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 Kriegstein

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 intrascleral “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 intrascleral “lake” (average 0.62 mm²) 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 intrascleral 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.

S everal 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 created by the removal of an inner scleral flap. Filtration is improved when the diameter of Schlemm’s canal is enlarged by the injection of a high viscosity viscoelastic material into the opened ostia of the canal.

The nature of the outflow pathways that lead to the lowering of IOP in viscocanalostomy surgery is controversial. Several mechanisms may be involved: these include permanent subconjunctival filtration (as in trabeculectomy), aqueous flow into the canalicular system that reaches the venous circulation or the uveoscleral space, with or without an intrascleral “lake,” and drainage from Schlemm’s canal to capillaries and veins within the intrascleral canals and subconjunctival tissue.

Morphological studies have shown varying dissection depths of the deep scleral flap that often leads to an unroofing of Schlemm’s canal. Posturgical examination with the high resolution ultrasound biomicroscope (UBM), developed by Pavlin and Foster, allows imaging of the trabeculo-descemetian membrane, the intrascleral hypoechoic cavity and subconjunctival filtration (clinically not visible during slit lamp examination) with a resolution of 50 μm. UBM examination can also detect the presence of small amount of fluid, such as subchoroidal effusion, between layers of the eye.

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 pseudoxefoliation glaucoma (n = 7), pigment 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.

### 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 nylon 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 cm³, 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 for 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. The Kaplan-Meier curve shows the cumulative probability of success until IOP exceeded 20 mm Hg (Fig 1).

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 $\leq 20$ mm Hg; of these, six required no additional treatment, four drug therapy, and three additional surgery.

A large intrascleral lake ($>0.50$ mm$^3$) was observed in six eyes (40%). All six eyes achieved an IOP of $\leq 20$ 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 mm$^3$) 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 $\leq 20$ 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 $\leq 20$ mm Hg; of these, three did not require additional treatment, one required drug therapy, and two additional surgery.

**Subconjunctival hyporeflexive cavity**
A hyporeflexive subconjunctival cavity was imaged in nine eyes (60%). All nine eyes achieved an IOP of $\leq 20$ 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**
Seperation 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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**Table 2** IOP at the scheduled follow up visits

<table>
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<tr>
<th>Patient No</th>
<th>Maximal (mm Hg)</th>
<th>Before (mm Hg)</th>
<th>1 week (mm Hg)</th>
<th>4 weeks (mm Hg)</th>
<th>6 months (mm Hg)</th>
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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.*
of Descemet’s membrane for water and because the sites of
perforations about the mechanisms by which such a procedure
lowers IOP, particularly because of the extremely low permeability
of aqueous veins but, in fact, the size of the intrascleral lake did not correlate with IOP.

UBM permits visualisation of the postoperative area and measurement of the thickness of the trabeculocorneal
membrane and the dimensions of the intrascleral lake. Despite an axial and lateral resolution capacity of 50 μm,
imaging of the exact preparation level is not possible. In this study the volume of the intrascleral lake was determined by
multiplying the maximum height by the limbus parallel and radial extension, resulting in a quadratic equation. This equa-
tion was chosen according to previous studies, although a more precise calculation would be that for lenticular objects.

Under physiological conditions, 85% of aqueous outflow is transtrabecular. Sclerectomy and viscocanalostomy lead to
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 cribriform interspace (similar to laser trabeculoplasty)
• opening or widening of Schlemm’s canal inner wall and of the juxtratrabecular 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 pa-
tency is a limitation of commercially available UBM technol-
ogy. 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.

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 pro-
cedure failed), a suprachoroidal hypoechogenic area visualised in the early postoperative period and a large intrascleral cavity were not prognostic of long term function. Earlier ultrasound
biomicroscopic studies have shown that blebs of the L-type (low reflective) are associated with good IOP control in trabeculoanatomised eyes with adjunctive mitomycin C. In this study filtering blebs were found in all but one eye 1 month after surgery; however, even a large hyporeflexive filtering bleb was not indicative of good IOP control, and in fact two eyes needed further surgical intervention. A hyporeflexive subconjunctival cavity was often found in unsuccessful viscoscanalostomies; however, two eyes with a hyporeflexive 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 guarantee for long term function. Earlier studies have shown that the thickness of the aqueous drainage route beneath the scleral flap needed additional surgery. A hyporeflexive subconjunctival cavity was often found in successful viscoscanalostomy; however, if the thickness of the deep scleral flap influence the intraocular pressure after deep sclerectomy – morphological analysis of the deep scleral flap. For this study filtering blebs were found in all but one eye 1 month after surgery; however, even a large hyporeflexive filtering bleb was not indicative of good IOP control, and in fact two eyes needed further surgical intervention. A hyporeflexive subconjunctival cavity was often found in unsuccessful viscoscanalostomies; however, two eyes with a hyporeflexive subconjunctival cavity needed additional surgery.

As far as the safety of viscoscanalostomy is concerned, there are certainly fewer complications, such as postoperative hypotensive complications, flat anterior chamber, and choroidal detachment; however, hyaluronate detachment of Descemet’s membrane can occur. UBM is a useful method for assessing the anatomical changes in eyes undergoing viscoscanalostomy, which may allow an understanding of the outflow mechanisms. In spite of many variations observed, it may be stated that non-penetrating viscoscanalostomy works best when ultrasound biomicroscopic 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 appearance. However, a larger number of patients needs to be studied to define what parameters predict successful IOP control.

**REFERENCES**


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