Ultrasound biomicroscopy and its value in predicting the long term outcome of viscocanalostomy

S Roters, C Lüke, C P Jonescu-Cuypers, B F Engels, P C Jacobi, W Konen, G K Krieglstein

Aims: To examine whether the early postoperative morphology at the site of sclerectomy, as visualised by ultrasound biomicroscopy (UBM), is an indicator of the mechanisms that lower intraocular pressure (IOP) and/or predictors of the long term outcome of viscocanalostomy.

Methods: 15 eyes of 14 patients with medically uncontrolled open angle glaucoma and no history of surgery underwent viscocanalostomy according to Stegmann’s technique. Ultrasound biomicroscopy was performed during the first month after surgery. The following parameters were assessed: dimensions of the intraocular “lake,” presence of a filtering bleb, presence of a subconjunctival cavity or a suprachoroidal hypoechoic area, and the thickness of the residual trabeculocorneal membrane. A complete ophthalmological examination was performed the day before and the day after surgery. Follow up visits were scheduled 1 week, 4 weeks, 6 months, and 12 months after surgery.

Results: At 1 year successful control of IOP (<20 mm Hg) was achieved without further manipulation or medication in six of 15 eyes. The size of the intraocular “lake” (average 0.62 mm) did not correlate with later IOP; however, a visible route under the scleral flap and accidental perforation of the trabeculocorneal membrane were associated with long term lowering of IOP. Normal thickness of the trabeculocorneal membrane (0.10–0.15 mm) was indicative of IOP control with and without medication. When UBM showed an early collapse of the intraocular cavity, control of IOP was not achieved. Other UBM findings did not predict long term function.

Conclusion: In accordance with previous studies, the authors found that UBM examination is a useful method to evaluate outflow mechanisms after glaucoma surgery. This study shows that UBM imaging of external filtration during the early postoperative period can be used to predict the success of viscocanalostomy. However, to establish conclusively what parameters of UBM predict successful viscocanalostomy a larger number of patients must be studied.

Several investigators have shown renewed interest in surgical reduction of intraocular pressure (IOP) by non-perforating glaucoma surgery. Non-perforating glaucoma surgery avoids opening the anterior chamber and decompressing the eye, thus circumventing many serious complications associated with standard trabeculectomy. In open angle glaucoma, the endothelium of Schlemm’s canal and the immediately adjacent trabecular meshwork show increased resistance to aqueous outflow, resulting in increased IOP. Recently, a new technique of non-penetrating glaucoma surgery, viscocanalostomy, has been described; it results in better outflow in open angle glaucoma. In this procedure Schlemm’s canal is unroofed and Descemet’s membrane is separated 1–2 mm from the corneoscleral junction, resulting in a thinner but intact window to the anterior chamber, through which aqueous humour diffuses into a subconjunctival cavity (UBM) and/or predictors of the long term outcome of viscocanalostomy.

The aim of the present study was to analyse the aqueous drainage pathways under the scleral flap and to examine the presence and dimensions of the subconjunctival and suprachoroidal space in eyes that underwent viscocanalostomy. In this study UBM findings were used to evaluate potential predictive parameters with reference to long term success or failure of viscocanalostomy.

Patients and methods
In this retrospective study we enrolled 15 eyes of 14 patients with uncontrolled open angle glaucoma. The patients had no history of glaucoma surgery or laser treatment and all had had maximal medical therapy without success. Included were patients with pseudoexfoliation glaucoma (n = 7), pigmented dispersion glaucoma (n = 4) and primary open angle glaucoma (n = 4) (Table 1). Exclusion criteria were secondary or dysgenetic glaucoma, narrow angle glaucoma, a legally blind fellow eye, or corneal abnormalities that prevented reliable applanation tonometry.
A complete ophthalmological examination was performed the day before and the day after surgery. The assessment included IOP measurement, visual acuity, gonioscopy, and anterior and posterior slit lamp examination. Follow up visits were scheduled at 1 week, 4 weeks, 6 months, and 12 months after surgery. Written informed consent was obtained from all subjects.

Patients were eight women and six men aged 34–67 years (mean 57.6 years). Between June 1999 and March 2000 these patients underwent viscocanalostomy according to the technique of Stegmann et al at the centre of ophthalmology, Cologne, Germany. Two experienced surgeons (WK and PCJ) performed all surgical procedures. No antiproliferative agents were used for the first surgical procedure.

### UBM examination

An ultrasound biomicroscope (Humphrey Inc, Zeiss Group, Jena) model 840 was used in this study. With the patients in a supine position and with the aid of a lid speculum and an examination gel of low viscosity the surgical area was scanned with the 50 MHZ probe. UBM was performed during the first month after surgery. The following parameters were analysed: the maximal height, the maximal radial and transverse dimensions of the intrascleral lake, the presence or absence of a filtering bleb or subconjunctival cavity, the presence or absence of a suprachoroidal hypoechoic area, and the thickness of the residual trabeculocorneal membrane. To avoid bias all examinations were performed once each by two experienced ophthalmologists.\(^\text{11}\)

### Viscocanalostomy procedure

A fornix based conjunctival flap was prepared, Tenon’s capsule was opened, and both were retracted to expose the sclera. Haemostasis was maintained by irrigation with balanced salt solution to avoid damage and scarring of the anatomical structures. A 5 × 5 mm triangular superficial flap was prepared and a second 4 × 4 mm deeper scleral flap deroofed Schlemm’s canal. This inner flap was pulled upward, and the floor of the canal and Descemet’s membrane were depressed with the tip of a cellulose sponge; the membrane was then separated from the cornea for a distance of about 1–2 mm. Afterwards the inner scleral flap was excised. After cannulation and correct positioning of the cannula using gonioscopy, the proximal ends of Schlemm’s canal and the intrascleral space were filled with sodium hyaluronate (Healon GV) according to Stegmann’s technique. Afterwards, the inner flap was cut off and the superficial flap was closed tightly with 10-0 Vicryl sutures. To prevent early scarring, Healon GV was injected underneath the flap. The conjunctiva was closed with 7-0 Vicryl sutures adjacent to the limbus. Immediately after surgery 40 mg of gentamicin (1 cm\(^3\)), 1:4 dilution) and 2 mg betamethasone were injected subconjunctivally. During postoperative recovery, each subject was administered a preservative-free local steroid five times a day and a combination of steroid and antibiotic ointment at night.

Surgical success was defined as IOP less than 20 mm Hg without the need of topical medication or additional surgery.

### RESULTS

The mean preoperative IOP was 25.26 mm Hg (range 22–40 mm Hg). After 1 year, six of 15 patients reached and maintained an IOP of ≤20 mm Hg without further surgery or medication. The mean IOP after 1 week was 16.1 (n=13), after 4 weeks was 14.6 mm Hg (n=10), after 6 months was 16.6 mm Hg (n=15), and after 12 months (including those patients who required drug therapy and those requiring additional surgery) the mean IOP was 18.2 mm Hg (n=15) (Tables 1 and 2).
No serious complications or long lasting side effects were noted in the operated eyes. Intraoperative complications were perforation of the trabeculocorneal membrane in two eyes. Postoperative complications included a leaking bleb in one eye, which closed spontaneously, and transient hyphaema of 1 mm and 2 mm in two eyes. Complications due to overfiltration, such as flat anterior chamber, prolonged ocular hypotony, and choroidal detachment were not observed. Significant cataract formation with a drop in visual acuity also was not observed. IOP spikes occurred in nine eyes; five of these eyes required additional surgery, three required drug therapy, and the patient in whom the spike was observed at the last follow up visit was instructed to use drug therapy. In two patients who had laser suturelysis, IOP control could not be achieved.

UBM was performed on average 12 days after viscocanalostomy and showed seven different morphological characteristics.

**Intrascleral lake**
A visible intrascleral hypoechoic zone was observed in 13 eyes (86.6%). All 13 eyes achieved an IOP of <20 mm Hg; of these, six required no additional treatment, four drug therapy, and three additional surgery.

A large intrascleral lake (>0.50 mm³) was observed in six eyes (40%). All six eyes achieved an IOP of ≤20 mm Hg; of these, three required no additional treatment, two drug therapy, and one additional surgery.

The dimension of the intrascleral lake (average 0.62 mm³) did not correlate with changes in IOP (Figs 2 and 3).

**Low reflective filtering bleb**
A filtering bleb was observed in 14 eyes (93.3%). A filtering bleb was not observed in only one eye, which required drug therapy.

A large filtering bleb was observed in four of six eyes that achieved an IOP of ≤20 mm Hg; one of the eyes required drug therapy and two required additional surgery.

**Subchoroidal hypoechoic area**
A subchoroidal space was observed in six eyes (40%); all six eyes achieved an IOP of ≤20 mm Hg; of these, three did not require additional treatment, one required drug therapy and two additional surgery.

**Subconjunctival hyporeflective cavity**
A hyporeflective subconjunctival cavity was imaged in nine eyes (60%). All nine eyes achieved an IOP of ≤20 mm Hg; of these, five required no additional treatment, two drug therapy and two additional surgery (Fig 3).

**Visibility of the route under the scleral flap**
Separation of the scleral flap owing to a presumed fluid stream was observed in two of the eyes that achieved an IOP of

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maximal = maximum value of IOP; rows in bold type = successful viscocanalostomy with IOP 20 mm Hg after 1 year of follow up.

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**Table 2** IOP at the scheduled follow up visits

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**Figure 1** Kaplan-Meier curve for all subjects (n=15). Time lapse until IOP exceeds 20 mmHg. Cumulative probability of survival.

**Figure 2** UBM (radial section) 28 days after viscocanalostomy. A small perforation of residual trabecular meshwork (arrow), the small intrascleral "lake" (volume 0.36 mm³), a small low reflective filtering bleb (arrowhead), and a convex iris configuration were visualised by UBM. AC = anterior chamber.
of Descemet's membrane for water and because the sites of
perforations about the mechanisms by which such a procedure low-
ers IOP, particularly because of the extremely low permeability
of aqueous veins but, in fact, the reduction of outflow resistance via a number of mechanisms, which include:

- thinning of the trabecular meshwork
- vaulting of residual trabecular meshwork vaults towards the intrascleral cavity leading to a widening of the cribiform interspace (similar to laser trabeculoplasty)
- opening or widening of Schlemm's canal inner wall and of the juxtrabulbar meshwork by injection of viscoelastic.

Other unconventional outflow mechanisms that may be improved by surgery include:
- scleral thinning when a superficial scleral flap permits passage into the subconjunctival space
- formation of an intrascleral lake, which leads to formation of aqueous veins
- trans-scleral filtration into the supraciliary/suprachoroidal space.

Accidental lesions that can lead to higher aqueous outflow include:
- opening of a cyclodialysis clefts (these may only be observed by UBM examination)
- localised choroidal effusion
- opening of the anterior chamber.

In our studies the residual trabeculo-descemetic membrane was unstable if its thickness was ≤ 0.05 mm. The inward vaulting into the intrascleral cavity led to collapse of the lumen of the cavity and an increase in IOP. A trabeculo-
descemetic membrane is stable when the thickness is 0.13 (SD 0.02) mm. A visible Schlemm's canal following viscoelastic injection was never observed, even when UBM examination was performed on the second postoperative day.

The inability to view Schlemm's canal and its degree of patency is a limitation of commercially available UBM technology. Without that information, one aspect of the mechanism (flow into a dilated Schlemm's canal) cannot be addressed. It would be expected that a large intrascleral lake would result in good trans-scleral and suprachoroidal filtration as well as increased contact with aqueous veins but, in fact, the size of the intrascleral lake did not correlate with IOP control.

Small perforations that open a hole in the anterior chamber result in a successful viscocanalostomy; however, unpublished observations indicate that large perforations lead to adhesions of the peripheral iris or collapse of the intrascleral lake and an increase in IOP.

In this study UBM of non-penetrating sclerectomy with viscocanalostomy showed seven significant postoperative findings. Of these findings, a visible intrascleral lake, which was found in 13 of 15 eyes (including those in which the procedure failed), a suprachoroidal hypoechoic area visualised in the early postoperative period and a large intrascleral cavity were not prognostic of long term function. Earlier ultrasound
bimicroscopic studies have shown that blebs of the L-type
(low reflective) are associated with good IOP control in
trabeculomised eyes22 with adjunctive mitomycin-C.
In this study filtering blebs were found in all but one eye 1 month
after surgery; however, even a large hyporeflective filtering bleb
was not indicative of good IOP control, and in fact two eyes
needed further surgical intervention. A hyporeflective subcon-
junctival cavity was often found in successful viscocanalosto-
my; however, two eyes with a hyporeflective subconjunctival
cavity needed additional surgery.
A UBM finding that was indicative of successful IOP control
was an easy visible “route” under the scleral flap; however, if
the diameter of the route was <0.05 mm, there was no guar-
antee for IOP control. Earlier studies have shown that
the thickness of the aqueous drainage route beneath the sce-
IOP control. A clinical finding of a filtering bleb was
not indicative of good IOP control, and in fact two eyes
needed further surgical intervention. A hyporeflective subcon-
This clinical finding of a filtering bleb was
not necessarily observable from UBM imaging, and in cases
with large hyporeflective blebs shown on UBM, the clinical
examination did not indicate the presence of a filtering bleb
despite evaluation by four experienced ophthalmologists (two
for clinical examination and two for UBM examination).
early studies of viscocanalostomy claimed that this procedure
was not as efficient for controlling IOP in white glaucoma
patients as standard filtration surgery and was therefore
indicated for its safety more than for its efficacy. Comparison
of trabeculectomy and viscocanalostomy showed that during a 6
month follow up, IOP was successfully controlled in five of 10
eyes in the trabeculectomy group and in none of the eyes in the
viscocanalostomy group.22 However, Carassa et al.22 reported a
success rate of 86.2% after 12 months in eyes that underwent
viscocanalostomy. In summary, these studies are difficult to
compare because of differences in the criteria of successful
control of IOP and varying follow up periods.
Numerous surgical modifications, such as laser gonipunc-
ture, trabecular stripping, trabecular microperforation, and
various implants into the scleral space have been introduced to
decrease IOP and reduce outflow resistance in trabecular mesh-
work and/or canalisation of aqueous flow into the subconjunc-
tival area. Johnson and Johnson4 identified microperforations
in the trabecular meshwork after non-penetrating surgery
bypassing the resistance of the juxtaanaculcular meshwork,
explaining why many patients who have had successful
non-penetrating operations developed filtering blebs. Drüsedau
et al.22 reported that none of the eyes in a series of 41 viscoacan-
ulamies after viscocanalostomy. Although these findings
perforation of the trabecular meshwork and an aqueous route
under the scleral flap indicate successful IOP control similar to
that obtained with standard filtration surgery.
As far as the safety of viscocanalostomy is concerned, there
are certainly fewer complications, such as postoperative hypo-
reflective complications, flat anterior chamber, and choroidal
detachment; however, hyaluronate detachment of Descemet's
membrane can occur.22
UBM is a useful method for assessing the anatomical changes in eyes undergoing viscocanalostomy, which may
allow an understanding of the outflow mechanisms. In spite
of many variations observed, it may be stated that non-
penetrating viscocanalostomy works best when ultrasound
bimicroscopic observations are similar to those observed
after filtration surgery. A study with later UBM is under way,
in order to compare the findings with the early UBM appear-
ance. However, a larger number of patients needs to be studied
to define what parameters predict successful IOP control.

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