EXTENDED REPORT

Viscocanalostomy versus trabeculotomy ab externo in primary congenital glaucoma: 1-year follow-up of a prospective controlled pilot study

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Br J Ophthalmol 2006;90:1281–1285. doi: 10.1136/bjo.2006.096388

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Accepted for publication
5 June 2006
Published Online First
12 July 2006

Aim: To study the effectiveness of viscocanalostomy in patients with primary congenital glaucoma of the isolated trabecular dysgenesis category and compare it with trabeculotomy ab externo.

Methods: Eight patients with bilateral primary congenital glaucoma were enrolled in the study. After establishing the diagnosis, the more severely affected eye was randomly selected to undergo either trabeculotomy ab externo or viscocanalostomy, whereas the second eye underwent the other surgery 2 weeks after the first. The patients were examined on day 1, week 1, week 4 and thereafter every 4 weeks. Intraocular pressure (IOP) and corneal diameter measurements were obtained at week 1, month 6 and at the last reported follow-up. The paired-sample's Student's *t* test was applied for statistical analysis.

Results: The mean (standard deviation (SD)) follow-up period was 12.5 (1.86) months. Preoperative IOP of eyes undergoing trabeculotomy (34.0 (2.6) mm Hg) and that of eyes undergoing viscocanalostomy (32.3 (4.1) mm Hg) showed no significant difference ($p > 0.1$). A drop in IOP was noted in both groups at week 1, month 6 and at the last follow-up visit ($p < 0.001$). Similarly, a decrease in the postoperative vertical and horizontal corneal diameters was noted in the two study groups.

Conclusion: Viscocanalostomy proved to be as effective as trabeculotomy ab externo in lowering IOP. Moreover, it is likely to be a good surgical alternative with a higher long-term success rate in eyes with more aggressive disease.

In congenital glaucoma, developmental anomalies of the angle and trabecular meshwork lead to a defective and decreased outflow of aqueous, resulting in markedly raised intraocular pressure (IOP) and associated symptoms and signs.

Although relatively responsive to medical treatment in the short term, this type of glaucoma has long been proved to be a surgical disease.

Primary surgeries include goniotomy, trabeculotomy, trabeculectomy and combined trabeculotomy-trabeculectomy. The success rate of these techniques has been reported to range between 80% and 90%. However, their effectiveness seems to be short lived in patients of Middle Eastern descent, in whom the disease is four times more common and has a tendency to be more aggressive.^{1–3}

In adult chronic glaucoma, viscocanalostomy is associated with a good success rate and with less complications than full-thickness filtering surgery.⁴ It is not affected by the degree of corneal transparency, and its mechanism of action requires a normal canal of Schlemm, but is not sensitive to the arrangement of the other angle structures.^{5–6}

Our controlled pilot study aims to evaluate the effectiveness of viscocanalostomy in patients with primary congenital glaucoma of the isolated trabecular dysgenesis category and compare it with trabeculotomy ab externo.

PATIENTS AND METHODS

Eight consecutive patients with newly diagnosed bilateral primary congenital glaucoma were enrolled in the study between June 2003 and December 2004.

The criteria for diagnosis were the classic symptoms of buphthalmos, photophobia and tearing, in addition to the signs of a large corneal diameter and IOP > 21 mm Hg. After the initial basic office examination, and to confirm the

diagnosis, all patients underwent a full ocular examination under ketamine anaesthesia.

The ophthalmic examination included the following: IOP measurements using Perkins applanation tonometry (Clement Clarke, Columbus, OH, USA) and Tonopen electronic tonometry (Mentor, Norwell, Massachusetts, USA); corneal examination to determine the vertical and horizontal diameters and the presence of oedema, haze and Habb's striae; assessment of the anterior chamber depth, iris structure, and pupil shape and reactivity; gonioscopy; funduscopy to assess the vitreous; and optic disc evaluation, with emphasis on the status of the neuroretinal rim and cup to disc ratio.

After establishing the bilateral diagnosis, the more severely affected eye was randomly assigned for either trabeculotomy ab externo or viscocanalostomy. The second eye underwent the alternative surgery 2 weeks after the first procedure. All surgeries were carried out by BNN. Patients were seen on day 1, week 1, week 4 and thereafter every 4 weeks. IOP, however, was measured under ketamine anaesthesia at week 1, month 6 and at the last reported follow-up.

The university ethics committee approved the study. Parents of each patient gave informed consent.

The trabeculotomy was started with a superior rectus 4-0 silk traction suture followed by a small fornix-based superior conjunctival flap. The sclera was cleaned, and haemostasis was achieved with gentle wet-field cautery. A sharp blade was used to make a radial superficial scleral incision at the 12 o'clock position, about 2–4 mm from the limbus. The incision was gradually deepened until aqueous started seeping into the groove. A 6-0 prolene suture was used as a guide wire and inserted into the left side of the suspected canal of Schlemm.

Abbreviation: IOP, intraocular pressure

Table 1 Clinical characteristics of patients and length of follow-up

Patient	Sex*	Eye†	Age at diagnosis (days)	Symptoms at diagnosis	Age at operation (weeks)	Family history of congenital glaucoma	Follow-up (months)
1	F	R	2	Corneal clouding	5	Negative	16
		L	2		2		16
2	F	R	24	Buphthalmos and corneal clouding	7	Negative	14
		L	24		5		14
3	M	R	15	Tearing and corneal clouding	4	Negative	11
		L	15		2		11
4	M	R	50	Buphthalmos and corneal clouding	9	Negative	12
		L	50		7		12
5	F	R	45	Buphthalmos	9	Negative	13
		L	45		7		13
6	M	R	365	Buphthalmos	53	Negative	11
		L	365		52		11
7	F	R	18	Buphthalmos and corneal clouding	4	Negative	13
		L	18		3		13
8	M	R	210	Tearing, buphthalmos and corneal clouding	34	Positive	10
		L	210		32		10
Mean			91.12		14.68		12.5
SD			124.65		17.61		1.86

*F, female; M, male.

†L, left; R, right.

If the suture passed without resistance, the trabeculotome was inserted into the canal and rotated into the anterior chamber. The same procedure was repeated to the right side of the canal of Schlemm. The scleral incision and the conjunctival flap were closed with 10-0 nylon interrupted sutures. A combination of lincomycin (Pharmacia-Upjohn, Puurs, Belgium), dexamethasone (Medochemie, Limassol, Cyprus) and gentamycin (Panpharma, SA, France) was finally injected into the lower fornix.

In the viscocanalostomy, a superior fornix-based conjunctival flap was created after stabilising the eye with a superior rectus 4-0 silk traction suture. Minimal wet-field cautery was applied. Using a mini crescent blade (Grieshaber, Alcon Laboratories, Fortworth, TX, USA), a parabolic 300 µm thick 4.0×4.0 mm limbus-based scleral flap was dissected 1.5 mm into the clear cornea. Half a millimetre inside the distal border of the first flap, a second flap was also dissected using a mini diamond blade, 1.5 mm into clear cornea. The dissection of the second flap was deepened at the apex to partially expose the choroid. The dissection was then carried forward to the scleral spur until the canal of Schlemm appeared on both sides. A paracentesis was carried out at the 3 o'clock position, and gentle pressure with a cellulose sponge was exerted on Schwalbe's line to separate Descemet's membrane from the corneoscleral junction. To positively identify the canal of Schlemm, balanced salt solution was injected through a 30-gauge cannula. Once the solution was seen leaving through the conjunctival vessels, high-viscosity

sodium hyaluronate (Healon GV, Pharmacia, Uppsala, Sweden) was injected 4–6 mm into both sides of the canal. This was repeated 6–7 times as was described for adult eyes. The second flap was excised with Vannas scissors (Storz Instruments, St Dimas, CA, USA), and the first flap was tightly closed with 10-0 nylon sutures after injecting Healon GV beneath it. The conjunctival flap was sutured with 10-0 nylon, and a subconjunctival injection in the lower fornix completed the surgery (same in composition as in the trabeculotomy).

After either surgery, patients were prescribed a fixed combination of tobramycin and dexamethasone (Tobradex, Alcon-Couvreur, Puurs, Belgium) 0.1% drops to be taken four times daily for 4 weeks.

Data were statistically analysed using SPSS V.13.0. The paired-samples Student's *t* test was applied on parameters such as IOP and corneal diameter to study the statistical significance of differences between preoperative and post-operative measurements in both study groups. The level of significance was 0.05 (two sided) in all statistical tests.

RESULTS

Eight consecutive patients (4 females and 4 males) met the inclusion criteria. Trabeculotomy was carried out on five right and three left eyes, whereas the other eight eyes underwent viscocanalostomy (termed trabeculotomy eyes and viscocanalostomy eyes, respectively, hereafter). The mean (standard deviation (SD)) follow-up time was 12.5 (1.86) months, and

Table 2 Mean intraocular pressure decrease in groups of patients undergoing trabeculotomy and viscocanalostomy

Trabeculotomy				Viscocanalostomy			
	No of eyes	IOP mean (SD) (mm Hg)	IOP decrease mean (SD) (mm Hg)		No of eyes	IOP mean (SD) (mm Hg)	IOP decrease mean (SD) (mm Hg)
			p Value*				p Value*
Preoperative	8	34.0 (2.6)			8	32.3 (4.1)	
Postoperative							
1 week	8	14.8 (2.9)	19.3 (4.1)	<0.001	8	14.5 (4.1)	17.8 (7.0)
6 months	8	13.5 (4.8)	20.5 (5.1)	<0.001	8	15.1 (6.6)	17.1 (8.4)
16 months	8	15.6 (4.3)	18.4 (5.9)	<0.001	8	12.9 (3.9)	19.4 (7.3)

IOP, intraocular pressure.

*Paired-samples Student's *t* test.

Table 3 Preoperative and postoperative vertical and horizontal corneal diameters

	Trabeculotomy			p Value*	Viscocanalostomy			p Value*
	No of eyes	Corneal diameter mean (SD) (mm)	Corneal diameter decrease mean (SD) (mm)		No of eyes	Corneal diameter mean (SD) (mm)	Corneal diameter decrease mean (SD) (mm)	
Vertical								
Preoperative	8	12.18 (0.53)			8	12.37 (0.44)		
Postoperative	8	11.75 (0.75)	0.43 (0.56)	0.064	8	12.00 (0.7)	0.37 (0.51)	0.08
Horizontal								
Preoperative	8	12.50 (0.59)			8	12.62 (0.58)		
Postoperative	8	11.75 (0.75)	0.75 (0.59)	0.009	8	12.00 (0.7)	0.62 (0.58)	0.019

*Paired-samples Student's t test.

only one patient had a positive family history of congenital glaucoma, (patient 8; table 1).

Table 1 lists the presenting symptoms, the age at the time of diagnosis and the age at the time of surgery. All patients except two (patients 2 and 4) were taking timolol (Merck & Co, Whitehouse Stutton, NJ, USA) 0.25% drops twice daily before the surgery. Figure 1 shows the mean (SD) IOP at different visits in either group of eyes. The mean (SD) preoperative IOP of trabeculotomy eyes was 34.0 (2.6) mm Hg, whereas that of viscocanalostomy eyes was 32.3 (4.1) mm Hg. One week after surgery, the mean (SD) IOP in trabeculotomy eyes was 14.75 (2.9) mm Hg compared with 14.5 (4.14) mm Hg in viscocanalostomy eyes. At month 6, we noted a mean (SD) IOP of 13.5 (4.84) mm Hg in the trabeculotomy eyes and 15.12 (6.55) mm Hg in the viscocanalostomy eyes. The mean (SD) IOP at the final visit was 15.62 (4.27) mm Hg in trabeculotomy eyes and 12.87 (3.87) mm Hg in viscocanalostomy eyes. Statistical analysis showed no significant difference in IOP measurements between the study groups at each follow-up visit ($p>0.1$). However, the decrease in IOP in each of the two groups was significant at week 1, month 6 and at the last follow-up, $p<0.001$ (table 2).

In harmony with the decrease in IOP, we found a significant decrease in the postoperative vertical (11.75 (0.75) mm) and horizontal (11.75 (0.75) mm) corneal diameters in the trabeculotomy eyes ($p<0.1$ and $p<0.01$, respectively) when compared with the preoperative ones (12.18 (0.53) mm and 12.50 (0.59) mm, respectively; table 3).

Similar findings were observed when we compared the viscocanalostomy postoperative vertical (12.00 (0.70) mm) and horizontal (12.00 (0.70) mm) corneal diameters with the preoperative ones (12.37 (0.44) mm and 12.62 (0.58) mm; $p<0.1$; table 3).

Table 4 shows the operative complications and length of follow-up. Hyphema was a short-lived common complication to both procedures, as it occurred in four of the eight trabeculotomy eyes (50%) and in two of the eight viscocanalostomy eyes (25%). It was subtle not exceeding 15% in either group, and always reversible by week 1 follow-up visit.

One trabeculotomy eye (patient 6, left eye) developed a shallow anterior chamber with a localised choroidal detachment, which was observed on day 1 but disappeared by week 1 of the follow-up visit.

One viscocanalostomy eye (patient 3, left eye) had an inadvertent small hole in the thin scleral bed, which was witnessed intraoperatively. The procedure was continued with no modifications, as the iris stayed away from the hole throughout the procedure and did not require a peripheral iridectomy.

A second viscocanalostomy eye (patient 5, left eye) developed a localised Descemet's membrane detachment with overlying corneal oedema. On follow-up, the detachment was not observed to extend, and the oedema subsided by month 2 of the follow-up visit. None of the patients in either surgical group needed any pressure-lowering drugs postoperatively for the whole follow-up period.

DISCUSSION

One of the incriminated factors in the pathogenesis of congenital glaucoma is the posterior position of the meshwork, whether the Barkan membrane exists or not.⁷⁻⁸ Evidence in part was provided by ultrasound biomicroscopy, which confirmed the presence of highly reflective tissue strands in front of the trabecular meshwork, gonioscopically characterised as ligamenta pectinata, as well as iris insertion in the ciliary body itself.⁹⁻¹⁰ Irrespective of the anatomical or imaging nature of studies on eyes with congenital glaucoma,

Table 4 Operative complications and length of follow up in trabeculotomy and viscocanalostomy eyes

Patient	Trabeculotomy			Follow-up (months)	Viscocanalostomy			Follow-up (months)
	Eye	Complications			Eye	Complications		
1	L	Hyphema		16	R	Hyphema		16
2	R	None		14	L	None		14
3	R	None		11	L	Button hole		11
4	R	None		12	L	Hyphema		12
5	R	Hyphema		13	L	Hyphema and Descemet's detachment		13
6	L	Vitreous loss and choroidal detachment		11	R	None		11
7	R	Hyphema		13	L	None		13
8	L	Hyphema		10	R	None		10

L, left; R, right.

Figure 1 The mean intraocular pressure (IOP) at baseline, week 1, month 6 and at last follow-up visit for the eyes undergoing trabeculotomy and those undergoing viscocanalostomy. The IOP difference between the two groups is not significant ($p > 0.1$).

a wide anterior chamber and an open angle were a persistent finding.¹¹

Trabeculotomy ab externo has stood the test of time as a treatment of choice for congenital glaucoma. Its main advantage over goniotomy is its relative indifference to the transparency of the cornea. The mechanism of action is through exposing the collecting channels of the trabecular meshwork to the aqueous in the anterior chamber.

Throughout the follow-up time of our study, the eight trabeculotomy eyes maintained a good IOP control, which conforms with results of much larger series.^{12–13} The same can be said about the low rate of complications, where half of the eyes developed a short-lived hyphema that did not require any intervention. The shallow anterior chamber and choroidal detachment in the left eye of patient 6 were transient and reversible.

Viscocanalostomy, on the other hand, works by providing the aqueous with direct access to the canal of Schlemm across a thin sheet of scleral lamellae, and by further dilating the canal with viscoelastics.¹⁴ It simply targets the aqueous outflow pathway responsible for the main resistance to outflow, to create filtration through the naturally occurring trabeculo–Descemet's membrane.¹⁵ In adult glaucoma, viscocanalostomy is claimed to be as efficient as full-thickness sclerectomy (trabeculectomy) in lowering IOP without the side effects of hypotony, leakage, and shallow or flat anterior chamber.¹⁶

Trabeculectomy works quite well in patients with congenital glaucoma as an acutely effective IOP-lowering technique.¹⁷ However, the success is short lived because of the aggressive scarring that invariably leads to bleb failure in these infantile eyes.¹⁸ This scarring was also observed to be more accentuated in infantile glaucoma in patients of Middle Eastern descent, in whom consanguineous marriages are common.² Although antimetabolites considerably increase the success rate, their potential side effects such as chronic hypotony, leakage and infection are too high a risk for these very young patients.^{18–19} The consideration of potential adverse effects led to the idea of attempting to carry out viscocanalostomy as the primary surgery in one eye, whereas the other eye underwent trabeculotomy.

The main difficulty encountered in viscocanalostomy in these infantile eyes is the relatively thinner limbal sclera than that in adults. Although the superficial scleral flap was relatively easily dissected, the thickness of the deeper flap was decided only when the choroid could be seen 0.5 mm within the distal border of the first flap. Consequently, we ended up having to carry out much finer dissections than those in adult eyes. Once clear cornea was reached, deroofting

the canal of Schlemm and the rest of the dissection could be carried out easily.

Viscocanalostomy works in congenital glaucoma because it bypasses the positional changes of anterior iris insertion and scleral spur that were documented by ultrasound biomicroscopy.²⁰ With this surgery, the aqueous egresses through the scleral window into the canal of Schlemm that is always reported to be normal in these eyes, except when they are untreated for a long time.

A second mechanism of action of viscocanalostomy is the increase in the uveoscleral flow due to the tight scleral flap sutures, forcing the percolating aqueous through the remaining sclera.¹⁵

The viscocanalostomy eyes maintained a considerably lower IOP all along the follow-up period. The hyphema that occurred in two patients rapidly resolved, and the scleral bed hole in the left eye of patient 3 did not necessitate any intraoperative modification, as there was no iris incarceration, either acutely or during follow-up. The Descemet's membrane detachment in the left eye of patient 5 remained localised, and its overlying oedema resolved.

All eight patients had the isolated trabecular dysgenesis subcategory of congenital glaucoma, and this was confirmed by the preoperative examination under ketamine anaesthesia. It is a well-known fact that the two other varieties of iridotrabecular and iridocorneotrabecular dysgenesis have a much lower rate of success with the conventional surgeries of goniotomy or trabeculotomy. This is mainly owing to the multiple anatomical associated abnormalities.²¹ Viscocanalostomy being a more demanding surgery would have the same fate, if not worse. Hence, it would be unethical to consider it in the two above-mentioned categories.

Our controlled pilot study has shown both procedures to be equally effective in lowering IOP for a mean follow-up of 12 months. Viscocanalostomy is technically a more difficult surgery than trabeculotomy, and requires both a longer intraoperative time and a longer learning curve. However, it seems to be a good surgical alternative, especially if it is going to be associated with a higher long-term success rate in eyes with more aggressive disease. Larger controlled studies with a longer follow-up time are needed to further clarify the issue.

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Competing interests: None.

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