Are There Filtering Blebs After Canaloplasty?

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Purpose: Aim of the study was to assess the development of filtering blebs after canaloplasty.

Methods: Twenty eyes of 20 consecutive patients receiving canaloplasty were included. All eyes were examined clinically (slit lamp), and by anterior segment optical coherence tomography and high-frequency ultrasound biomicroscopy to detect filtering blebs. Preoperative and postoperative intraocular pressure (IOP) and medications were recorded. No antimetabolites were used at any time. Two success criteria were defined to assess a possible correlation of bleb formation and success: (1) IOP ≤21 mm Hg and minimum 20% IOP reduction without medication and (2) IOP < 18 mm Hg without medication.

Results: No filtering blebs were detected clinically. One patient had a filtering bleb-like structure as detected by anterior segment optical coherence tomography and ultrasound biomicroscopy. Mean IOP decreased significantly from 22.15 ± 9.35 mm Hg preoperatively to 13.3 ± 9.9 mm Hg at last follow-up (at 245 ± 120.0 d). The number of medications was reduced significantly from 3.15 ± 1.2 preoperatively to 0.55 ± 0.94 postoperatively. Complete success rate was 65% for both success criteria.

Conclusions: Filtering blebs occur rarely after canaloplasty. In canaloplasty, IOP reduction seems to be independent of subconjunctival aqueous drainage, thus, avoiding the problems of conjunctival scarring.

Key Words: glaucoma surgery, canaloplasty, nonpenetrating glaucoma surgery, filtering bleb, anterior segment OCT, high-frequency ultrasound biomicroscopy

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Canaloplasty is a new surgical approach to treat patients with medically uncontrolled open-angle glaucoma. Using this technique in a single or combined procedure, 3 prospective studies showed encouraging results regarding intraocular pressure (IOP) reduction and success rates. A retrospective study showed superior complete success rates for canaloplasty as compared with viscocanalostomy. Canaloplasty aims to restore the physiological outflow through Schlemm’s canal and the collector channels, avoiding subconjunctival drainage as in trabeculectomy. Therefore, antimetabolites are not necessary and complications like filtering bleb leakage, bleb-related infections, or discomfort, hardly, can occur. Canaloplasty evolved from viscocanalostomy. Schlemm’s canal is opened and sustained by a suture inserted with the aid of a microcatheter. Recently published data showed a 10-0 Prolene as the suture of choice. As in viscocanalostomy, a superficial scleral flap is sutured watertight to prevent the development of filtering bleb. After viscocanalostomy, filtering blebs have repeatedly been detected clinically or by ultrasound biomicroscopy (UBM), despite meticulous surgical technique. Some studies reported lower IOPs and higher success rates in eyes with a filtering bleb after viscocanalostomy. To evaluate a possible role of conjunctival drainage and subsequent scarring in canaloplasty, we conducted a study in consecutive patients with canaloplasty to detect filtering blebs clinically, by high-resolution UBM or by anterior segment optical coherence tomography (AS-OCT).

PATIENTS AND METHODS

Twenty eyes of 20 consecutive patients had undergone canaloplasty (as a single or combined procedure with cataract surgery) at the University Eye Hospital Würzburg, between May 2008 and June 2009, and were investigated for the presence of a filtering bleb in July 2009 in a cross-sectional manner within the scope of the routine follow-up. The study has received Institutional Review Board approval, and informed consent was obtained from all patients before the study. Inclusion criteria were 360-degree canaloplasty (as a single or combined procedure with cataract surgery) in the mentioned period of time, open-angle glaucoma, and age > 18 years. Phakic and pseudophakic eyes were included. Exclusion criteria were earlier trabeculectomy, more than 1 laser trabeculoplasty, more than 2 cyclophotocoagulations, intraoperative conversion to a trabeculectomy, and impossibility of suture placement in Schlemm’s canal.

In all patients, gonioscopy was performed before surgery. Canaloplasty was only indicated when the scleral spur was visible without indentation. Combined procedures were indicated when a significant cataract (best-corrected visual acuity ≤20/30) was detected.

Surgery

All patients underwent a 360-degree canaloplasty in general anesthesia. The procedure has been described in detail by Lewis et al. After the placement of a 6 o’clock traction suture (6-0 silk) a limbal peritomy was performed. Conjunctiva and tenon were retracted. A superficial parabolic flap (5 × 5 mm) of half of the scleral thickness was dissected reaching 1 mm into the clear cornea. Next, a smaller deep corneoscleral lamella was dissected leaving a...
Search for a conjunctival thickening was added to the criteria of the WBCS. Directly after clinical examination, all eyes were investigated with the AS-OCT (Visante-OCT, Carl Zeiss Meditec, Jena, Germany). Both superior quadrants were scanned 3 times with the AS-OCT searching for an elevation, cysts, or thickening of the conjunctiva. Representative AS-OCT scans of high quality were stored. In addition, scans were placed vertically through the scleral lake (12 to 6 o’clock position, Fig. 2A) and in the horizontal 3 to 9 o’clock position (Fig. 2B). Finally, after AS-OCT, the patients were screened with a high-frequency (80 MHz) UBM device (iUltraSound, iScience Interventional, Inc., 4055 Campbell Avenue, Menlo Park, CA). Again both superior quadrants were scanned 3 times with the UBM searching for an elevation, cysts, or a thickening of the conjunctiva. Representative scans of high quality were stored. Further scans were placed through the scleral lake (12 o’clock position, Fig. 2C) and the 3, 6, and 9 o’clock position (Fig. 2D), respectively, similar to the procedure using AS-OCT.

Preoperative and postoperative IOP and medication were recorded.

Success Criteria

Complete success was defined: (1) IOP \( \leq 21 \text{ mm Hg} \) and at least 20% IOP reduction without medication and (2) IOP \( < 18 \text{ mm Hg} \) without medication. Qualified success was defined respectively, with or without medication.

Statistical Analysis

Statistical Analysis was carried out using Excel for Windows statistical software (Excel 2003, Microsoft). As a Gaussian distribution was expected for all parameters, the \( t \) test for independent samples was used for statistical analysis. \( P \) values of \( < 0.05 \) were considered to indicate statistical significance (\( *P < 0.05, **P < 0.01, ***P < 0.001 \)).

RESULTS

Twenty patients (11 male, 9 female) were included in the study. The group consisted of 8 right and 12 left eyes. The mean age was 72.45 ± 10.0 years. All patients underwent 360-degree canaloplasty because of medically uncontrolled glaucoma. Nine patients had a combined procedure with phacoemulsification and intraocular lens. Nine patients had neither laser nor surgery before. Seven patients had 1 laser trabeculoplasty, 5 phacoemulsification with intraocular lens, and 1 patient had cyclodestructive laser. The mean follow-up was 245 ± 120.0 days (median 276.5 d).

Table 1 summarizes the demographic data, IOP, medical treatment, and occurrence of a filtering bleb (clinically and with imaging devices).

Clinical Examination

During slit lamp investigation, using the WBCS, particular attention was turned to microcysts, conjunctival thickening, and conjunctival elevation. Finally, in none of the patients filtering bleb was detected.

Anterior Segment OCT

The anterior segment OCT showed a filtering bleb-like structure only in 1 patient (Fig. 3A). Only a very thin layer of the conjunctiva bulged out. Compared with filtering blebs after trabeculectomy (Fig. 3B), it appeared not like a...
typical filtering bleb. The filtering bleb in Figure 3B showed clinically (3 years after surgery) multiple microcysts, an elevation of twice the corneal thickness and no signs of encapsulation or increased vascularity. The thickening and elevation of the conjunctiva and the hypoechoic space formed by the aqueous was seen in the AS-OCT. In all other eyes, neither in the screening scans in the superior quadrants nor in the standard scans at 12 to 6 o’clock and 3 to 9 o’clock position filtering bleb was detected. The mean height of the scleral lake was 0.4±0.14 mm. The mean length of the Descemet window was 0.41±0.16 mm. The mean thickness of trabeculodescemetic membrane was 0.1±0.05 mm. Two patients had an atrophy of the scleral lake. One of them belonged to the success group and other to the failure group.

Ultrasound Biomicroscopy
The UBM showed filtering bleb-like structure only in 1 patient (Fig. 3C). It was the same patient the AS-OCT had identified earlier (Fig. 3A). In Figure 3D the same filtering bleb after trabeculectomy is shown for comparison. In all other eyes, no filtering blebs could be detected during scanning of the superior quadrants and in the standard scans. The patient with the bleb-like structure had a postoperative IOP of 14 mm Hg without medication (at the time of AS-OCT and UBM examination, 270 d after surgery). There was no significant correlation between filtering blebs and complete/qualified success. The mean height of the scleral lake was 0.44±0.15 mm. The mean length of the Descemet’s window was 0.42±0.1 mm. The mean thickness of trabeculodescemetic membrane was 0.09±0.04 mm. The same 2 patients, as in AS-OCT, had an atrophy of the scleral lake. The height of the scleral lake and the length of Descemet’s window did not correlate with IOP or complete/qualified success either.

Intraocular Pressure
The maximal preoperative IOP in all eyes was 32.8±7.0 mm Hg. The mean preoperative IOP was 22.15±9.5 mm Hg. The mean postoperative IOP at last follow-up (time of examination for clinical bleb appearance and imaging for filtering blebs) was 13.3±9.9 mm Hg. The reduction of IOP was significant compared with maximal preoperative IOP ($P < 0.0000001$) and preoperative IOP ($P = 0.0012$), respectively.

Medication
The number of medications decreased from 3.15±1.2 preoperatively to 0.55±0.94 postoperatively (time of examination for clinical bleb appearance and imaging for filtering blebs). The reduction in IOP lowering substances was highly significant ($P < 0.0000001$).

Success
Complete success (without medication) was reached for both success criteria in 13 patients (65%). Seven patients (35%) did not reach complete success for criteria. Qualified success (with and without medication) was reached for criterion 1 in 17 patients (85%) and for criterion 2 in 18 patients (90%). Three patients (15%) did not reach qualified success for criterion 1, and 2 patients (10%) did not reach qualified success for criterion 2. No correlation between complete and qualified success rates and bleb findings (clinically and with imaging devices) was detected.

Complications and Postoperative Interventions
One patient had an intraoperative macroperforation of the trabeculodescemetic window and an iridectomy was necessary. Nevertheless, the catheter could be inserted 360 degrees and the sutures were placed as intended. The patient had no filtering bleb in all investigations.
Three patients had hyphema (<1 mm), which resolved spontaneously. Five patients had a YAG-goniopuncture before the assessment, but in none of them filtering bleb was detected. In 2 patients the procedure was successful; the other 3 patients belong to the failure group. Two patients of the failure group had an additional unsuccessful iridectomy. One patient needed a cyclophotocoagulation to lower the IOP during follow-up.

**DISCUSSION**

Currently, several imaging devices are available to assess filtering blebs after trabeculectomy or deep sclerectomy.\(^{16–18}\) AS-OCT and UBM are most frequently used. Here, we used both the techniques to evaluate the development of filtering blebs after canaloplasty. No filtering bleb was detected at slit-lamp examination. However, UBM and AS-OCT showed a filtering bleb-like structure in single patient. This suggests that tomographic imaging techniques are required to rule out filtering bleb formation. Both the techniques gave unequivocal results. The bleb-like structure showed no connection to the scleral lake and was morphologically different from filtering blebs occurring with trabeculectomy (Figs. 3B, D). A superficial flap suture might have induced a cystic space, but the true nature of the bleb-like structure remains unclear. There are 2 publications describing filtering blebs after canaloplasty. Two years after surgery, Lewis et al\(^{1}\) clinically detected filtering blebs in 4 of 127 patients. Grieshaber et al\(^{19}\) found filtering blebs in 4 of 32 patients. Superficial flap closure technique may influence these results. In this study, 9 sutures were placed in 16 patients, and an additional suture was necessary in 4 patients. Grieshaber et al\(^{19}\) used 5 sutures for superficial flap closure, whereas all other reports refer to “watertight closure” without further specifying technical details.\(^{1,3}\) In terms of imaging for filtering blebs in patients with canaloplasty, there are currently no comparable data available. Thus, it remains unclear whether the number of sutures influences bleb formation.

In most of our patients, including the one with a bleb-like structure (Table 1), IOP was regulated without medication. The postoperative success was independent of the height of the scleral lake, thickness of the trabeculodescemetic membrane, and length of the Descemet’s window. A correlation between complete and qualified success rates and bleb findings (clinically and with imaging devices) was not detectable. There were 2 cases of an atrophy of the scleral lake, 1 in the success group and 1 in the failure group. Thus, our data indicate no association of filtering blebs and IOP or success rate in canaloplasty. This is in contrast to a report for viscosocanalostomy,\(^{1,5}\) suggesting superior success in the presence of filtering blebs. Different long-term modes of action may account for these observations. At the time of surgery, both techniques share the potential to disrupt Schlemm’s canal obliterations. However, viscosocanalostomy allows only for transient distension of Schlemm’s canal, whereas the suture placed in canaloplasty will maintain tension over longer periods of time, which may translate into different relevance of bleb formation for long-term success. At this point, the mechanism

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**TABLE 1. Demographic Data**

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*Last IOP reading before surgery.
†Preoperative topical medication.
‡Medication at time of examination with imaging devices.
§Surgery-examination with imaging devices.
¶Appearance of a filtering bleb clinically.
§Appearance of a filtering bleb with imaging devices.
*One patient had a prostaglandin in his topical treatment, all others had β-blockers or a combination of β-blockers and carbonic anhydrase inhibitors.
Max. IOP indicates maximal intraocular pressure in preoperative curve; PEX, pseudoexfoliation glaucoma; PG, pigmentary glaucoma; POAG, primary open-angle glaucoma.
of IOP reduction in canaloplasty remains to be elucidated. The inserted suture may have effects similar to pilocarpine on the trabecular meshwork. Another possibility is the creation of trabecular meshwork microperforations.

The amount of IOP reduction achieved by canaloplasty seems to be higher than with viscocanalostomy or deep sclerectomy without implants and/or mitomycin C. In this study, postoperative IOP was comparable to published results.1–4 The reduction in topical medication and the complete and qualified success rates were similar to the published data.1,2,4 We encountered only few rather mild complications. Iridectomy was necessary in a single patient, when the catheter was already in place. In this case, surgery was finished regularly and no filtering bleb was detectable. All other complications and interventions were comparable to earlier studies.

In summary, our data suggest that canaloplasty allows to achieve IOP regulation independent of subconjunctival drainage. This has important implications as filtering blebs are avoided, which eliminates the risk of blebitis, endophthalmitis, bleb leaks, and bleb-related dysaesthesia. The risk of sight threatening complications seems to be minimal. Moreover, success seems to be independent of conjunctival scarring, which is currently the major cause for failure in filtering glaucoma surgery. This spares the need for antimetabolites and has the potential to significantly ease postoperative care and improve patient comfort.

REFERENCES


