Scientific Foundation SPIROSKI, Skopje, Republic of Macedonia
Open Access Macedonian Journal of Medical Sciences. 2020 Jul 20; 8(F):103-107.
https://doi.org/10.3889/oamjms.2020.3893
eISSN: 1857-9655
Category: *F - Review Articles*
Section: *Narrative Review Article*

Ab Externum Canaloplasty – An Overview

Julinda Jaho[1]*, Valbon Ajazi[2]

[1]University Hospital Center of "Mother Theresa", Tirana, Albania; [2]German Eye Clinic, Prishtina, Kosovo

Edited by: Sinisa Stojanoski
Citation: Jaho J, Ajazi V. Ab Externum Canaloplasty – An Overview. Open Access Maced J Med Sci. 2020 Jul 20; 8(F):103-107. https://doi.org/10.3889/oamjms.2020.3893
Keywords: Canaloplasty; Glaucoma; Non-penetrating glaucoma surgery
***Correspondence:** Julinda Jaho, University Hospital Center of "Mother Theresa", Tirana, Albania. E-mail: julindajaho@gmail.com
Received: 16-Oct-2019
Revised: 29-Jun-2020
Accepted: 03-Jul-2020

Funding: This research did not receive any financial support
Competing Interests: The authors have declared that no competing interests exist.

Abstract

Canaloplasty is a non-penetrating glaucoma surgery used to treat patients with open-angle glaucoma. It was developed as an alternative method to traditional glaucoma surgery and is one of the recent techniques of non-penetrating glaucoma surgery. Studies have shown its efficacy and safety in the reduction of intraocular pressure, having a lower rate of intraoperative and post-operative complications compared to trabeculectomy. A combination of canaloplasty with phacoemulsification represents a good option for patients with concomitant cataract. Canaloplasty appears to be a good alternative for the treatment of open-angle glaucoma.

Introduction

Glaucoma is the main cause of irreversible blindness in the world. The global prevalence of glaucoma in the population aged 40–80 years old is 3.54%. In 2013, it was estimated that there were 64.3 million people suffering from glaucoma (40–80 years old), which are expected to reach 76 million in 2020 and 1118 million in 2040 [1].

Open-angle glaucoma constitutes 90% of cases with glaucoma in the USA and Europe. Raised intraocular pressure (IOP) remains the main risk factor for glaucoma and also the target of treatment as lowering of IOP is the only proven way of slowing down or halting the progression of the disease [2], [3], [4], [5], [6], [7], [8]. Medications, laser treatments, or surgery can be used for this purpose. There are different surgical techniques, trabeculectomy still being considered the gold standard in the surgical treatment of glaucoma. Nowadays, newer techniques include non-penetrating glaucoma surgeries, such as deep sclerectomy, viscocanaloplasty, and recently canaloplasty.

Ab externum canaloplasty is a non-filtering, bleb-free method aiming to restore the natural conventional aqueous outflow pathway. This is believed to be achieved by catheterization of the Schlemm's canal. Thinking to achieve a 360° widening of the Schlemm's canal, a special catheter was developed, leading to the new surgical technique and canaloplasty. During this procedure, the catheter is used to pass a suture through the entire circumference of the Schlemm's canal, which, after being tied, exerts a centripetal force in the inner wall of the Schlemm's canal. Consequently, the canal remains open. The surgery can be performed in any quadrant of the sclera, although the superior part is preferred one. Canaloplasty can be performed under local or general anesthesia, depending on the surgeon's preference.

Surgical technique

A fornix-based conjunctival peritomy and dissection of the conjunctiva are performed. A parabolic scleral flap measuring 5 × 5 mm is created. The parabolic shape makes the watertight closure at the end of the procedure more effective. A crescent knife is used to dissect the flap, which has to be approximately about 1/3 of the scleral thickness (200–300 μm). The flap has to reach the clear cornea anteriorly (Figure 1).

Then, the second internal flap is created, being 1 mm smaller than the superior one. The crescent knife helps again to advance the flap dissection anteriorly toward the Schlemm's canal. The choroid remains covered by a very thin layer of the sclera (Figure 2). Finding the proper plane of the dissection is very important. Going too deep will lead to perforation. Going too superficial would lead the flap over the Schlemm's canal itself, without going through it. If this happens, a new deeper dissection needs to be done. The identification of anatomical structures is critical at this point. The scleral spur fibers run parallel to the limbus. Once the scleral spur fibers are visualized, we check for the external wall of the Schlemm's canal under the deep flap. A paracentesis is performed to reduce the intraocular pressure, preventing the Descemet membrane bulging, and making the further dissection anteriorly more safe and easy. The dissection is extended for further 1 mm anteriorly, exposing the

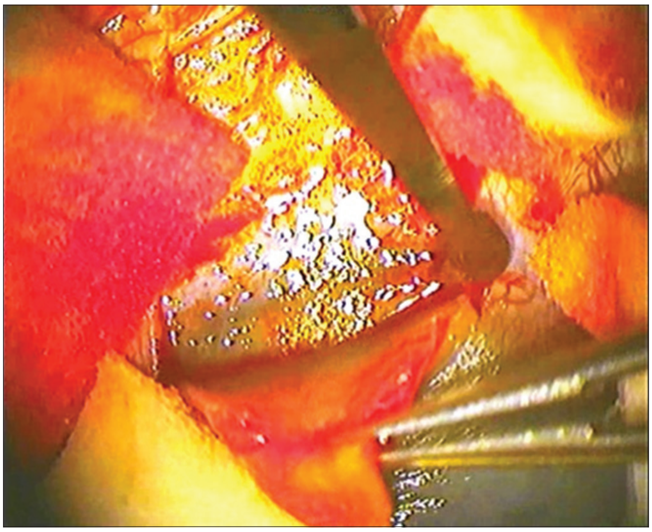

Figure 1: Creation of the superficial scleral flap

Descemet membrane. A thin strip of tissue from the internal wall of the Schlemm's canal is removed using a Mermoud forceps. This is believed to increase the perfusion of aqueous through the trabeculo-Descemet window. The Descemet membrane has to be clear of corneal tissue. An excess of pressure exerted at this point, even from a dry sponge, could easily perforate the trabeculo-Descemet membrane. This is the reason for which the tip of the sponge should always be wet. A minimal amount of BSS (balanced salt solution) is used for this purpose. Once the trabeculo-Descemet window is created, the deep flap is amputated using Vannas scissors. A small amount of high viscosity sodium hyaluronate is injected in each of the Schlemm's canal ends (Figure 3), making the catheterization easier.

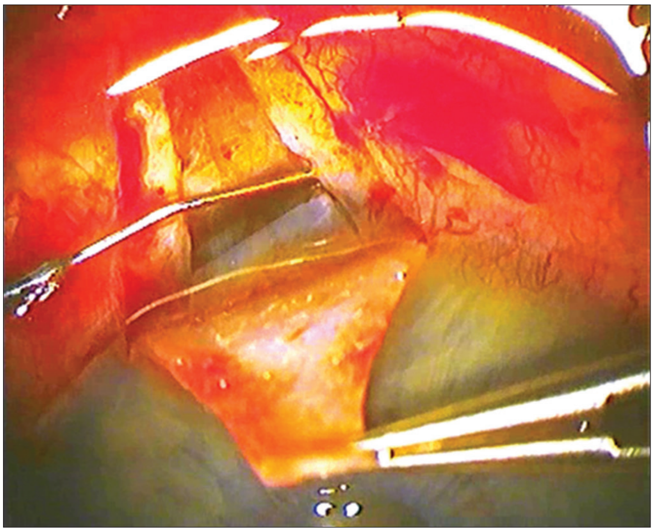

Figure 3: Injection of viscoelastic in both ends of the Schlemm's canal

The catheter is passed through 360° of Schlemm's canal circumference (Figure 4). A 10–0 Prolene suture is tied at the leading tip, and the catheter is withdrawn backward until it comes out from the insertion end of the Schlemm's canal. The suture comes out also, being passed through the whole circumference of the canal. The catheter is removed, and the suture ends are tied in a slipknot fashion (Figure 5). It is believed that the suture exerts a similar effect to pilocarpine, increasing the aqueous flow through the Schlemm's canal and its collector channels. The tension that the suture exerts plays a very important role in the final result of canaloplasty [9]. Stegmann canal expander can be implanted in the Schlemm's canal instead of the tensioning suture. The superficial scleral flap is sutured in its initial position (Figure 6), using five interrupted sutures (10–0 nylon or 10–0 vicryl). The aim is to achieve a watertight closure of the flap (Figure 6). A scleral lake is created under

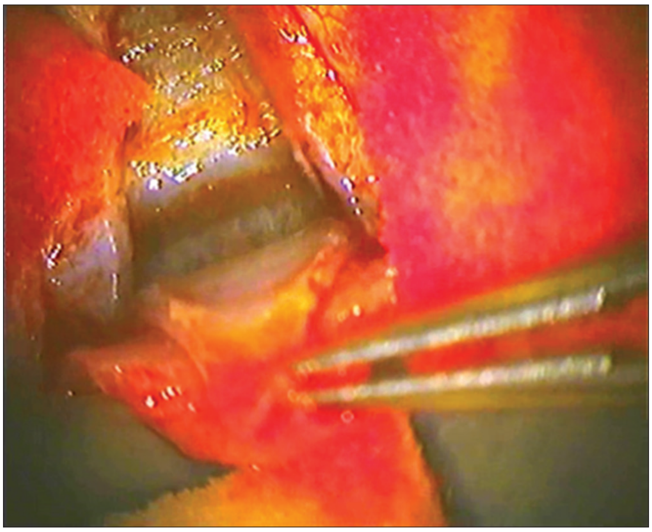

Figure 2: Creation of the deep scleral flap

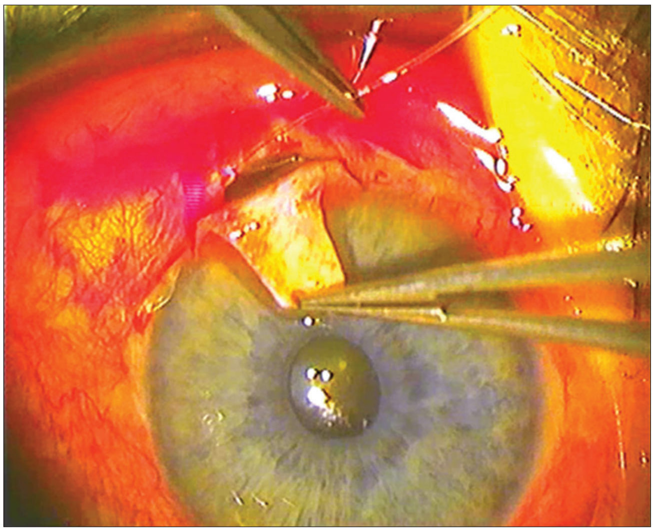

Figure 4: Insertion of glauconite catheter in the Schlemm's canal

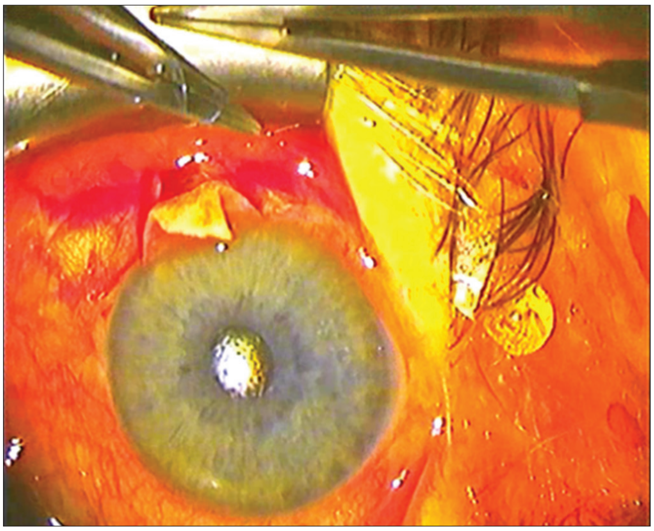

Figure 5: Tying of the tensioned suture

the scleral flap. High viscosity sodium hyaluronate is preferred to be injected under the scleral flap before its closure. This helps to keep the space open. Watertight closure of the conjunctiva with 10–0 vicryl suture remains the last step of the surgery.

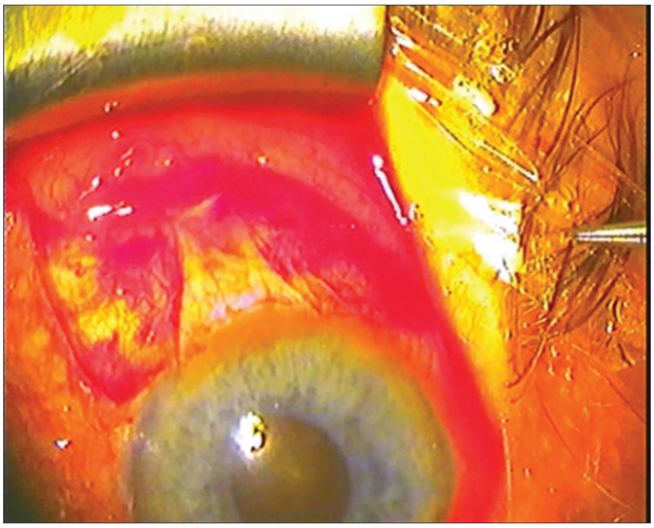

Figure 6: Watertight closure of the superficial scleral flap

Types of catheters

Up to date, there are two different catheters that can be used to perform canaloplasty:

1. iTrack (iScience International, Menlo Park, California, USA) was the first developed one. It is composed of three main parts: The microcatheter (with a diameter of 250 μm at the tip and 200 μm at the half) the Viscoinjector, and the illumination source. The microcatheter has a lumen inside, through which the viscoelastic is injected to widen the Schlemm's canal.
2. Glaucolight (DORC International, Zuidland, The Netherlands) is another type of catheter developed after iTrack was used. It has a thinner microcatheter with a diameter of 150 μm. It does not have a lumen for the injection of the viscoelastic substance; therefore, it does not aim to inject viscoelastic through the whole circumference of the Schlemm's canal.

Discussion

It is a well-known that trabeculectomy is still considered the gold standard procedure for the treatment of glaucoma, despite the high rate of complications related to the penetrating nature of the technique. Consequently, non-penetrating glaucoma surgery was developed. Sclerectomy was introduced, followed by viscocanalostomy and later canaloplasty.

Canaloplasty was first performed by Lewis *et al*. in 2007. This technique was designed to enhance the outflow of aqueous humor by dilating SC, establishing circumferential flow, and stretching out the trabecular meshwork. The effect on IOP reduction seemed to be correlated with suture tension, so many researchers tried to measure the distension of Schlemm's canal created by the suture. Lewis *et al*. applied a grading system for suture tension measurement. After 2 years of follow-up, he observed that there was a 31% IOP reduction in the group with an evident post-operative distension, compared to 20% reduction in the group without such a one [10].

Bradao *et al*. used ultrasound biomicroscopy (UBM) and anterior segment optic coherence tomography (OCT) to measure Schlemm's canal distension pre-operatively, 12 and 36 months post-operatively. The conclusion was that suture tension contributed to IOP reduction. Both equipments were equally efficient in the identification of the structures [11]. Another mechanism proposed as contributing to the reduction of IOP after canaloplasty is enhanced aqueous humor filtration across the sclera and conjunctiva. Mastropasqua *et al.* showed that conjunctival microcysts had a four-fold increase measured with confocal laser-scanning microscopy before and after the surgery [12].

The effect of canaloplasty on IOP is reported by many studies. Data reported by Lewis *et al*. show clear IOP reduction after canaloplasty in glaucoma patients [9], [10], [13]. Grieshaber *et al*. have also observed the reduction of IOP following canaloplasty but with lower complete success rates 3 years after surgery compared to 1 year after surgery [14], [15].

Comparative studies that investigate trabeculectomy versus canaloplasty show a greater reduction of IOP in patients who have undergone trabeculectomy, but higher complication rates [16], [17], [18].

Correct patient selection is the key to canaloplasty success [19]. Canaloplasty is mainly advised for open-angle glaucoma patients, including patients with pigmentary and pseudoexfoliative glaucoma, but also for angle-closure glaucoma patients who are undergoing or have previously undergone lensectomy. Canaloplasty is mainly indicated for patients with mild-to-moderate primary open-angle glaucoma and a low-to-mid-IOP target [20]. It is also indicated for patients with advanced glaucoma who is not good candidates for trabeculectomy [19]. Many surgeons prefer it for contact lens users due to the lack of the conjunctival bleb, which could be traumatized by the chronic friction of lens over the bleb. It is advised for the fellow eye in patients who have gone through serious complications in the other eye having undergone trabeculectomy. It is preferred for young patients, thinking to keep the list of other more aggressive techniques for later during life.

The safety profile is similar to the rates reported after classic non-penetrating glaucoma surgery [21]. The most common adverse effect reported by Lewis *et al.*is microhyphema in the first post-operative day (3,19 %), followed by IOP spikes, Descemet membrane detachment, hypotonia, choroidal effusion, and exposed suture. Iris prolapse has been reported by Shingleton *et al*. (1,9%), and one case of Bilateral Descemet membrane detachment has been reported by Palmiero *et al*. [22]. Few cases of Prolene suture erosion in the anterior chamber have also been reported.

Conclusions

Canaloplasty gives a satisfactory IOP reduction, with less intraoperative and post-operative complications compared to trabeculectomy, making it a preferred type of surgery for patients with a higher risk of complications. Ab externum canaloplasty has recently advanced toward ab interno canaloplasty, which eliminates the trauma to the conjunctiva. Further studies will be needed to evaluate the effectiveness of ab interno canaloplasty.

References

1. Yih-Chung T, Li X, Wong TY, Quigley HA, Aung T, Cheng CY. Global prevalence of glaucoma and projections of glaucoma burden through 2040. Ophthalmology. 2014;121(11):2081-90. https://doi.org/10.1016/j.ophtha.2014.05.013
2. Kass MA, Heuer DK, Higginbotham EJ, Johnson CA, Keltner JL, Miller JP, *et al*. The ocular hypertension treatment study: A randomized trial determines that topical ocular hypotensive medication delays or prevents the onset of primary open-angle glaucoma. Arch Ophthalmol. 2002;120(6):701-13. https://doi.org/10.1001/archopht.120.6.701
   PMid:12049574
3. Lichter PR, Musch DC, Gillespie BW, Guire KE, Janz NK, Wren PA, *et al*. Interim clinical outcomes in the collaborative initial glaucoma treatment study comparing initial treatment randomized to medical or surgery. Ophthalmology. 2001;108(11):1943-53. https://doi.org/10.1016/s0161-6420(01)00873-9
   PMid:11713061
4. Heijl A, Leske MC, Bengtsson B, Hyman L, Bengtsson B, Hussein M, *et al*. Reduction of intraocular pressure and glaucoma progression: Results from the early manifest glaucoma trial. Arch Ophthalmol. 2002;120(10):1268-79. https://doi.org/10.1001/archopht.120.10.1268
   PMid:12365904
5. Leske MC, Heijl A, Hussein M, Bengtsson B, Hyman L, Komaroff E, *et al*. Factors for glaucoma progression and the effect of treatment: The early manifest glaucoma trial. Arch Ophthalmol. 2003;121(1):48-56. https://doi.org/10.1001/archopht.121.1.48
   PMid:12523884
6. Comparision of glaucomatous progression between untreated patients with normal-tension glaucoma and patients with therapeutically reduced intraocular pressures. Collaborative initial normal-tension glaucoma study group. Am J Ophthalmol. 1998;126(4):487-97. https://doi.org/10.1016/s0002-9394(98)00223-2
   PMid:9780093
7. The effectiveness of intraocular pressure reduction in the treatment of normal-tension glaucoma. Collaborative initial normal-tension glaucoma study group. Am J Ophthalmol. 1998;126(4):498-505. https://doi.org/10.1016/s0002-9394(98)00272-4
   PMid:9780094
8. The Advanced Glaucoma Intervention Study (AGIS): 7. The relationship between control of intraocular pressure and visual field detoriation. AGIS Investigators. Am J Ophthalmol. 2000;130(4):429-40. https://doi.org/10.1016/s0002-9394(00)00538-9
   PMid:11024415
9. Lewis RA, von Wolff K, Tetz M, Koerber N, Kearney JR, Shingleton BJ, *et al*. Canaloplasty: Circumferential viscodilation and tensioning of Schlemm's canal using a flexible microcatheter for the treatment of open-angle glaucoma in adults: Interim clinical study analysis. J Cataract Refract Surg. 2007;33(7):1217-26. https://doi.org/10.1016/j.jcrs.2007.03.051
   PMid:17586378
10. Lewis RA, von Wolff K, Tetz M, Koerber N, Kearney JR, Shingleton BJ, et al. Canaloplasty: Circumferential viscodilation and tensioning of Schlemm's canal using a flexible microcatheter for the treatment of open-angle glaucoma in adults: Two-year interim clinical study results. J Cataract Refract Surg. 2009;35(5):814-24. https://doi.org/10.1016/j.jcrs.2009.01.010
    PMid:19393879
11. Brandao LM, Schötzau A, Grieshaber MC. Suture distension of Schlemm's canal in canaloplasty: An anterior segment imaging study. J Ophthalmol. 2015;2015:7. https://doi.org/10.1155/2015/457605
12. Mastropasqua L, Agnifili L, Salvetat ML, Ciancaglini M, Fasanella V, Nubile M, *et al*. *In vivo* analysis of conjunctiva in canaloplasty for glaucoma. Br J Ophthalmol. 2012;96(5):634-9. https://doi.org/10.1136/bjophthalmol-2011-301058
    PMid:22296832
13. Lewis RA, von Wolff K, Tetz M, Koerber N, Kearney JR, Shingleton BJ, *et al*. Canaloplasty: Three-year results of

circumferential viscodilation and tensioning of Schlemm canal using a microcatheter to treat open-angle glaucoma. J Cataract Refract Surg. 2011;37(4):682-90. https://doi.org/10.1016/j.jcrs.2010.10.055

PMid:21420593

14. Grieshaber MC, Fraenkl S, Schoetzau A, Flammer J, Orgül S. Circumferential viscocanalostomy and suture canal distension (canaloplasty) for whites with open-angle glaucoma. J Glaucoma. 2011;20(5):298-302. https://doi.org/10.1097/ijg.0b013e3181e3d46e

    PMid:20577106

15. Grieshaber MC, Pienaar A, Olivier J, Stegmann R. Canaloplasty for primary open-angle glaucoma: Long-term outcome. Br J Ophthalmol. 2010;94(11):1478-82. https://doi.org/10.1136/bjo.2009.163170

    PMid:20962352

16. Ayyala RS, Chaudhry AL, Okogbaa CB, Zurakowski D. Comparison of surgical outcomes between canaloplasty and trabeculectomy at 12 months follow-up. Ophthalmology. 2011;118(12):242733. https://doi.org/10.1016/j.ophtha.2011.05.021

    PMid:21856008

17. Brüggemann A, Despouy JT, Wegent A, Müller M. Intraindividual comparison of canaloplasty versus trabeculectomy with mitomycin C in a single-surgeon series. J Glaucoma. 2013;22(7):577-83. https://doi.org/10.1097/ijg.0b013e318255bb30

    PMid:23632395

18. Matlach J, Dhillon C, Hain J, Schlunck G, Grehn F, Klink T. Trabeculectomy versus canaloplasty (TVC study) in the treatment of patients with open angle glaucoma: A prospective randomized clinical trial. Acta Ophthalmol. 2015;93(8):753-61. https://doi.org/10.1111/aos.12722

    PMid:25847610

19. Cagini C, Peruzzi C, Fiore T, Spadea L, Lippera M, Lippera S. canaloplasty: Current value in the management of glaucoma. J Ophthalmol. 2016;2016:7080475. https://doi.org/10.1155/2016/7080475

    PMid:27239337

20. Brusini P. Canaloplasty in open-angle glaucoma surgery: A four-year follow-up. ScientificWorldJournal. 2014;2014:7. https://doi.org/10.1155/2014/469609

    PMid:24574892

21. Mansouri K, Tran HV, Ravinet E, Mermoud A. Comparing deep sclerectomy with collagen implant to the new method of very deep sclerectomy with collagen implant: A single-masked randomized controlled trial. J Glaucoma. 2010;19(1):24-30. https://doi.org/10.1097/ijg.0b013e3181a2fa46

    PMid:19373103

22. Palmiero PM, Aktas Z, Lee O, Tello C, Sbeity Z. Bilateral descemet membrane detachment after canaloplasty. J Cataract Refract Surg. 2010;36(3):508-11. https://doi.org/10.1016/j.jcrs.2009.08.039

    PMid:20202554