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Original Article

Long-term results of viscocanalostomy in pseudoexfoliative and primary open angle glaucoma

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Abstract

Purpose: To document the outcome of viscocanalostomy (VC) alone or combined with phacoemulsification (phaco-VC) in eyes with pseudoexfoliation glaucoma (PEXG) and primary open angle glaucoma (POAG).

Methods: A prospective, comparative study of 314 eyes undergoing VC in two centres over 6 years was conducted. Main outcome measures were: (i) intraocular pressure (IOP) control (complete success was IOP ≤ 18 mmHg without medication and failure IOP > 18 mmHg); and (ii) requirement for Nd:YAG laser goniopuncture (YAG-GP) if IOP > 21 mmHg.

Results: In the POAG group, 174 eyes underwent phaco-VC and 104 VC. In the PEX group, 20 eyes underwent phaco-VC and 16 VC. At final follow up, complete success rate (CSR) was 76% for POAG phaco-VC, 67% for POAG VC, 95% for PEXG phaco-VC and 63% for PEXG VC with mean IOP reduction of 29.9%, 40%, 42.5% and 51%, respectively. Without YAG-GP, by 3 years postoperatively the failure rate was 100% for PEXG eyes and 21% for POAG eyes undergoing VC alone, but PEXG eyes undergoing phaco-VC were 100% successful. CSR for YAG-GP was 92% in PEXG VC eyes and 55% in POAG VC eyes.

Conclusions: In phakic eyes with PEXG undergoing VC, an absolute requirement for long-term success was YAG-GP. This was not the case in POAG eyes or PEXG eyes undergoing phaco-VC. Late IOP rise in phakic PEXG eyes and restoration of IOP control following YAG-GP suggests that continued release of PEX material from the lens capsule with time blocks the outflow through the trabecular-Descemetic window created by VC.

Key words: Nd:YAG laser goniopuncture, pseudoexfoliation, viscocanalostomy.

Introduction

The pseudoexfoliation (PEX) syndrome is an age-related, generalized disorder of the extracellular matrix, characterized by the presence of fibrillar extracellular material and frequently associated with severe and often rapidly progressive chronic secondary open angle glaucoma.[1–4]

Viscocanalostomy (VC) has been shown to be an effective surgical treatment for both primary open angle glaucoma (POAG) and pseudoexfoliative glaucoma (PEXG),[5,6] relieving outflow obstruction by creating a trabecular-Descemetic window (TDW) which removes the inner wall endothelium of Schlemm's canal as well as the juxtacanalicular tissue (JCT), the normal site of outflow resistance.[7–9] Our previous study showed a clear difference in outcome of VC in PEXG eyes[10] with phakic PEXG eyes initially successful but later developing raised intraocular pressure (IOP). Combined cataract extraction by phacoemulsification (phaco) plus VC (phaco-VC) in PEXG eyes was successful and did not show any tendency to late IOP rise.[10] No difference was observed in outcome of VC or phaco-VC in POAG eyes.

The aim of this study was to observe in a larger group of eyes with longer follow up whether this late IOP rise was indeed specific to phakic PEXG eyes undergoing VC alone. Confirmation of late IOP rise in PEXG eyes would establish the need to perform Nd:YAG laser goniopuncture (YAG-GP) in all PEXG eyes undergoing VC within 2 postoperative years to prevent late IOP rise. It would also suggest continued release of PEX material from the lens capsule builds up in the remaining corneoscleral/uveoscleral trabecular meshwork, blocking outflow in PEXG eyes undergoing VC. A

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secondary aim was to provide long-term prospective follow-up data on a large cohort of patients undergoing VC.

METHODS

This study develops further the prospective investigation described in our previous report[10] and includes all the patients of that study and additional consecutive patients undergoing VC at the same two centres by the same two surgeons (PKW and MSW) until April 2004, so providing prospective follow up for a minimum of 2 years. We included in this study only eyes with POAG and eyes with PEXG with uncontrolled glaucoma (diagnosed by IOP > 21 mmHg, glaucomatous disc damage and characteristic glaucomatous visual field loss detected on programme 24-2 of the Humphrey Visual Field Analyser) on maximum tolerated medication. We used the Advanced Glaucoma Intervention Study (AGIS) criteria whereby depending on the level of IOP and estimated stage of field loss eyes were deemed to be at an AGIS defined 'critical level' requiring surgical intervention (IOP ≥ 30 mmHg and almost no field loss was an indication for surgery as was advanced field loss and IOP of ≥18 mmHg).[11] The indication for combined phaco-VC was the presence of a visually disabling cataract and PEXG or POAG in an eye with uncontrolled IOP.

In the present study, we excluded any eye that had undergone previous glaucoma or cataract surgery, or suffered from uveitis. The diagnosis of PEX was made in those eyes in which the presence of typical PEX deposits were visible on the anterior lens capsule of the dilated pupil and/or on the pupillary border of the iris on slit-lamp examination.

As the present study examines the possible effect of PEX material on the outflow through the intact TDW created by VC, eyes that underwent preoperative perforation of the TDW were excluded. Details of examination methods and follow up were unchanged from our earlier report.[10] Gonioscopy was performed preoperatively and six monthly after surgery and at any time when raised IOP developed. Angle pigmentation was recorded as per the Spaeth grading system.[12] As the TDW is depigmented postoperatively due to removal of JCT, any change in postoperative pigmentation would be easy to recognize.

To perform VC, a superficial 5 mm by 5 mm scleral flap was reflected forward, 2 mm into clear cornea. Next, a 4 mm by 4 mm deep scleral flap, almost down to the depth of the choroid, was then prepared below the superficial flap and dissected forward to open and de-roof Schlemm's canal and continued forward into the cornea in the same plane, thus exposing the anterior trabecular meshwork and a segment of Descemet's membrane. The endothelial lining of Schlemm's canal is fractured by this process and removed along with adjacent JCT by forceps or a capsule polisher. Thus, an 'ostomy' is produced in the canal – a 'Canalostomy'. The deep scleral block with the roof of Schlemm's canal is then removed – a 'Deep Sclerectomy' (DS). Thus, both a DS and a canalostomy are performed simultaneously by all surgeons undertaking non-penetrating trabecular filtering surgery with the aim of creating a TDW.[5,6,13] In our two centres, we prefer the term 'viscocanalostomy' as we use a viscoelastic to dilate the cut ends of Schlemm's canal, whereas surgeons who prefer to use an implant of collagen or reticulated sodium hyaluronate[13,14] call the procedure a DS. No eye in our study underwent bleb needling, laser suture lysis, antimetabolite injection or any other manipulation.

If the IOP rose above 21 mmHg in the early postoperative period, first the topical steroids were stopped to see if this was a steroid response. If the IOP continued to be elevated, or if elevation occurred at a later period when not on steroids, a laser goniopuncture was performed using the Nd:YAG laser. YAG-GP was performed as described by Mermoud *et al*.[15] with approximately six shots aimed at the TDW with an energy setting of 5 millijoules. Our definition of successful YAG-GP was a fall in IOP to less than 21 mmHg without medications. Need for topical medication to keep the IOP < 21 mmHg was considered as failure of YAG-GP. For VC we defined success according to IOP ≤ 18 mmHg and ≤21 mmHg to aid comparison with other studies: complete success was IOP ≤ 18 mmHg (and ≤21 mmHg) without medication, qualified success was IOP ≤ 18 mmHg (and ≤21 mmHg) on not more than one medication.

Statistical analysis

Statistical analysis was performed using the SPSS 14 software for windows (SPSS Inc., Chicago, IL, USA). Descriptive statistics were employed to summarize demographics and outcome characteristics of the groups. Student's *t*-test was used to determine the significance of any differences in the continuous variables within each group. Wilcoxan signed rank test was used to compare the pre- and postoperative antiglaucoma medication scores. Mann–Whitney *U*-test was used to compare continuous variables between the groups. A *P*-value of <0.05 was taken as statistically significant. The cumulative probability of success was derived using the Kaplan–Meier survival curve and compared using the log rank test.

RESULTS

Viscocanalostomy was performed on 314 eyes with POAG or PEXG between August 1997 and April 2004 in the two units and all details entered into a database. The demographic details of the patients and the details of the 314 eyes included are given in Table 1. Patients were predominantly elderly Caucasians with only two of Black race and three Asians.

In our study, precise field analysis was not always possible because of coexisting ocular disease (e.g. cataract), but the field loss was classed by AGIS classification[10] as: None in 6%, Mild in 31%, Moderate in 36%, Severe in 25% and End-stage in 2% of eyes. Three eyes had undergone previous argon laser trabeculoplasty. The mean follow up was 5 years (range 2–9 years).

Table 1. Patient demographics and characteristics of study population

	POAG (phaco-visco)	POAG (visco)	PEXG (phaco-visco)	PEXG (visco)
No. of eyes	174	104	20	16
Age (year)	77.9 ± 8.4 (48–96)	64.8 ± 13.7 (20–90)	79.4 ± 8.4 (64–90)	72.4 ± 5.8 (64–82)
Male/female	84/90	63/41	6/14	9/7
Mean year glaucoma	6.5 ± 5.3 (0.3–30)	5.7 ± 4.9 (0.2–25)	4.9 ± 4.5 (0.3–16)	4.6 ± 4.04 (0.2–12)
Mean C/D ratio	0.73 ± 0.7 (0.0–0.9)	0.71 ± 0.16 (0.2–0.95)	0.67 ± 0.5 (0.2–0.9)	0.71 ± 0.12 (0.5–0.9)
Mean preop IOP (mmHg)	23.98 ± 5.4 (14–49)	27.8 ± 5.7 (20–46)	25.8 ± 6.2 (17–38)	31.5 ± 7.2 (22–45)
Mean preop medications	2.4 ± 0.9 (0–5)	2.7 ± 1.2 (0–10)	2.42 ± 0.8 (1–4)	2.5 ± 0.8 (1–3)

C/D, cup/disc; IOP, intraocular pressure; PEXG, pseudoexfoliative glaucoma; phaco-visco, phacoemulsification and viscocanalostomy; POAG, primary open angle glaucoma; preop, preoperative; visco, viscocanalostomy.

Table 2. Results

	POAG (phaco-visco)	POAG (visco)	PEXG (phaco-visco)	PEXG (visco)
Mean follow up	47.05 ± 23.7 (6–96)	55.4 ± 27.2 (1–108)	42.6 ± 28.5 (6–96)	59.2 ± 20.5 (30–90)
Mean preop IOP	23.98 ± 5.4 (14–49)	27.8 ± 5.7 (20–46)	25.8 ± 6.2 (17–38)	31.5 ± 7.2 (22–45)
Mean postop IOP (final visit)	16.2 ± 3.9 (6–37)	16.2 ± 5.2 (8–48)	15.3 3.2 (8–24)	15.7 ± 4.2 (8–26)
Mean % IOP reduction	29.9 ± 19.6 (−54.2–71.4%)	40.1 ± 18.4 (−25–75.7%)	42.5 ± 30.7 (−26.3–100%)	51.1 ± 24.1 (3.7–100%)
Mean change in IOP	7.74 ± 6.2 (−13–30)	11.6 ± 7.08 (−7–32)	12.2 ± 9.5 (−5–30)	16.7 ± 8.8 (1–30)
Outcome (%)				
IOP ≤ 18 mmHg				
Complete success	76	67	95	63
Qualified success	76	74	95	75
IOP ≤ 21 mmHg				
Complete success	88.5	76.9	100	68.5
Qualified success	90.2	87.5	100	87.5
Preop medications	2.4 ± 0.9 (0–5)	2.7 ± 1.2 (0–10)	2.42 ± 0.8 (1–4)	2.5 ± 0.8 (1–3)
Postop medications	0.16 ± 0.58 (0–3)	0.36 ± 0.75 (0–3)	0	0.2 ± 0.41 (0–1)

IOP, intraocular pressure; PEXG, pseudoexfoliative glaucoma; phaco-visco, phacoemulsification and viscocanalostomy; POAG, primary open angle glaucoma; postop, postoperative; preop, preoperative; visco, viscocanalostomy.

Table 2 gives the results in all four groups, showing a statistically significant reduction in both IOP and mean medications in all four groups following VC ($P < 0.05$). The percentage reduction in IOP was between 29.9% and 51.1%. Change in IOP was significantly greater in the POAG VC group compared with the POAG phaco-VC group ($P < 0.05$, Mann–Whitney *U*-test), but there was no statistically significant difference for the PEX groups ($P > 0.05$). Figures 1 and 2 show the mean IOP with time. The requirement for and results of YAG-GP are given in Table 3.

Kaplan–Meier curves showed similar success in all four groups when YAG-GP is allowed ($P > 0.05$), but when censored for YAG-GP, PEXG eyes all fail with time ($P = 0.00$) (Figs 3,4). As PEXG phaco-VC eyes had 100% success, it was not possible to conduct a Kaplan–Meier survival curve for this group.

Table 2 shows the complete success rate (CSR), qualified success rate and IOP reduction achieved in each group. In the PEXG VC group, four of the 16 eyes underwent cataract extraction before 2 years, and the 12 eyes that remained

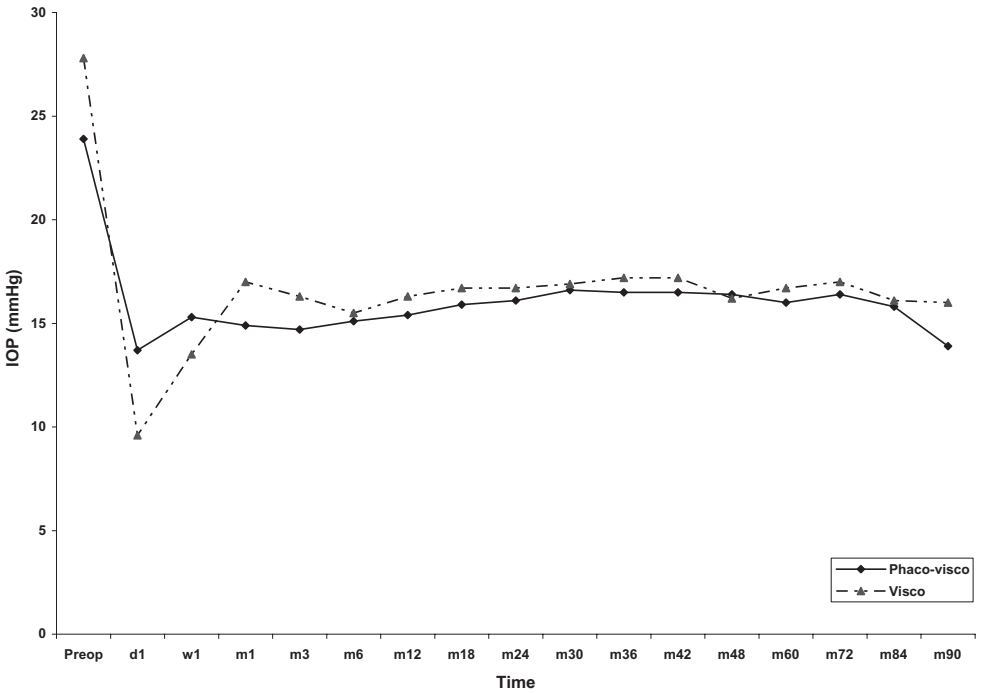

Figure 1. Change in mean intraocular pressure (IOP) with time (POAG group). d, day; m, month; phaco-visco, phacoemulsification and viscocanalostomy; POAG, primary open angle glaucoma; preop, preoperative; visco, viscocanalostomy; w, week.

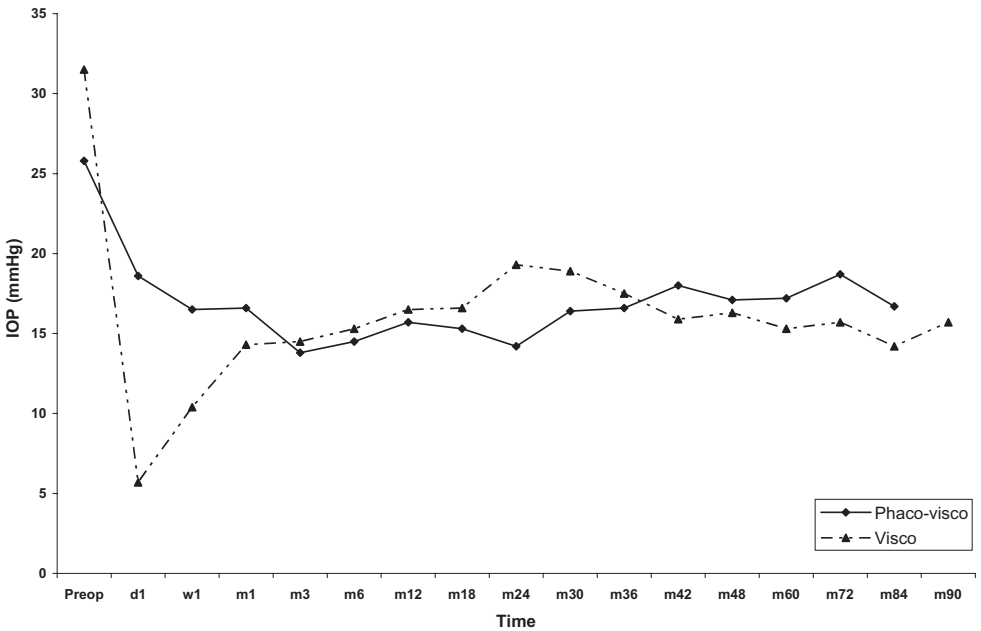

Figure 2. Change in mean intraocular pressure (IOP) with time (PEX group). d, day; m, month; PEX, pseudoexfoliative; phaco-visco, phacoemulsification and viscocanalostomy; preop, preoperative; visco, viscocanalostomy; w, week.

phakic all developed IOP > 21 mmHg. Only one PEXG eye developed raised IOP before 2 years postoperatively (at 6 months) and YAG-GP was unsuccessful in restoring IOP control. Final CSR (IOP ≤ 18 mmHg) was 63% in PEXG VC group. Only one PEXG phaco-VC eye required YAG-GP following an increase in IOP at 6 years postoperatively. Gonioscopy of the study eyes during follow up did not show any increase in pigmentation of the TDW except in one phakic eye with PEXG which developed raised IOP.

Twenty-one eyes showed a steroid response which in all cases consisted of a postoperative IOP > 21 mmHg to a mean peak of 26 mmHg occurring between 7 and 30 days with return to IOP < 21 mmHg on withdrawal of steroids.

Complications and need for further procedures are detailed in Table 4. Two large blebs developed in POAG VC eyes, with bleb dysaesthesia. No thin-walled blebs, no blebitis, nor endophthalmitis occurred. Central visual loss due to glaucoma occurred in two eyes with end-stage glaucoma. Eleven eyes had reduction in central vision from age-related

Table 3. Requirement and outcome of YAG goniopuncture

	No. of eyes	Success	Pre-YAG-GP IOP (mmHg)	Post-YAG-GP IOP (mmHg)	Mean time for GP (month)
POAG pv	8	2 (25%)	28 (22–36)	18.5 (16–21)	18.5 (1–36)
POAG v	22	12 (54%)	26.17 ± 5.84 (20–42)	14.5 ± 2.19 (11–18)	27.1 ± 19.5 (1–63)
PEXG pv	1	1 (100%)	28	16	60
PEXG v	12	11 (92%)	26.09 ± 4.78 (18–38)	13.73 ± 4.05 (6–26)	28.64 ± 12.70 (12–54)

GP, goniopuncture; IOP, intraocular pressure; PEXG, pseudoexfoliative glaucoma; POAG, primary open angle glaucoma; Post-YAG-GP, post YAG laser goniopuncture; Pre-YAG-GP, pre YAG laser goniopuncture; pv, phaco-viscocanolostomy; v, viscocanalostomy.

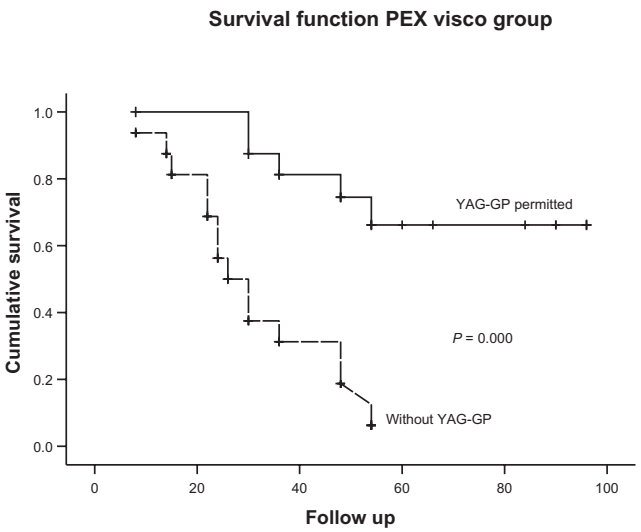

Figure 3. Kaplan–Meier survival curve (PEXG visco group). Kaplan–Meier survival curve analysis showed that a cumulative probability of maintaining an intraocular pressure ≤ 21 mmHg without topical anti-glaucoma medication was 100% at 1 year, 86.7% at 3 years, 79.4% at 4 years, 70.6% at 5 years and 70.6% at 8 years with a mean survival time of 80.4 months (95% CI 67.4, 93.5) when YAG-GP was permitted and 87.5% at 1 year, 56.3% at 2 years, 18.8% at 4 years and 6.3% at 5 years with a mean survival time of 31.8 months (95% CI 24.26, 39.35) when censored for YAG-GP. PEXG, pseudoexfoliation glaucoma; visco, viscocanalostomy; YAG-GP, Nd:YAG laser goniopuncture.

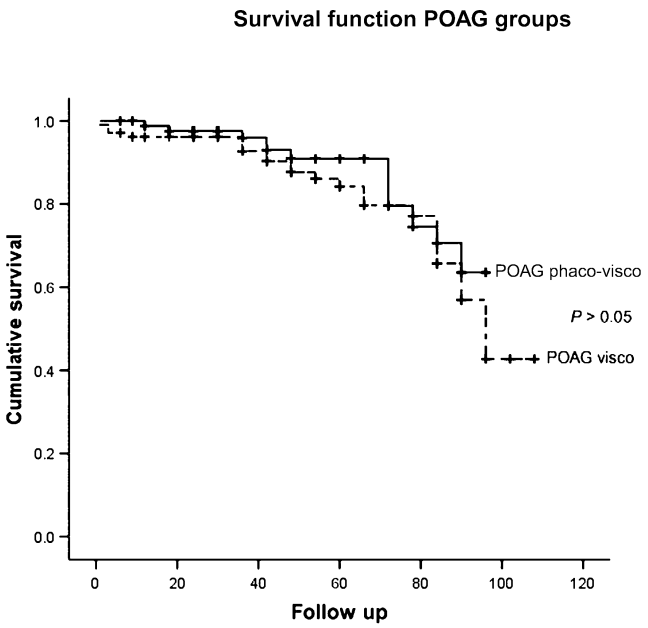

Figure 4. Kaplan–Meier survival curve (POAG groups). Kaplan–Meier survival curve analysis showed that a cumulative probability of maintaining an intraocular pressure ≤ 21 mmHg without topical anti-glaucoma medication was 98.8% at 1 year, 96% at 3 years, 89.8% at 4 years, 78.6% at 6 years, 69.8% at 7 years and 62.8% at 8 years with a mean survival time of 85.5 months (95% CI 81.5, 89.4) for the POAG phaco-visco group and 96.1% at 1 year, 92.7% at 3 years , 87.6% at 4 years, 84.2% at 5 years, 79.7% at 6 years, 65.7% at 7 years and 42.7% at 8 years with a mean survival time of 87.9 months (95% CI 81.5, 94.3) for the POAG visco group. phaco-visco, phacoemulsification and viscocanalostomy; POAG, primary open angle glaucoma; visco, viscocanalostomy.

macular degeneration, four from retinal vascular disease and two from diabetic retinopathy.

Discussion

Our prospective study of VC provides the largest number of eyes with the longest follow up yet reported for this procedure. Our patients had high IOP glaucoma of a similar severity by field classification to the eyes reported in the AGIS study.[11] In our study, visual field defects were classed as mild in 31%, moderate in 36% and severe in 25% compared with eyes of the AGIS study which had mild visual field defects in 24%, moderate in 45% and severe in 31% patients.

Our results show a clear difference in the postoperative IOP control of those PEXG eyes that underwent VC alone and those PEXG eyes that underwent combined phaco-VC (Fig. 3). Without YAG-GP, 90% of phakic PEXG eyes developed IOP > 21 mmHg (mean 26 mmHg, range 25–60 mmHg) at a mean time of 28 months postoperatively. In contrast, all 20 PEXG eyes that underwent combined cataract extraction and VC had normal IOP without medication up to 6 years follow-up. When YAG-GP is allowed as a treatment, then the results of VC in PEXG eyes are not significantly different between the groups that had VC alone or phaco-VC ($P > 0.05$). When good postoperative IOP control was later lost (more than 12 months), YAG goniopuncture was successful in restoring IOP control in 95% of PEXG eyes, indicating that in PEXG eyes late IOP

Table 4. Complications and requirement for other procedures

	POAG pv (eyes)	POAG v (eyes)	PEXG pv (eyes)	PEXG v (eyes)
Cataract extraction		14		7
GP	8	22	1	12
PI	0	6	0	2
Further surgery	6	8	0	2
Complications				
Preoperative				
Posterior capsule tear	1			
Zonule dehiscence			1	
Postoperative				
Iris prolapse after GP		1		
Haemorrhagic detachment of DM		1		
Large blebs with dysaesthesia		2		

DM, Descemet's membrane; GP, YAG laser goniopuncture; PEXG, pseudoexfoliative glaucoma; PI, peripheral iridotomy; POAG, primary open angle glaucoma; pv, phaco-viscocanolostomy; v, viscocanalostomy.

rise is likely to be due to TDW obstruction (Table 3). In POAG eyes with late IOP rise, YAG-GP was only successful in restoring IOP control in 54%. Kaplan–Meier survival curves show no significant difference between POAG eyes undergoing VC alone or phaco-VC.

After cataract surgery, an increased anterior chamber depth means the iris is no longer in contact with the anterior lens capsule[16] reducing the liberation of PEX material from the anterior lens capsule in the pseudophakic eye compared with the phakic eye.[4,17,18] A study by Konstas *et al*. has suggested that loss of irido-lenticular contact in eyes with PEX syndrome may protect against glaucoma.[17]

The follow up of eyes after YAG-GP in our study ranges from 12 months to 4 years and in no case has there been a late pressure rise after successful YAG-GP. This finding lends support for the following suggested mechanism: local obstruction of the remaining corneo-scleral/uveal trabecular meshwork of the TDW occurs as a consequence of late accumulation of PEX material derived from iris-lens chaffing. The accumulated PEX material fibres are large enough to block aqueous passage through the TDW, but after YAG-GP, the holes in the disrupted TDW are large enough to permit further liberated PEX material to cross the TDW and pass into the canal of Schlemm.

In our study, 9% of eyes had PEXG, which is the same proportion of PEXG as reported in the recent study by Fontana *et al*.[19] of 292 OAG eyes undergoing trabeculectomy and is similar to the proportion of PEXG eyes found in other large studies of OAG such as the Early Manifest Glaucoma Trial[20] and Collaborative Initial Glaucoma Treatment Study[21] with 9.8% and 4.6%, respectively, having PEXG.

Shaarawy *et al*. have also shown an increased need for YAG-GP following DS in phakic eyes with 51% of PEXG compared with 20% of POAG eyes requiring postoperative YAG-GP for IOP control.[13]

Two recent studies failed to demonstrate a significant difference between POAG eyes and PEXG eyes undergoing DS.[22,23] However, in the study by Drolsum,[22] 85.7% of the PEXG eyes had previous argon laser trabeculoplasty and 21.4% had undergone previous trabeculectomy, procedures which can induce scarring of the trabecular meshwork and narrowing of Schlemm's canal affecting the permeability of the TDW following DS.[24,25] Such previous treatments may explain the 30% early failure of IOP control with need for early YAG-GP in Drolsum's study, where 32% of PEXG eyes and 29.6% of POAG eyes required early YAG goniopuncture at a mean of 8.3 months and 3.3 months, respectively.[22] In Drolsum's PEXG group, 43% were or became pseudophakic and would therefore be protected from late release of PEX material from the anterior lens capsule. Similarly, in the study of Rekonen *et al*., the outcome of DS may be affected by inclusion of combined surgery and DS alone in their results, universal prior laser treatment and also an unspecified number with previous glaucoma surgery.[23] Our study specifically analysed combined and non-combined operations separately and excluded eyes with previous surgery to provide a cohort of eyes with a TDW affected by only POAG or PEXG.

Damji *et al*. showed that phaco-cataract extraction alone in eyes with early PEXG resulted in a sustained IOP reduction of 3 mmHg and suggested that PEXG eyes with cataract and adequate IOP control might benefit from cataract extraction alone.[26] However, the mean preoperative IOP in Damji *et al*.'s study[26] in the PEXG eyes was 17.6 mmHg and no record of requirement for pre- or postoperative glaucoma medication or of change in medication following surgery is given. Our PEXG eyes in the phaco-VC group had mostly severe glaucoma with a mean preoperative IOP of 25.8 mmHg taking a mean of 2.5 medications each and therefore were not suitable for consideration of phaco-cataract extraction alone.

As VC is not common in all countries, it is relevant to compare our results with those of recent studies of primary trabeculectomy in OAG. Outcomes compared were: successful control of IOP, mean IOP and complications including cataract formation. A recent prospective study by Chaudhry

et al. showed that at 1-year post-trabeculectomy with no antimetabolites or only low-dose 5-fluorouracil, the success rate (IOP < 21 mmHg with or without medications and >20% reduction in IOP) was 29%, with a mean IOP of 15.5 mmHg on a mean 0.6 medications.[27] Using stronger antimetaolites such as mitomycin C (MMC) improves the success rate and achieves lower IOP, but as a consequence may increase the rate of severe complications to 23% in 5 years.[28] Lopes *et al*. performing MMC trabeculectomy reported a CSR (IOP ≤ 21 mmHg without medication) of 81% at 12 months, a mean IOP of 12 mmHg on a mean of 0.15 medications, but 16% suffered hypotony, 4% hypotony maculopathy and 4% flat anterior chambers.[29] Cashwell and Martin reported a 22-month follow up of 62 MMC trabeculectomies, achieving a mean IOP of 9.8 mmHg.[30] However, 20% of these eyes suffered from a hypotony-related complication, with 4% developing hypotony maculopathy and 68% requiring cataract extraction postoperatively. A large retrospective study of 304 primary trabeculectomies for OAG with 50% use of antimetabolites gave a 1-year mean IOP of 14.1 mmHg with CSR of 91% for IOP < 21 mmHg and 61.2% for IOP < 16 mmHg.[31] Complications included shallow AC in 23.4% of cases and hypotony in 17.8% of cases. The retrospective study by Fontana *et al*. reported qualified success (IOP ≤ 18 mmHg with or without medications) at 3 years of 62%.[19]

Table 2 shows that our success rates on no treatment at 5 years are similar to those reported in the trabeculectomy studies at 1 year. Our surgery avoided causing any hypotony, shallow ACs or bleb-related complications and by 5 years follow-up only 17.5% of our eyes required cataract extraction. Following trabeculectomy, the need for cataract extraction was 35% at 3 years in Fontana *et al*.'s study,[19] 68% at 2 years in Cashwell and Martin's study and 61% in the Collaborative Initial Glaucoma Treatment Study by a median of 7.7 years.[21,30]

In our PEXG and POAG eyes, Kaplan–Meier survival curves (Figs 3,4) showed no difference in the success of combined phaco-VC eyes compared with VC alone eyes. Combined phaco-cataract extraction with trabeculectomy has been reported to be less successful than trabeculectomy alone[32,33] and most glaucoma surgeons advise the use of MMC in combined procedures.[34] Banitt *et al*.[35] reported a 4-year follow up of 173 eyes undergoing phacotrabeculectomy with preoperative adjunctive 0.5 mg/mL MMC use in 59% with a mean follow up of 44.8 months. Their CSR (IOP ≤ 18 mmHg) at 4 years was 18.5%. The paper reports nine patients experienced postsurgical hypotony and the use of MMC increased the risk of hypotony by 14-fold. Table 2 shows that our CSRs for VC combined with phaco in both POAG (76%) and PEXG (95%) eyes were considerably higher than Banitt's CSR. It has been suggested that the reason for a worse outcome with combined phacotrabeculectomy compared with trabeculectomy alone is that the added inflammation occurring from the phaco-cataract extraction gives rise to an increase in release of inflammatory mediators such as transforming growth factor-beta 1,[1] which promote subconjunctival/episcleral scarring and failure of the filtering bleb.[32,33]

By performing phaco-VC rather than phacotrabeculectomy and so not encouraging bleb formation, these aqueous derived vasoactive stimulators of fibroblast activation cross the TDW into Schlemm's canal and probably leave the eye either through existing collector channels, or through the uveoscleral outflow and therefore do not come into contact with the episcleral/subconjunctival space fibroblasts as they would after trabeculectomy.

A major advantage of VC compared with trabeculectomy is retention of the TDW which prevents sudden bulk outflow of aqueous, thus avoiding hypotony and its complications such as shallow and flat anterior chamber, choroidal detachments and suprachoroidal haemorrhages. Also VC does not produce drainage blebs, thus avoiding bleb-related complications.

Our study indicates that in the long term whenever phakic eyes with PEXG undergo VC, after 2 years a pressure rise is common, probably because of obstruction of the TDW by further accumulation of PEX aggregates. We recommend that all phakic PEXG eyes should undergo YAG-GP of the TDW before 2 years postoperatively to prevent late IOP rise.

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