



Long-term outcomes of viscocanalostomy and phaco-viscocanalostomy in patients with narrow angle glaucoma

Tasmin Berman¹ · Tobi Somerville¹ · Anshoo Choudhary¹

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Abstract

Purpose To assess the outcomes of viscocanalostomy and phaco-viscocanalostomy in patients with narrow angle glaucoma at a single tertiary eye centre.

Method All patients undergoing viscocanalostomy for narrow angle glaucoma between June 2010 and June 2017 with a minimum follow-up of 12 months were included. Data was analysed from a prospectively maintained surgical outcome database. Primary outcome was a change in intraocular pressure (IOP). Secondary outcomes were changes in LogMAR visual acuity, number of eye drops, post-operative complications and further surgical interventions. Success was defined at two IOP cut-off points: $IOP \leq 21$ mmHg and $IOP \leq 15$ mmHg with (qualified success) or without (complete success) drops. Failure was any repeat glaucoma surgery or loss of light perception.

Results Seventy eyes of 46 patients with a mean follow-up of 41.31 months (range 12–60 months) were included. Mean IOP changed from 25.7 ± 9.6 to 15.2, 15.6, 14.6, 13.8 and 14.0 mmHg at 1, 2, 3, 4 and 5 years post-operatively. Drops reduced from 3.2 ± 1.1 pre-operatively to 0.5 at 1 year and 1.1 at all time points thereafter. Qualified success for an $IOP \leq 21$ mmHg was achieved in 94.2%, 88.1%, 92.5%, 91.1% and 92.0% and complete success in 63.8%, 37.3%, 30.2%, 22.2% and 24.0% in years 1 to 5, respectively. Qualified success for an $IOP \leq 15$ mmHg was achieved in 53.6%, 60.9%, 69.8%, 68.9% and 64.0% and complete success in 39.1%, 26.9%, 22.6%, 20.0% and 8.0% in years 1 to 5, respectively.

IOP was significantly lower at all examined post-operative time points (41.1%, 39.3%, 43.3%, 46.4% and 45.3% at years 1 to 5, respectively, $p < 0.001$ at all time points).

Four eyes (5.7%) failed to meet any of the success criteria. Of these, 3 eyes (4.3%) required further glaucoma surgery and one eye (1.4%) progressed to no perception of light at 48 months. No patients had an $IOP \leq 5$ mmHg on two consecutive occasions after 3 months.

Conclusion Viscocanalostomy and phaco-viscocanalostomy are a safe and effective surgical option in the management of chronic narrow angle glaucoma.

Keywords Glaucoma · Narrow angle · Viscocanalostomy · Phaco-viscocanalostomy · Non-penetrating glaucoma surgery

✉ Tasmin Berman
Tasminberman@nhs.net

¹ St Pauls Eye Unit, Liverpool University Hospital, Liverpool, UK

Key messages

- Management of chronic narrow angle glaucoma had traditionally involved cataract surgery alone, trabeculectomy with Mitomycin C or a combined procedure. Visco canalostomy has lower complication rates compared to trabeculectomy and can be combined with cataract surgery without affecting clinical outcome.
- Visco canalostomy achieves a significant and sustained reduction in intraocular pressure and drop usage at 5 years post-operatively in narrow angle glaucoma.
- Patients undergoing visco canalostomy for narrow angle glaucoma require less post-operative intervention and fewer post-operative clinic visits, which in the current climate with COVID 19 helps reduce the risk to patients and staff as well as reducing the strain on the health care system.

Introduction

Glaucoma is the most common cause of preventable vision loss and accounted for almost one-third of the new vision impairment certificates in England from 2017 to 2018 [1]. Primary open-angle glaucoma is three times more common than chronic angle-closure glaucoma, although angle closure is responsible for 50% of blindness caused by glaucoma. The primary risk factors for angle closure include older age, female gender and Asian or Eskimoan race [2]. The global prevalence of primary angle closure was reported as 0.6% in a systemic review by Zhang et al. [3].

Management of chronic narrow angle glaucoma has traditionally involved cataract surgery alone [4, 5], trabeculectomy with mitomycin C (MMC) [6] or a combined procedure [7–9]. Cataract surgery alone might not be as effective in satisfactorily reducing the intraocular pressure (IOP) when patients are poorly controlled with topical medication [7, 8]. Combined surgery has also been shown to be more cost-effective than cataract surgery alone [7, 9].

Glaucoma services within the hospital eye service were stretched to breaking point even before the COVID-19 pandemic with up to 22 patients per month suffering permanent and severe vision loss due to delayed follow-up [10, 11]. We are now having to change our current practice to try and reduce the risk to patients and staff as well as reduce the strain on the healthcare system as a whole [12].

Compared to trabeculectomy, non-penetrating glaucoma surgery (NPGS) has been shown to have a lower incidence of complications with comparable long-term success rates [13–16]. In addition, due to the reduced need for additional interventions and complications post-operatively, patients may require less follow-up appointments [17]

which might help reduce the strain on the already overwhelmed system. However, there is limited literature for NPGS in narrow angle glaucoma. There have been no previous studies except for a small series by Yuen et al. of 29 eyes undergoing combined phacoemulsification and non-penetrating deep sclerectomy [18].

In this study, we assessed the outcomes of visco canalostomy (VC) and phaco-visco canalostomy (Phaco-VC) in patients with narrow angle glaucoma to evaluate success in terms of IOP and the post-operative interventions undertaken to achieve this.

Method

All patients with narrow angle glaucoma undergoing VC and Phaco-VC between 2010 and 2017 under a single surgical team at the Royal Liverpool University Hospital were included from a prospective database.

The technique involved a superior corneal traction suture with 7–0 vicryl. A fornix-based conjunctival flap was raised superiorly, and haemostasis was achieved. A two-third depth scleral thickness limbal-based flap measuring 5×5 mm was raised and advanced into clear cornea. A deep 4×4 mm scleral flap was dissected to the level of Schlemm's canal, deroofing it and extended into the corneal stroma at the level of Descemet's membrane to create the Trabeculo-Descemet window (TDW). Viscoat® (sodium hyaluronate and sodium chondroitin sulphate) was injected onto the canal and applied to the scleral bed. The deep flap was excised close to the TDW. The superficial scleral flap and conjunctiva were closed tightly with 10–0 vicryl sutures. Where there were peripheral anterior synechiae (PAS) blocking the TDW, an intentional peripheral iridectomy (PI) was performed. No antimetabolite was used.

Patients were excluded if they did not have 12 months of follow-up. There were no other exclusion criteria. An intervention was defined as any procedure carried out after the VC to assist with the success of the surgery. In this series this was Nd:YAG laser goniopuncture (Yag GP).

The primary outcome was a change in IOP. This was analysed from a prospectively maintained surgical outcome database. Secondary outcomes were post-operative complications and interventions and the number of glaucoma drops used. Change in visual acuity (VA) and visual field (VF) mean deviation (MD) were also noted.

Subgroup analysis was performed to look at outcomes when VC was combined with cataract surgery.

SPSS v22 (SPSS, Chicago, IL) was used to perform statistical analysis. Normality of data (IOP, drops, visual acuity (VA) and mean deviation (MD)) was examined using the Kolmogorov–Smirnov test. A linear mixed model with Bonferroni correction was used to examine for differences in IOP and drops between pre-operative and post-operative years 1–5. Change in VA and visual field MD pre- and post-operatively were examined using the Wilcoxon signed rank test. The study conduct adhered to the tenets of the Declaration of Helsinki. No formal ethical approval was required because it was a retrospective study.

Success definition

Success was defined at two IOP cut-off points: $IOP \leq 21$ mmHg and $IOP \leq 15$ mmHg. Complete surgical success was defined as $IOP \leq 21$ or ≤ 15 mmHg with no additional medications and qualified surgical success as $IOP \leq 21$ or ≤ 15 mmHg with additional glaucoma medications. Failure was defined as $IOP > 21$ mmHg on two consecutive visits, $IOP \leq 5$ mmHg on two consecutive occasions after 3 months (numerical hypotony as described by the World Glaucoma Association's Guidelines on Design and Reporting Glaucoma Surgical Trials [19]), any repeat operation for glaucoma or loss of light perception.

Results

Eighty-five eyes of 54 patients were included from the database. Fifteen eyes (8 patients) were excluded due to lack of 12 months of data. Of these patients, 3 patients died, 2 patients were followed up in their local hospital, 2 patients failed to attend follow-up multiple times and 1 patient was followed up in the private sector. Therefore,

Table 1 Patient demographics

	Mean \pm SD (range)
Age (years)	71.9 \pm 10.5 (47–92)
Male:female (%)	37:63
Follow-up (months)	41.31 \pm 17.91 (12–60)
Pre-operative IOP (mmHg)	25.73 \pm 9.59 (14–58)
Pre-operative drops (number)	3.03 \pm 1.12 (0–5)
Pre-operative visual acuity (Log MAR)	0.23 \pm 0.43 (–0.1–2.2)
Pre-operative mean deviation (dB)	–8.76 \pm 8.03 (1.6 to –26.79)
Procedure performed	
Viscocanalostomy	24 (34%)
Phaco-viscocanalostomy	46 (66%)
Previous procedures	
None	4 (5.7%)
Peripheral iridotomy	64 (91.4%)
Phacoemulsification	8 (11.4%)
Combined phacoemulsification, vitrectomy and anterior hyaloidectomy	2 (2.9%)
Argon laser peripheral iridotomy	2 (2.9%)
Cyclodiode	1 (1.4%)
Pan retinal photocoagulation for diabetic retinopathy	2 (2.9%)
Glaucoma type	
Chronic narrow angle glaucoma	59 (84.3%)
Acute angle-closure glaucoma	5 (7.1%)
Ocular hypertension with narrow angles	3 (4.3%)
Normal tension glaucoma with narrow angles	1 (1.4%)
Nanophthalmos	2 (2.9%)

Fig. 1 A graph showing mean intraocular pressure (IOP) and mean number of drops pre-operatively (Pre-op) and at all post-operative time points

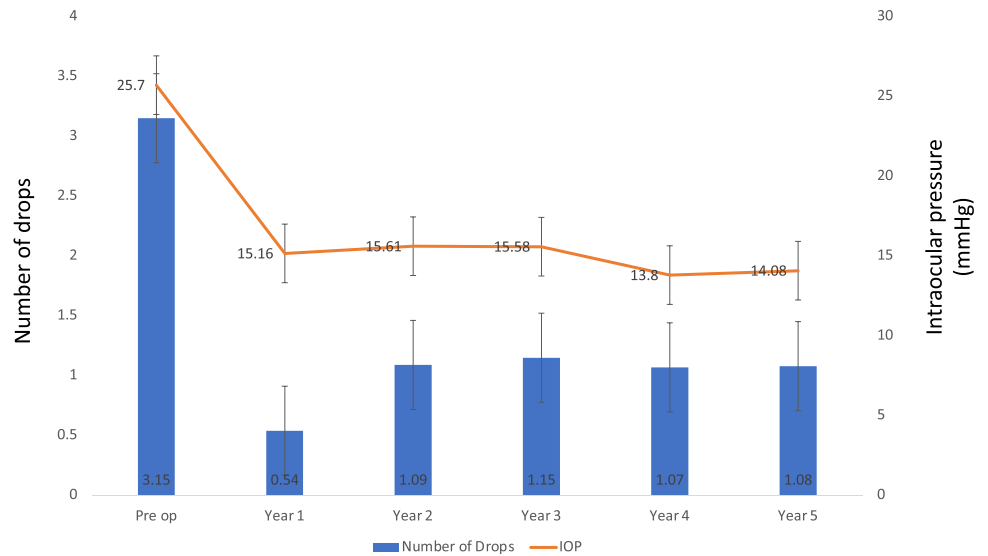


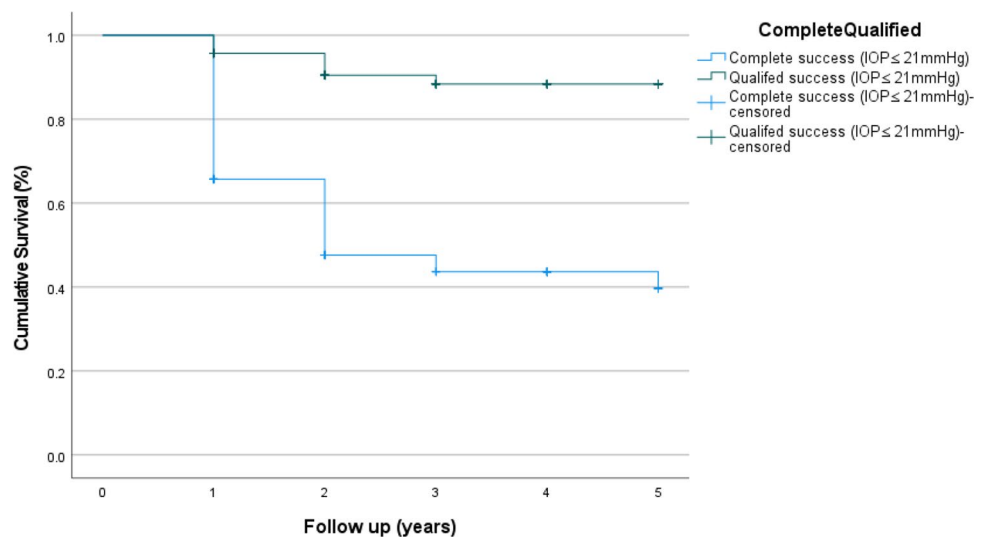
Table 2 Descriptive statistics of mean intraocular pressure (IOP) and drops pre-operatively and at all post-operative time points including number of patients per year

	Pre-op (70)	Year 1 (69)	Year 2 (67)	Year 3 (53)	Year 4 (45)	Year 5 (25)
IOP (mmHg)	25.73 ± 9.7	15.16 ± 3.59	15.46 ± 3.76	14.58 ± 3.46	13.80 ± 3.17	14.08 ± 2.61
Drops (number)	3.15 ± 1.14	0.54 ± 0.93	1.03 ± 1.11	1.15 ± 1.02	1.07 ± 0.96	1.08 ± 1.00

Table 3 Complete and qualified success for intraocular pressure ≤ 15 mmHg and intraocular pressure ≤ 21 mmHg (number of patients and percentage) at each time point post-operatively

	IOP	Year 1	Year 2	Year 3	Year 4	Year 5
Qualified success (with additional medication)	≤ 21 mmHg	65/69 94.2%	59/67 88.1%	49/53 92.5%	41/45 91.1%	23/25 92.0%
	≤ 15 mmHg	37/69 53.6%	42/67 60.9%	37/53 69.8%	31/45 68.9%	15/25 64.0%
Complete success (with no medication)	≤ 21 mmHg	44/69 63.8%	25/67 37.3%	16/53 30.2%	10/45 22.2%	6/25 24.0%
	≤ 15 mmHg	27/69 39.1%	18/67 26.9%	12/53 22.6%	9/45 20.0%	2/25 8.0%

Fig. 2 Kaplan–Meier survival plot for complete (defined as intraocular pressure ≤ 21 mmHg with no medication) and qualified (defined as intraocular pressure ≤ 21 mmHg with additional glaucoma medications) success



70 eyes of 46 patients were included in the final analysis. Patient demographics are shown in Table 1. Forty-six eyes had Phaco-VC and 24 eyes had VC alone (Table 1); 10 eyes were pseudophakic pre-operatively in the latter group.

IOP outcome

IOP was significantly lower at all examined post-operative time points (year 1 by 41.1%, year 2 by 39.3%, year 3 43.3%, year 4 46.4% and year 5 45.3%, $p < 0.001$ at all time points) compared to pre-operative values. The number of post-operative glaucoma drops was also significantly reduced compared to that pre-operatively at all time points ($p < 0.001$) (Fig. 1 and Table 2). Of the patients that required post-operative glaucoma drops, the majority were on mono or dual therapy (77.2%, 74.3%, 80.5%, 83.8% and 77.8% for years 1 to 5 respectively). One patient was lost to follow-up at 1 year and reappeared at 2 years.

Qualified success for an IOP ≤ 21 mmHg was achieved in 94.2%, 88.1%, 92.5%, 91.1% and 92.0% and complete success in 63.8%, 37.3%, 30.2%, 22.2% and 24.0% in years 1 to 5, respectively. Qualified success for an IOP ≤ 15 mmHg was achieved in 53.6%, 60.9%, 69.8%, 68.9% and 64.0% and complete success in 39.1%, 26.9%, 22.6%, 20.0% and 8.0% in years 1 to 5, respectively (Table 3).

Kaplan–Meier survival curves were significantly different for complete and qualified success with IOP ≤ 21 mmHg ($p = 0.001$, Fig. 2) but there was no significant difference between the outcomes of patient who had VC alone and those that had a Phaco-VC ($p = 0.181$).

Table 4 Intra- and post-operative complications

Complication type	Number of patients
Trabeculo-Descemet's window perforation	12/70 (17.1%)
Scleral flap perforation during surgery repaired with Tutoplast®	2/70 (2.9%)
Corneal perforation with traction suture	1/70 (1.4%)
Bandage contact lens post-operatively due to shallow anterior chamber	10/70 (14.3%)

Table 5 Patients that progressed to failure

Type of glaucoma	Pre-op IOP	Pre-op MD (dB)	Pre-op drops	Pre-op BCVA	BCVA final FU	Failure (months)	IOP at point time of failure	IOP final FU	Procedure
CNAG	28	-3.98	4	6/6	6/9	8	22	14	Ahmed valve
CNAG	53	-24.3	4	6/18	6/36	23	31	18	Ahmed valve
CNAG	22	-8.92	None	6/5	6/36*	28	21	15	Repeat VC
CNAG	20	-26.97	4	HM	NPL	48	16	11	None

CNAG, chronic narrow angle glaucoma; IOP, intraocular pressure; FU, follow-up; * from cataract and central retinal vein occlusion; VC, viscosceralostomy

Visual acuity outcome

VA was stable for the vast majority of patients (59 eyes, 84.3%). This was defined as a change of less than 0.2 LogMAR. There was no significant difference between pre- and post-operative VA ($p = 0.831$).

Eleven eyes lost more than 0.2 LogMAR. This was due to glaucoma in 7 patients, decompensated cornea in 1, proliferative diabetic retinopathy in 1, epiretinal membrane in 1 and retinal vein occlusion with cystoid macular oedema in 1.

Visual fields

Thirteen eyes did not have a visual field test recorded; this was either because they were unable to perform them reliably, or they were not available for review in the patients' record. Pre-operatively, of the 57 eyes that had a visual field performed, 21 eyes had advanced visual field loss pre-surgery, 5 had moderate loss and 31 had mild loss (mild ≥ -6 dB; moderate -6 to -12 dB and advanced ≤ -12 dB). Post-operatively, 48 eyes had visual fields available at final follow-up. Mean post-operative MD was -9.79 dB ± 9.03 dB compared to -8.76 ± 8.03 pre-operatively. There was no statistical difference between pre- and post-operative MD ($p = 0.415$).

Cataract surgery

Twenty-four patients underwent VC, of which 10 (41.7%) were pseudophakic at the time of surgery. Four (28.6%) out of 14 eyes that were phakic at the time of their VC underwent cataract surgery by the end of the study period.

Intentional peripheral iridectomy

Sixty-six eyes had already had a pre-operative laser peripheral iridotomy. Fourteen eyes (20%) had an intentional PI at the time of surgery due to PAS at the TDW; this included all patients that had not had a pre-operative laser peripheral iridotomy.

Complications

Table 4 shows intraoperative and post-operative complications. No patients had any long-term complications.

Post-operative intervention

Seven patients (10.8%) required Yag GP following surgery, which was performed between 6 and 36 months.

Failure

Four eyes (5.7%) failed to meet any of the above success criteria (Table 5). Of these, 3 eyes (4.3%) required further glaucoma surgery due to poorly controlled IOP; one at 8 months (Ahmed valve), one at 23 months (Ahmed valve) and one at 28 months (repeat VC). One patient (1.4%) progressed to no perception of light (NPL) at 48 months. This patient had a best corrected visual acuity (BCVA) of hand movements (HM) at time of listing and end stage glaucoma. No patients had an IOP \leq 5 mmHg on two consecutive occasions after 3 months.

Discussion

We report our results of un-augmented VC and Phaco-VC in patients with narrow angle glaucoma. VC was able to achieve qualified success with an IOP \leq 21 mmHg in 92% of patients at 5 years with a 45.3% reduction in IOP from baseline. The number of glaucoma drops was also significantly reduced compared to that pre-operatively at all time points. To our knowledge, our study provides the longest follow-up for the largest number of eyes undergoing VC for narrow angle glaucoma.

There is limited evidence for the outcome of NPGS for narrow angle glaucoma. In 2007, Yuen et al. [18] reported their outcomes for 29 eyes undergoing deep sclerectomy combined with phacoemulsification in patients with chronic angle-closure glaucoma. The authors reported that 86% of eyes had a qualified success with IOP \leq 21 mmHg and a reduction in IOP from 20.3 ± 3.9 mmHg (mean \pm SD) pre-operatively to 15.9 ± 3.1 mmHg post-operatively at the last follow-up visit ($p < 0.001$). In our cohort, IOP reduction was maintained significantly below pre-operative levels up to 5 years after surgery.

We have previously reported our results of qualified (87.5–90.2%) and complete success (78–90%) rates in a cohort of patients with POAG [14] and qualified (80–95%) and complete success (30.6–52.5%) for a cohort of patients with advanced glaucoma [16] undergoing VC and Phaco-VC.

Trabeculectomy is still considered the gold standard surgical treatment for glaucoma and has better IOP control than

VC [20]. NPGS however has significant benefits both for the patient and the operating team with reduced need for post-operative interventions, lower rates of sight-threatening complications and a better quality of life for patients [20]. A multicentre analysis of trabeculectomies by Kirwan et al. [21] suggested that the initial trabeculectomy was just the beginning of the patient's surgical journey and that the majority of patients required frequent post-operative interventions.

There are no direct comparative trials comparing NPGS and trabeculectomies in narrow angle glaucoma. Romero et al. [22] reported the outcomes of trabeculectomy for primary angle-closure glaucoma. Qualified success rates (\pm SD) after 1, 3 and 5 years of follow-up for IOP $<$ 18 mmHg were 92% (\pm 2.2%), 78% (\pm 3.8%) and 72% (\pm 4.3%), respectively and for IOP $<$ 15 mmHg, 86% (\pm 3.0%), 65% (\pm 4.4%) and 59% (\pm 4.7%), respectively which are comparable to our results. Although our IOP reduction was not as low, our pre-operative IOP was higher (25.73 ± 9.7) compared to $18.8 (\pm 3.5)$ in the study by Romero et al. [22]. In addition, 16.9% of patients from this study required additional surgery (second trabeculectomy (47.8), glaucoma drainage device (39.1%) and bleb revision (13%)) compared with 4.3% of our patients requiring further glaucoma surgery and 10.8% requiring a Yag GP. Song et al. [23] reported 12-month data for trabeculectomy and combined phaco-trabeculectomy in primary angle-closure glaucoma and the qualified success rate 12 months after surgery was $65.7\% \pm 7.2\%$, for IOP $<$ 21 mmHg and $38.2\% \pm 7.4\%$, for IOP $<$ 15 mmHg. Our 1-year data is more favourable than this. Our complete success rates were lower than the results for trabeculectomy in the literature. However, our qualified success rates are comparable, and the majority of patients were controlled on dual (76%) or mono (52%) therapy post-operatively.

Previous studies suggest a collapse of the Schlemm's canal with raised IOP [24]. There is expansion of the trabecular meshwork into the Schlemm's canal (SC) with raised IOP which is reversed with VC [25]. Hong et al. [26] also suggested a similar mechanism for trabeculectomies so the mechanism by which VC helps in narrow angle glaucoma might be through SC dilatation.

Cataract formation is also a well reported complication after trabeculectomy. It has been reported that trabeculectomies increase the risk of cataract formation by 78% [27]. In our study, of those patients who had a VC and were phakic, 4 patients (28.6%) went on to require a cataract surgery during the study period. However, this is a small cohort (14 eyes in total) to make assumptions from. Cataract surgery has been shown to increase the need for post-operative interventions and glaucoma drops reducing the success of trabeculectomies in 30–39% of cases [28, 29]. There was no difference in success rates in our study between VC and Phaco-VC. Although our numbers for VC were small, a similar

conclusion was made by Wishart et al. [14]. In addition, combined surgery has also been shown to be more cost-effective [9] than cataract surgery alone in controlling IOP in narrow angle glaucoma patients.

NPGS have a greater safety profile with a lower risk of complications compared to trabeculectomy [30–33]. A Cochrane review reported fewer complications with NPGS (17%) compared to trabeculectomy (65%) [20]. The UK national trabeculectomy surgery survey [34] reported early complications in 46.6% and late complications in 42.3% of cases. Trabeculectomy in narrow angles is particularly challenging, further increasing the risk of complications [7, 8]. In our study, 10 patients (14.3%) had early post-operative complications, with a shallow anterior chamber requiring a bandage contact lens. These had resolved in all patients by 2 weeks post-operatively. There were no long-term complications. This is significantly lower than the results for trabeculectomy with 2.6% requiring resuturing or revision for significant early hypotony and a 0.5–3.9% incidence of blebitis and 0.5% incidence of bleb-related endophthalmitis (Kirwan et al. [21], Tham et al. [7]).

There was no statistical difference between pre- and post-operative visual field MD ($p=0.145$). In addition, we found no difference between success and severity of glaucoma based on visual field MD. Not all patients had visual fields performed for a variety of reasons and the number of patients completing visual fields reduced year on year. This may be expected with time [35]; however, 68% of patients were able to complete visual fields at their final follow-up. This is higher than in our previously reported paper [16] where only 45.2% of patients had a visual field completed at their final follow-up. This is likely because 44.29% of our cohort had mild glaucoma based on visual field MD and therefore will be likely to be able to continue performing visual fields for longer compared to advanced glaucoma.

Seven patients (10.8%) required a post-operative intervention of Yag GP. This was performed between 6 and 36 months. This is in line with other studies in the literature [16, 18].

Of the 4 eyes that failed, 2 of the eyes had advanced glaucoma pre-operatively and one of these with a vision of hand movements at presentation and progressed to no perception of light. One other patient was lost to follow-up and reappeared with progression requiring surgery. The final patient had further surgery for sub-optimal IOP with good visual acuity and IOP outcome. These results are in-keeping with the results from our advanced glaucoma and viscocanalostomy study [16] and better than the results reported by Yuen et al. [18].

Limitations of this study include data being retrospectively analysed and there being no control group. However, data was collected from a prospectively maintained database and a significant proportion of patients were followed

up to 4 years. In addition, we have included data from both eyes of patients where available in our analysis, this can potentially affect the statistical analysis especially as there is not equal numbers of patients having both eyes operated on in the Phaco and Phaco-VC groups. However, we are not comparing risk factors between the two groups so feel this would not have a significant effect on the final data. It would also have been desirable to have a higher number of patients completing a visual field test both pre- and post-operatively to further strengthen the study.

To our knowledge, this is the longest study reporting the effectiveness of un-augmented VC in narrow angle glaucoma to date. VC was able to achieve an IOP ≤ 21 in up to 92% patients for a period of up to 5 years. VC has similar qualified success rates as trabeculectomy with MMC with a good safety profile and minimal requirement for post-operative interventions. This is particularly important in the current climate with COVID-19 where we want to keep attendances to a hospital setting to a minimum [11, 12, 17].

Author contribution All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by Tasmin Berman and Tobi Somerville. The first draft of the manuscript was written by Tasmin Berman, and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

Code availability Non-applicable.

Declarations

Ethics approval This is a retrospective study. For this type of study, formal consent is not required and all the procedures performed were part of the routine care. Therefore, ethical approval is not required.

Conflict of interest The authors declare no competing interests.

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