed slightly lower postoperative anterior chamber reaction compared to conventional in-the-bag implantation during 4-week follow-up, indicating that POBH might trigger somewhat less inflammatory response. This could be explained by the posterior capsule sandwiching between the optic and the anterior capsule, preventing direct contact-mediated myofibroblastic trans-differentiation of anterior lens epithelial cells with consecutive cytokine depletion.

residual ophthalmic viscosurgical device (OVD) bolus captured behind the IOL–capsule diaphragm accessing the anterior chamber in the first postoperative hours. In addition, the close bonding between the lens capsule and the optic and the contiguous OVD layer between this tight diaphragm and the anterior vitreous surface could impede the dissipation of cytokines by the lens epithelial cells (LECs).

Consequently, the present study was designed to evaluate postoperative intraocular flare after cataract surgery with combined PPC and POBH compared to conventional in-the-bag implantation of the IOL.

PATIENTS AND METHODS

In this prospective clinical study, 50 consecutive age-related cataract patients awaiting bilateral same-day cataract surgery were enrolled (100 eyes total).

Patients with any history of intraocular surgery, eye trauma, primary or secondary glaucoma, ocular hypertension (IOP greater than 22 mm Hg), or uveitis were excluded from the study population. The patients' mean (SD) age was 76 (8.4) years (range: 56–88 years; 54% female).

The study protocol was approved by the ethics committee of the Medical University of Vienna. In accordance with the Declaration of Helsinki, informed consent was obtained.

Abbreviations: AC, Anterior capsulorhexis; IOL, intraocular lens; LEC, lens epithelial cells; LFCM, laser flare cell meter; OVD, ophthalmic viscosurgical device; POBH, posterior optic buttonholing; PPC, primary posterior capsulorhexis

Surgical technique

In randomised order, cataract surgery with combined PPC and POBH was performed in one eye; in the patient's other eye cataract surgery was performed conventionally with in-the-bag IOL implantation keeping the posterior lens capsule intact. The sequence of right and left eyes was randomised, as well the sequence of surgical procedures (ie, whether the in-the-bag IOL implantation or the PPC/POBH procedure was performed first).

Before surgery (1–2 h prior), diclofenac, phenylephrine 2.5%, tropicamide 0.5%, and cyclopentolate 1% eye drops were administered.

All surgery was performed by one experienced surgeon (RM) under topical anaesthesia using oxybuprocaine and 4% lidocaine drops, as well as an intracameral bolus of 1% lidocaine solution.

In all surgeries, a temporal 3.0 mm posterior limbal incision was performed. MedioClear® (hydroxy-propyl-methylcellulose 2%; Aivimed, Germany) was used as a dispersive OVD for endothelial protection during phacoemulsification, and sodium hyaluronate 1% (Healon®, Advanced Medical Optics, Ettlingen, Germany) as a cohesive OVD for IOL implantation and for the PPC/POBH manoeuvres. Anterior capsulorhexis (AC), hydrodissection, and phacoemulsification of the nucleus were followed by aspiration of the cortical remnants and cleaning of the capsular bag.

In case of conventional cataract surgery, the capsular bag was expanded with the OVD, and a foldable acryl IOL (HOYA AF-1 YA-60BB) was implanted into the capsular bag. The OVD was aspirated in a standardised fashion from the retrolental space, the capsule fornix, and the anterior chamber using a coaxial irrigation/aspiration (I/A) tip. Pump settings were 15 ml/min flow rate and 150 mm Hg vacuum limit. First, the proximal optic edge was tilted up with a spatula and the I/A tip inserted behind the optic. After the central portion of the OVD was removed, the I/A tip was swept across and along the capsular equator to capture peripheral residues. The I/A tip was then redirected into the anterior chamber and the optic repositioned. While the aspiration opening was rotated right, left and posteriorly, the OVD was removed circumferentially from the prelental, retroiridal and preiridal spaces. The surgeon was careful not to approach the delicate structures of the endothelium and the chamber angle too closely. Finally, the I/A tip was positioned on the centre of the optic; while the aspiration opening was directed upwards and the tip pressed down on the optic, the anterior chamber was rinsed before retraction of the I/A tip. The incision was left sutureless. No miotic agent was used intracamerally. Capsular rupture did not occur in any patient. The incisions were then hydrated, the globe was pressurised, and all eyes were left unpatched.

For all eyes, the overall duration of surgery (min) and the phaco time (s) were recorded and statistically compared.

Surgical technique in PPC/POBH eyes

Standard AC and phacoemulsification with I/A were completed. Residual lens fibres were meticulously peeled from the peripheral posterior capsule by vacuuming the capsule (lens fibre peeling). In this series, the anterior capsule was left unpolished, because this additional surgical manoeuvre might bias the statistical analyses of the present study by relevantly influencing the postoperative anterior chamber flare. Then, the anterior segment was filled with the medium-viscosity OVD (Healon®, AMO) to allow the remaining peripheral anterior capsule to settle down on the posterior capsule and to flatten the central posterior capsule. As a result, the capsular fornix then collapsed and both capsules formed a common flat diaphragm. Following the outlines of the AC, a well centred 4.5–5.0 mm PPC was then created as earlier described in detail.¹

After the central capsule portion was removed from the eye, the OVD was gently injected beneath the peripheral ring of residual posterior capsule to separate it from the underlying vitreous surface and lift it up toward the anterior capsule. When this was completed along the whole circumference, the anterior segment was prepared for the implantation of the foldable IOL (HOYA AF-1 YA-60BB). The central chamber was deepened, and the capsular fornix to the surgeon's left expanded and thus prepared to take up the tip of the leading IOL haptic. The tip of the leading IOL haptic was guided into the capsular bag fornix, to then be followed by the optic and trailing haptic. By gently pressing on the optic with two phaco spatulas at a time to avoid excessive tilt, the optic was finally enclaved in the PPC. The OVD was then gently aspirated from the anterior chamber and capsular bag fornix with the pump set at 7 ml/min and 100 mm Hg. As the posterior capsule is firmly pressed unto the anterior optic surface, the optic–capsule diaphragm hermetically seals off the posterior segment and no OVD is allowed to access anterior chamber from the retrolental space during this manoeuvre. Again, the incisions were then hydrated, the globe was pressurised, and all eyes were left unpatched. No intra-operative complications occurred.

The same OVDs (MedioClear® and Healon®) and IOL (HOYA AF-1 YA-60BB) were used for both eyes and both surgical techniques. Example retroillumination photographs of both surgical techniques are shown in fig 1.

Postoperative medication

Immediately after the end of the cataract surgery, all patients received once a mixed dexamethasone and gentamycine ointment (Dexagenta®, Croma Pharma, Leobendorf, Austria) in the operated eyes. Both eyes received the same postoperative drop therapy (Voltaren® and Ultracortenol® eye drops, Novartis Pharma and Ciba Vision, Vienna, Austria, respectively) 4 times daily for 4 weeks, starting on the day of surgery 1 h post-operatively.

Anterior chamber flare measurements

Anterior chamber flare was measured 1, 2, 4, 6, 12 and 24 h postoperatively, as well as 1 week and 1 month postoperatively, using a Kowa FC-1000 laser flare cell meter (LFCM) about 30 min after pupil dilation by 1 drop of tropicamide 1% (Mydriatikum-Roche®, Hoffmann-La Roche AG, Vienna, Austria) and phenylephrine 2.5%. The examiner was masked to the surgical technique used.

Eight consecutive laser flare readings with background scatter of less than 10% were taken. The highest and lowest readings were discarded, and the remaining six were averaged to obtain the flare measurement. Laser flare values were all expressed in photons/ms. Calibration of the LFCM was performed according to the manual.

Statistical analysis

Repeated-measures analysis of variance was used to reveal differences between postoperative and preoperative anterior chamber flare measurements. The compound symmetry covariance structure was specified, allowing the variance to be different at various time points. Comparisons of postoperative anterior chamber flare measurements with the baseline measurement were adjusted for multiple comparisons using the Bonferroni post hoc test. For paired analyses, paired two-sided t-tests were used. P values of <0.05 were considered as indicating statistical significance. All calculations were performed with SPSS for Windows V.12.0.

RESULTS

The peak of intraocular flare was observed in POBH-eyes and eyes with in-the-bag IOL implantation 1 h postoperatively (fig 2).

Figure 1 Retroillumination photographs 1 week after (A) cataract surgery with combined primary posterior capsulorhexis (PPC) and posterior optic buttonholing (POBH) in comparison to (B) conventional in-the-bag IOL implantation.

Maximum postoperative anterior chamber flare (mean (SD)) was 29.8 (7.1) photons/ms in the POBH-eyes, and 34.1 (6.8) photons/ms in eyes with IOL in-the-bag implantation, respectively.

In both groups, the response steadily decreased thereafter (fig 2).

The repeated-measures analysis of variance revealed significant differences between postoperative and preoperative anterior chamber flare measurements ($p < 0.001$).

During the anterior chamber flare measurements at day 1, slightly though significantly higher flare measurements were observed in eyes with in-the-bag IOL implantation ($p < 0.05$; fig 2). At 1 week and 1 month postoperatively, intraocular flare measurements were comparable again ($p > 0.05$).

In the POBH eyes, a small round central puncture of the anterior vitreous surface without vitreous prolapse out of the vitreous body was observed in 36% of cases, which did not significantly increase the inflammatory response when compared to eyes with intact anterior vitreous surface (all examinations: $p > 0.05$; fig 3).

Vitreous herniation into the anterior chamber did not occur in any of the study patients. In addition, relevantly increased clinical signs of postoperative inflammation were not seen in any of the study patients.

When comparing PPC/POBH cataract surgery to the conventional in-the-bag IOL implantation, overall duration of surgery ($p = 0.34$) and phaco time (0.56) were both found to be statistically comparable. In addition, no statistically significant differences were found in any clinical parameters as cataract grading ($p = 0.3$), visual acuity (preoperatively: $p = 0.5$; postoperatively: $p = 0.43$), and intraocular pressure ($p = 0.45$). Preoperative anterior chamber baseline flare measurements were also found to be statistically comparable between POBH-eyes and eyes with IOL in-the-bag implantation ($p = 0.77$).

DISCUSSION

Phacoemulsification cataract surgery with combined PPC and POBH showed slightly lower postoperative anterior chamber reaction compared to conventional in-the-bag IOL implantation at 4-week follow-up. It is remarkable that anterior chamber flare was less in the POBH eyes despite the fact that aspiration of residual OVD inherently cannot be as thorough as in conventionally operated eyes. This indicates that POBH might trigger somewhat less of an inflammatory response. In any case, the low LFCM counts prove that the combined performance of a PPC with posterior buttonholing of the optic results in a hermetically sealed IOL–capsule diaphragm. This closed

Figure 2 Postoperative anterior chamber flare measurements (LFCM; photons/ms) during time course in eyes with cataract surgery and combined primary posterior capsulorhexis (PPC) and posterior optic buttonholing (POBH) in comparison to eyes with conventional in-the-bag IOL implantation.

Figure 3 Comparing anterior chamber flare measurements (LFCM; photons/ms) of eyes with combined PPC/POBH with accidentally punctured (n=18) and intact (n=32) anterior vitreous surface.

diaphragm effectively prevents the residual OVD bolus captured behind the IOL accessing the anterior chamber in the first postoperative hours. Consequently, a cause of postoperative anterior chamber flare is prevented, as significantly fewer OVD particles are dissolved in the aqueous humour. As a side effect, the clearance of the aqueous humour might be higher without OVD residuals congesting the chamber angle.

Previously, the influence of performing a sole PPC on the postoperative anterior chamber flare was evaluated in a clinical study: it has been shown that the surgical trauma significantly increased aqueous flare values 1 day, 1 week, and 1 month after surgery in PPC eyes, as well as in eyes with IOL in-the-bag implantation.³ At 3 months postoperatively, flare values in both groups were not different from preoperative values.³ No differences were found in flare intensity measurements or in best-corrected visual acuity before and after uneventful surgery.³ The primary removal of the central posterior capsule during cataract surgery without optic buttonholing was also shown not to increase the rate of cystoid macular oedema or retinal detachment and does not adversely affect the diffusion barrier.³⁻⁵

The reduced LFCM counts found after additional buttonholing compared to sole PPC could be explained as follows: firstly, buttonholing hermetically seals off the posterior capsule opening left after sole PPC. This prevents OVD particle dissipation from the retro-optical space into the anterior chamber. Secondly, as a result of buttonholing the residual peripheral posterior capsule is sandwiched between the optic and the anterior capsule, which prevents direct contact between them. This direct optic contact, however, is the prerequisite for myofibroblastic trans-differentiation of anterior LECs as the source in cytokine depletion. Therefore, inflammatory response could be reduced.

In any case, the results of the present study indicate that an additionally performed posterior buttonholing of the IOL optic does not induce additional postoperative trauma when compared to conventional phacoemulsification cataract surgery with in-the-bag IOL implantation. This can be seen to be in consent with the finding of the present study that the overall duration of cataract surgery and the phacoemulsification time were found to be statistically comparable.

In addition to the findings of the present study, a primary report of the first 500 cases of combined PPC and POBH

cataract surgery¹ and the monitoring of intraocular pressure during the early postoperative period demonstrated the clinical safety of this method in a standardised clinical setting.⁶

Other than performing a sole PPC, posterior buttonholing of the IOL optic precludes the secondary closure of the PPC opening by migrating LECs using the anterior hyaloid membrane or the back surface of the IOL optic as a scaffold, which was observed in up to a third of patients.⁷⁻¹⁰ Longer follow-up will help to determine whether combining PPC with POBH is an alternative to standard in-the-bag IOL implantation in routine cataract surgery.

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