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# Efficacy and Safety of Deep Sclerectomy With the Esnoper Clip Implant for Uncontrolled Primary Open Angle Glaucoma: A 1 Year Prospective Study

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**Précis:** Deep sclerectomy (DS) with the Esnoper Clip drainage implant in patients with uncontrolled primary open angle glaucoma (POAG) achieved a complete success rate of 87.2% at the 1-year follow-up.

**Purpose:** To investigate the efficacy and safety of DS followed by Esnoper Clip implantation in patients with uncontrolled POAG.

**Materials and Methods:** In a prospective, consecutive, interventional study, we investigated 39 eyes of 35 patients with uncontrolled POAG who underwent DS with Esnoper Clip implantation. Complete ophthalmologic examinations including corrected visual acuity and intraocular pressure (IOP), were performed preoperatively, and at 1 day, at 1 week as well as at 1, 3, 6, 9, and 12 months postoperatively. Moreover, any goniopunctures and glaucoma medications required postoperatively were noted.

**Results:** The mean preoperative IOP was $20.8 \pm 5.2$ mm Hg and it decreased to $13.9 \pm 3.1$ mm Hg at 1 year postoperatively ($P < 0.001$). The number of glaucoma medications decreased from $2.9 \pm 0.7$ preoperatively to $0.3 \pm 0.8$ after 1 year ($P < 0.001$). The complete success rate (IOP $\leq$ 21 mm Hg without glaucoma medication) and the qualified success rate (IOP $\leq$ 21 mm Hg with or without glaucoma medication) were 87.2% and 94.9%, respectively. Goniopuncture was performed in 33.3% of cases. No significant corrected visual acuity changes were registered at the final follow-up. Perioperative complications consisted of 3 micro-perforations of the trabeculo-descemet membrane. Postoperative complications included: hyphema (6 eyes), hypotony (6 eyes), shallow anterior chamber (3 eyes), choroidal detachment (4 eyes)—all of which were resolved without surgical intervention during the first postoperative month—and conjunctival dehiscence, which required resuture (2 eyes).

**Conclusion:** Deep sclerectomy with the Esnoper Clip implant was safe and effectively lowered IOP in patients with uncontrolled POAG.

**Key words:** deep sclerectomy, Esnoper Clip, suprachoroidal space, primary open angle glaucoma

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Glaucoma is a progressive, multifactorial, neurodegenerative disease characterized by optic-disc and retinal-nerve fiber layer morphologic changes, followed by irreversible visual-field impairment.[1] It represents the second leading cause of blindness today and affects 2% of the population worldwide.[1–3] Primary open angle glaucoma (POAG) is the most common form of glaucoma, especially in people of European and African descent.[1] Increased intraocular pressure (IOP) is the main risk factor responsible for the development and progression of glaucoma.[3] Therefore, the only effective glaucoma treatment is IOP reduction, as this is currently the only modifiable risk factor.[1,3] Trabeculectomy (TE) has been considered the standard filtration technique for glaucoma since it was first introduced by Cairns in 1968.[4] Nevertheless, the procedure is plagued by a significant number of complications in the immediate postoperative period, including hyphema, hypotony with or without maculopathy, shallow or flat anterior chamber, serous or hemorrhagic choroidal detachment, uveal reaction, endophthalmitis, and cataract formation.[5,6] Modern ophthalmology has focused on finding a solution that improves upon this gold-standard procedure with a safer profile, yet similar efficiency in IOP control.[7] Thus, in the 1990s, Fyodorov and Kozlov[8] proposed an improved technique of nonpenetrating glaucoma surgery called deep sclerectomy (DS) as an alternative to TE. DS is a filtration technique in which IOP is decreased by reducing the resistance to drainage of aqueous humor, which is abnormally elevated in glaucoma patients. DS creates a trabeculo-descemet window by removing the deep scleral flap and the corneal stroma. This allows gradual aqueous filtration through the thin trabeculo-descemet membrane (TDM) and thus prevents dangerously rapid IOP decreases.[7,8] Due to the fact that DS preserves the integrity of the anterior chamber, it offers the advantage of superior filtration control and therefore reduces the occurrence of perioperative and postoperative complications (eg, hypotonia, flat anterior chamber, and choroidal detachment). An increase in surgical experience and marked technological development in recent years has led to the use of a variety of drainage

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implants, which have significantly increased the mid-term and long-term efficiency of DS.[9–29] These devices have generally been implanted on the scleral bed, but their placement in the supraciliary space promises an effective alternative treatment for greater postoperative IOP reduction.[30–34] Historically, Dr Kozlov and colleagues first introduced the concept of using drainage implants in DS in 1989.[14] The first space-maintaining device developed was a purified porcine collagen AquaFlow implant (Staar Surgical AG), which was absorbed within 6–9 months.[10,15] According to Shaarawy et al[12] and Sanchez et al,[15] the IOP levels, the need for postoperative antiglaucoma therapies, and postoperative bleb fibrosis were all significantly lower with the use of a collagen implant at both short-term and long-term follow-ups. The next generation of implants focused on the use of the various rheological properties of sodium hyaluronate derivates to preserve the intrascleral filtering space postoperatively.[16–18] Thus, biodegradable materials for implants with a slow absorption rate were introduced, such as a reticulated hyaluronic acid (SK-gel, Corneal Laboratories), a highly cross-linked sodium hyaluronate (HealaFlow, Anteis), and a viscoelastic agent (Healon 5 and Healon GV, Pharmacia-Upjohn).[16–19] However, one of the main disadvantages of this collagen or hyaluronic acid-based resorbable implants was the risk of the collapse of the intrascleral draining space due to fibrosis caused by the postoperative gradual degradation of the device over time.[11,18,20] Thus, over the subsequent years, nonabsorbable implants were developed to provide a permanent filtering intrascleral space while minimizing the adhesion of the scleral bed to the scleral flap.[19,21,22] Among the first nonabsorbable drainage devices marketed were the rigid implant Homdec (Homdec SA) made of polymethyl methacrylate and the highly hydrophilic, flexible acrylic implant T-flux (IOLTECH Laboratoires).[19,21–24] Another implant that belongs to the new generation of nonabsorbable devices is the Esnoper V2000 (AJL Ophthalmic) which is made of 2-hydroxyethyl methacrylate (HEMA).[25,35,36] The Esnoper V2000 represents the second generation of this model and has been improved with internal channels to facilitate aqueous humor flow through the device and also with lateral notches for nonsuture supraciliary placement.[35] A related nonabsorbable drainage device specially designed for supraciliary implantation is the foldable HEMA implant Esnoper Clip (AJL Ophthalmic). It was first implanted by Dr Loscos-Arenas at the Hospital Germans Trias i Pujol, Barcelona, Spain in 2011.[31,32] This newer implant is equipped with 2 plates of which one is placed on the scleral bed and the other in the supraciliary space. The shape of the implant has been designed to preserve the patency of the intrascleral and suprachoroidal spaces and to maximize both aqueous-humor drainage pathways long after surgery.[32] Unfolded, the Esnoper Clip is 5.5 mm in length, of which the lamella designed for scleral implantation measures 3.0 mm and the plate for supraciliary implantation 2.5 mm.[30] Its minimum width is 1.3 mm, while its thickness is 0.1–0.2 mm (Fig. 1). No study comparing the clinical efficacy of the Esnoper V2000 with the Esnoper Clip implant has been published to date. The superiority of the Esnoper Clip implant can be theoretically argued by the newer design of the implant, which is made with 2 plates, ensuring a larger filtering surface compared with the Esnoper V2000, which has only 1 plate. The 2 plates of the Esnoper Clip device increase the outflow capacity of aqueous humor and simultaneously reduce the risk of the fibrotization of these 2 filtering spaces (intrascleral and suprachoroidal). Thus, the theoretical potential for lowering IOP in the postoperative period is increased. Both implants are fully covered by Czech national health insurance for all patients and there are no price differences between them.

Regarding DS with intrascleral device implantation, current comparative studies are insufficient to prove the superiority of a specific drainage implant.[22,23,25] The reported success rates vary, due to the different surgical methods used, as well as due to differences in the success criteria. As for DS outcomes with suprachoroidal implantation of a nonabsorbable drainage device (T-flux), the first results were reported by Muñoz[34] in 2009. In that study, the author highlighted the potential benefits of this surgical technique, such as the advantage of suprachoroidal implant

**FIGURE 1.** Photographs of the Esnoper Clip, folded and unfolded. *Source*: AJL Ophthalmic, A´lava, Spain.

fixation without sutures and the increase in uveoscleral outflow through direct aqueous humor access to the suprachoroidal space. To our knowledge, our current study is the first DS study performed with the Esnoper Clip implant, which is a device specially designed for suprachoroidal implantation, in a homogeneous group of patients with POAG and without perioperative or postoperative use of any antifibrotic agents. The purpose of this paper is to report on the safety and efficacy of DS with the Esnoper Clip implant in patients with uncontrolled POAG at the 1-year follow-up.

## MATERIALS AND METHODS

This prospective, consecutive, interventional case series included a total of 39 eyes of 35 patients with uncontrolled POAG recruited between November 2017 and April 2020 from the Glaucoma Department of Královské Vinohrady Teaching Hospital, 3rd Faculty of Medicine, Charles University in Prague. The inclusion criteria were: patients without a history of previous filtration surgery who suffered from uncontrolled POAG where DS was the primary glaucoma procedure indicated. POAG is a chronic progressive and irreversible optic neuropathy characterized by optic nerve-rim and retinal-nerve fiber-layer loss, followed by visual-field loss associated with glaucomatous morphologic changes. These changes take place in the presence of open angles and the absence of other explanations for the pathologic changes to the optic nerve head. The risk of developing the disease rises with the level of IOP and with increasing age.[1,3] Uncontrolled POAG was defined as the progression of structural and functional optic nerve head glaucoma changes, given the maximum medical treatment tolerated by the patient, regardless of the IOP values recorded. Those patients with a history of previous laser trabeculoplasty procedures (including those which were uncomplicated) or of glaucoma surgeries were excluded from this study. This guarantees subject uniformity in our study, which included only eyes without structural changes in the trabecular meshwork or the iridocorneal angle due to these filtration procedures. Also, we excluded patients with a history of eye surgery including cataract surgery which occurred <6 months before the DS with Esnoper Clip. All procedures within the study followed the tenets of the Declaration of Helsinki, and the approval of the Institutional Ethical Review Board was obtained for all procedures undertaken. Written informed consent was obtained from all patients. All the included surgical procedures were performed by the same experienced surgeon (P.S.) and the uveoscleral implant Esnoper Clip (AJL Ophthalmic) was implanted in all participating patients. The surgeries were carried out under subconjunctival anesthesia with Lidocaine; the conjunctiva was opened 4 mm from the limbus and the eye was fixated by suturing the prepared conjunctiva with Silk 4/0 stitch on the eyelid speculum. Subsequently, dissection of the superficial and deep scleral flaps in a square shape was carried out. Preparation of a superficial scleral lamella of $4 \times 4$ mm at a depth of approximately one third of the thickness of the sclera followed. The superficial scleral dissection was extended 1.5–2 mm through the limbus into the clear cornea. Preparation and resection of a deep scleral lamella of $3 \times 3$ mm followed. Then the Schlemm canal endothelium was peeled off with capsular forceps. Further, ~1.5–2 mm behind the scleral spur, a suprachoroidal pocket was created in which the part of the implant provided with lateral fixation cut-outs was placed. At this point, one part of the implant remained in the suprachoroidal space and the other part on the scleral bed (Fig. 2). No implant included in this study was fixed to the scleral bed by suturing. We sutured the scleral lamella loosely using Vicryl 8/0 absorbable stitches. At the end of the surgery, the Tenon membrane and the conjunctiva were sutured separately with continuous absorbable stitches, also Vicryl 8/0. None of the patients in this study received antimetabolites, such as Mitomycin C (MMC) or 5-Fluorouracil (5-FU), or a wound healing modulator, such as the collagen matrix implant (Ologen) during or after the surgery. Postoperatively, all patients were prescribed a suspension of topical antibiotics and steroids (3 mg/mL tobramycine, 1 mg/mL dexamethasone, Alcon Pharmaceuticals s.r.o.) 5 times daily for 2 weeks and cycloplegics (4% homatropine hydrobromide) when necessary. Afterwards therapy was continued through mild steroids (0.1% fluorometholone acetate; Alcon-Couvreur n.v.) for 10 weeks. Preoperatively and at all follow-up visits, the patients received a complete slit-lamp examination including a corrected distance visual acuity (BCVA) evaluation and an IOP evaluation. IOP was measured on the first day, at 1 week after surgery, and at 1, 3, 6, 9, and 12 months postoperatively. The IOP measurements were performed by a glaucoma specialist (A.-D.B. or J.B.) in the Glaucoma Department of Královské Vinohrady Teaching Hospital at a consistent period of the day (in the morning), using a calibrated Goldmann tonometer (Zeiss AT 020, Carl Zeiss Meditec AG). The mean of 3 consecutive measurements in which the difference between the measurements not greater than 1 mm Hg was noted.

Any postoperative goniopuncture required and any glaucoma medication required were noted. Goniopuncture was indicated and performed with an Nd:YAG Ellex UltraQ Reflex laser (Ellex Deutschland GmbH) in eyes in which the individual IOP target was not reached or when the IOP was $>21$ mm Hg without glaucoma medication and also when a significant POAG progression was detected.

Also, we evaluated for the following perioperative and postoperative complications: TDM perforation (which occurred intraoperatively during the corneal stroma dissection); postoperative complications such as hypotony (when IOP $\leq 5$ mm Hg), hyphema (when pooling of erythrocytes in the anterior chamber was present), shallow anterior chamber (when iridocorneal touch was detected in the periphery) and choroidal detachment (which was detected by fundus biomicroscopy) and for other complications such as malignant glaucoma, uveal reaction, endophthalmitis, or retinal detachment. According to The World Glaucoma Association (WGA), complete success (CS) was defined as a postoperative IOP of $\leq 21$ mm Hg without additional glaucoma medication and qualified success (QS) was classified as an IOP of $\leq 21$ mm Hg achieved with or without glaucoma medication. Failure was defined as: an IOP value of $>21$ or $<6$ mm Hg, confirmed at 2 consecutive follow-ups; required additional glaucoma surgery or/and a loss of light perception. Additional glaucoma surgery was defined as any glaucoma procedure carried out in the operating theater as an open bleb revision (except needling), such as TE or other types of incisional glaucoma surgeries. The primary outcomes of our study were: (1) IOP decreases throughout all follow-

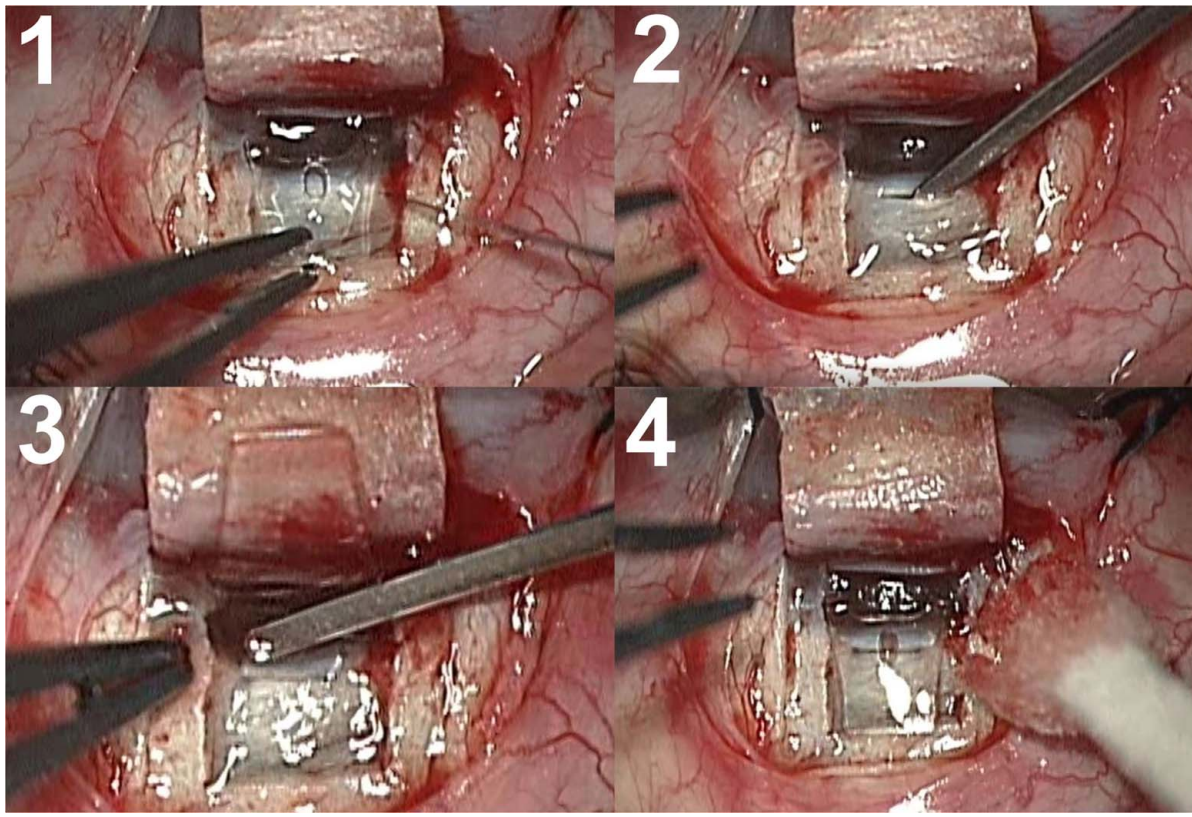


**FIGURE 2.** Photographs showing Esnoper Clip implantation: (1) the scleral bed incision ~1.5–2 mm behind the scleral spur, (2) the suprachoroidal pocket formation, (3) the lamella of the implant provided with lateral fixation cut-outs is placed in the suprachoroidal pocket, (4) the other plate of the Esnoper Clip remaining on the scleral bed.

ups, (2) the CS and QS rates at 1 year after surgery, and (3) the proportion of cases that needed adjacent interventions, such as laser goniopuncture or glaucoma medication. The need for adjacent intervention was indicated by: a postoperative IOP level of $>21$ mm Hg without glaucoma medication, or by exceeding the patient's individual IOP target, or by a structural and/or functional POAG progression regardless of the individual IOP value. The secondary outcomes included BCVA and the number of intraoperative and postoperative complications registered.

## Statistical Analysis

The observed quantitative variables [IOP, BCVA, and number of glaucoma therapies (nAGT)] are given as means and SDs. As BCVA and nAGT did not fulfil the normal distribution conditions, medians, quartile 1 to quartile 3 [interquartile ranges (IQR)] and minimum to maximum ranges were added. These characteristics were calculated for all observed time intervals (ie, follow-up visits). Statistical analysis of the normally distributed variable (IOP) was carried out using the analysis of variance (ANOVA) with repeated measurements following the multiple comparison post hoc Bonferroni method to compare the measured values of IOP among all observed time intervals. For the comparison of skewed variables among all time intervals (BCVA and nAGT) we used the nonparametric Kruskal-Wallis ANOVA with multiple comparisons of mean ranks. For the ANOVA, the required sample size was calculated. Finally, Kaplan-Meier survival analysis was used to calculate the 1-year CS and QS rates. Statistical analysis was performed through the program IBM SPSS Statistics version 15.0 (SPSS Inc.). To calculate the required sample size, the program G*Power 3.1.9.4 (Universität Kiel, Germany) was used. A $P$-value $<0.05$ was considered to be statistically significant.

## RESULTS

The mean age of the patients was $68.6 \pm 11.4$ years, with a range between 39 and 87 years. Male (eyes)/female (eyes) ratio: 12 (12)/23 (27); 16 right eyes and 23 left eyes; $n = 39$. Of a total of 39 eyes enrolled, there were 20 eyes with a history of uneventful clear cornea phacoemulsification with posterior intraocular lens implantation (12 females and 8 males, averaging more than 4 y between the cataract surgery and our procedure).

The required sample size for ANOVA with repeated measurements [for $\alpha = 0.05$, power of test $1-\beta = 0.80$, number of groups (time intervals) $= 8$ and effect size $d = 0.25$ (medium effect)] was 240 eyes. The total number of our patients meets the conditions for the required sample size, as our total eyes revisited is equal $8 \times 39 = 312$. The mean IOP was initially $20.8 \pm 5.2$ mm Hg (min. 13 mm Hg, max. 37 mm Hg). However, there were 5 eyes with low preoperative IOPs (13–15 mm Hg) who underwent DS with Esnoper Clip due to significant POAG progression with maximal tolerated glaucoma therapy (2.8 drugs in mean). IOP was significantly reduced in all follow-up periods ($P < 0.001$) from $20.8 \pm 5.2$ mm Hg preoperatively to $6.9 \pm 2.6$ mm Hg at 1 day postoperative, $8.4 \pm 4.3$ mm Hg at

1 week, 12.1 ± 3.3 mm Hg at 1 month, 11.9 ± 2.6 mm Hg at 3 months, 12.1 ± 2.8 mm Hg at 6 months, 13.6 ± 3.8 mm Hg at 9 months, and 13.9 ± 3.1 mm Hg (min. 9 mm Hg, max. 22 mm Hg) at 1 year after surgery (Fig. 3). The gaps in IOP mean reduction were statistically insignificant between the first-, third- and sixth-month follow-ups, and between the ninth and 12-month follow-ups ($P > 0.05$). Furthermore, we did not observe any statistical difference between phakic and pseudophakic eyes, as at the end of the follow-up period, they demonstrated a similar IOP decrease and also a similar reduction in glaucoma medication required ($P > 0.05$). The number of glaucoma medications significantly decreased in all postoperative periods ($P < 0.001$) from 2.9 ± 0.7 drugs prescribed preoperatively [median, 3 (IQR, 3–3)] to: no antiglaucoma drugs prescribed at 1 day, at 1 week, and at 1 month postoperatively; 0.1 ± 0.3 drugs prescribed at 3 months postoperatively [median, 0 (IQR, 0–0)]; 0.1 ± 0.4 drugs prescribed at 6 months [median, 0 (IQR, 0–-0)]; 0.1 ± 0.5 drugs prescribed at 9 months [median, 0 (IQR, 0–0)]; and 0.3 ± 0.8 drugs [median, 0 (IQR, 0–0)] prescribed at 1 year (Table 1). The differences in the use of antiglaucoma drugs were statistically insignificant when comparing all postoperative follow-up periods ($P > 0.05$). The decrease in glaucoma medications was 2.6 drugs in mean as of the last follow-up, representing a reduction of almost 90% compared with the preoperative period ($P < 0.001$).

At 1 year after surgery, the CS rate was 87.2% (34 of 39 eyes) and the QS rate was 94.9% (37 of 39 eyes) with IOP at ≤ 21 mm Hg. Figure 4 shows the Kaplan-Meier survival curves, plotting the cumulative probabilities against time that the IOP remains ≤ 21 mm Hg without additional glaucoma medication (CS) and that the IOP remains ≤ 21 mm Hg with or without additional glaucoma medication (QS). No patient dropped out during the follow-up periods of our study.

Nd:YAG goniopuncture was performed in 13 eyes, representing 33.3% of all studied cases. Thus, at 3 months after surgery, goniopuncture was undertaken in 2.6% of eyes, at 6 months in 7.7% eyes, and at 9 and 12 months in 23.1% and 33.3% of eyes, respectively. Moreover, no patient required bleb needling postoperatively or additional glaucoma incisional surgeries. Seven eyes (17.9%) met the criteria for surgical failure at certain points of follow-up. Of these, 6 eyes recorded an IOP < 6 mm Hg, at 1 day and 1 week after surgery and 1 eye had an IOP value > 21 mm Hg at 9 and 12 months postoperatively. The BCVA mean dropped from 0.9 ± 0.2 [median, 1.0 (IQR, 0.6–1.0)] preoperatively to 0.4 ± 0.3 [median, 0.5 (IQR, 0.3–0.6)] during the first postoperative day. Beginning with the first postoperative week BCVA achieved a value of 0.7 ± 0.2 [median, 0.6 (IQR, 0.6–1.0)], and beginning with the first postoperative month, it gradually returned to preoperative values and remained stable. Six perioperative complications were recorded as follows: in 3 cases, TDM perforation occurred, followed by iris prolapse, and in those eyes, DS was converted to TE. In 3 other cases, insignificant TDM microperforation was registered. The cases which required TE were excluded from the statistical analysis. With regard to postoperative complications, we noted the presence of hyphema in 6 eyes, hypotony (2–5 mm Hg) in 6 eyes, a shallow anterior chamber in 3 eyes, choroidal detachment in 4 eyes—all of which resolved during the first month without surgical intervention—and conjunctival dehiscence, which required resuture in 2 eyes. On the other hand, we did not encounter any case of retinal detachment, postoperative uveal reaction or endophthalmitis.

## DISCUSSION

Despite the fact that TE is an effective treatment to decrease IOP, most surgeons prefer to delay surgery and to perform it only in the advanced stages of glaucoma, due to the high rate of complications occurring perioperatively and postoperatively.[5,10,12,23]

TE is a filtration procedure which implies anterior chamber penetration and the removal of the full-thickness of the trabecular meshwork.[20,26,37–39] The resulting sclerostomy formation allows aqueous humor to drain from the anterior chamber into the subconjunctival space, forming a conjunctival filtering bleb.[38,39] This procedure is the longest-lived filtration surgery and has, over time, become the gold standard in the treatment of glaucoma.[26,37–42] Although in the last few decades TE has undergone some changes

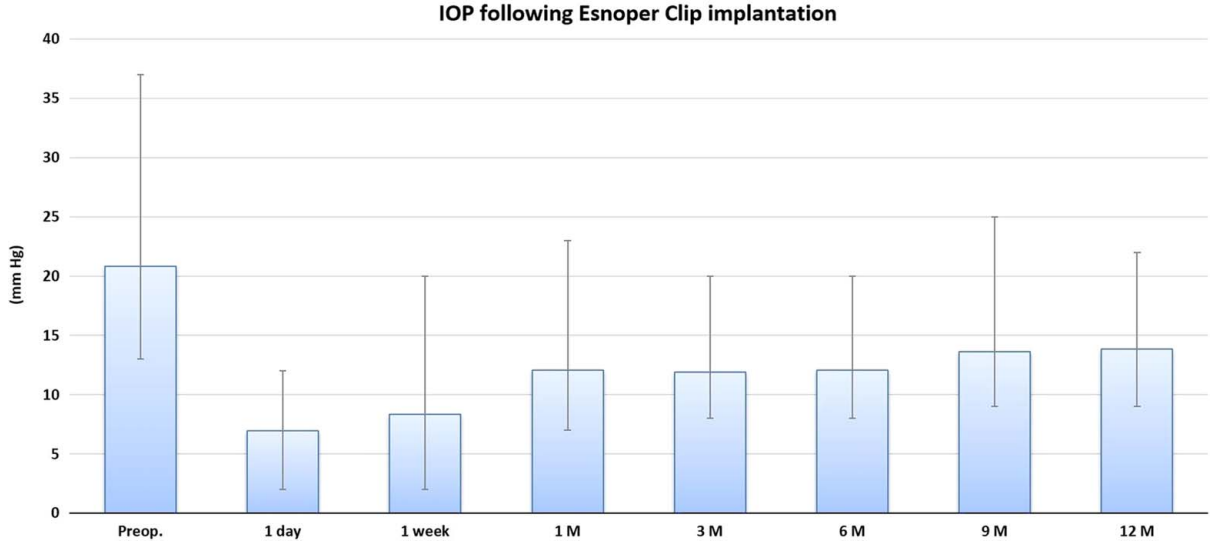


**FIGURE 3.** A graph showing IOP reduction at 1 day, 1 week, 1 month (1 M), 3 months (3 M), 6 months (6 M), 9 months (9 M), and 12 months (12 M) postoperatively compared with preoperative values (preop.). IOP indicates pressure.

 

**TABLE 1.** Preoperative and Postoperative Data From DS With Esnoper Clip Implantation; *P*-values of Post Hoc Bonferroni Multiple Comparison Test Always Between Preoperative and Specific Time Interval; Number of Studied Eyes n = 39

| Time Interval | Mean IOP ± SD (mm Hg) | Median IOP (Q1–Q3) (Min.–Max.) | Mean nAGT ± SD | Median nAGT (Q1–Q3) (Min.–Max.) | *P* | Goniopuncture (%) |
|---|---|---|---|---|---|---|
| Preoperatively | 20.8 ± 5.2 | 21 (17–23) (13–37) | 2.9 ± 0.7 | 3 (3–3) (1–4) | NA | NA |
| 1 d postoperatively | 6.9 ± 2.6 | 7 (5–9) (2–12) | 0 | 0 (0–0) (0–0) | < 0.001 | 0 |
| 1 wk postoperatively | 8.4 ± 4.3 | 7 (5–11) (2–20) | 0 | 0 (0–0) (0–0) | < 0.001 | 0 |
| 1 M postoperatively | 12.1 ± 3.3 | 12 (10–14) (7–23) | 0 | 0 (0–0) (0–0) | < 0.001 | 0 |
| 3 M postoperatively | 11.9 ± 2.6 | 11 (10–13) (8–20) | 0.1 ± 0.3 | 0 (0–0) (0–2) | < 0.001 | 2.6 |
| 6 M postoperatively | 12.1 ± 2.8 | 11 (10–13) (8–20) | 0.1 ± 0.4 | 0 (0–0) (0–2) | < 0.001 | 7.7 |
| 9 M postoperatively | 13.6 ± 3.8 | 13 (11–15) (9–25) | 0.1 ± 0.5 | 0 (0–0) (0–2) | < 0.001 | 23.1 |
| 12 M postoperatively | 13.9 ± 3.1 | 13 (12–15) (9–22) | 0.3 ± 0.8 | 0 (0–0) (0–4) | < 0.001 | 33.3 |

DS indicates deep sclerectomy; IOP, intraocular pressure; M, month; Max., maximum; Min., minimum; nAGT, the number of antiglaucoma therapies; NA, not applicable; Q1, quartile 1; Q3, quartile 3.

intended to improve its safety profile, the procedure is still plagued by a rather high percentage of postoperative complications including hyphema, shallow anterior chamber, hypotony, cataract formation, choroidal detachment, and endophthalmitis.[19,26] In an effort to minimize the risk of complications which often follow TE, various nonperforating antiglaucoma treatments have been developed, including DS.[26,43] The major advantage of DS is that it prevents damage to the trabecular meshwork and thus preserves the integrity of the anterior chamber.[43] As a result, it promotes

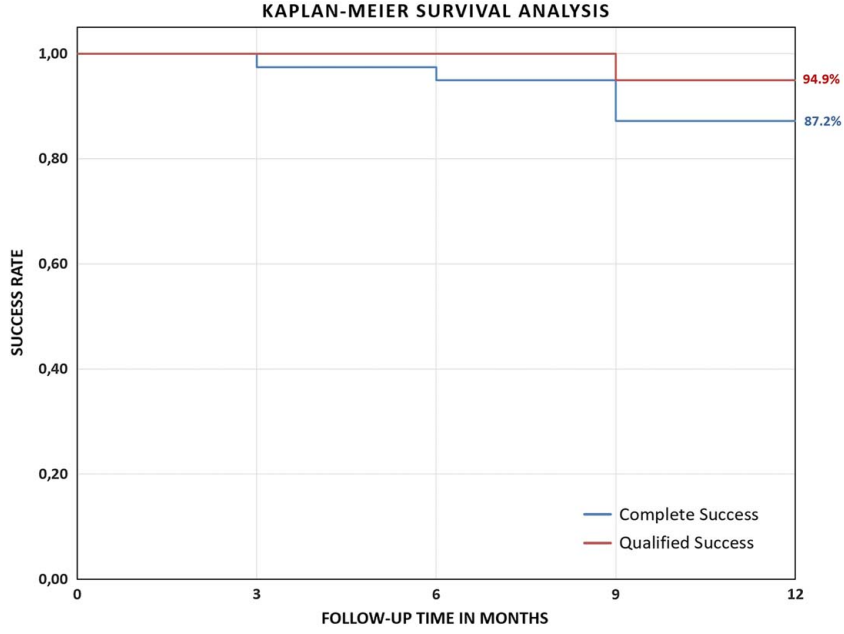


**FIGURE 4.** The Kaplan-Meier survival curve of the complete success rate (without glaucoma medication) and of the qualified success rate (with or without glaucoma medication) for intraocular pressure ≤ 21 mm Hg.

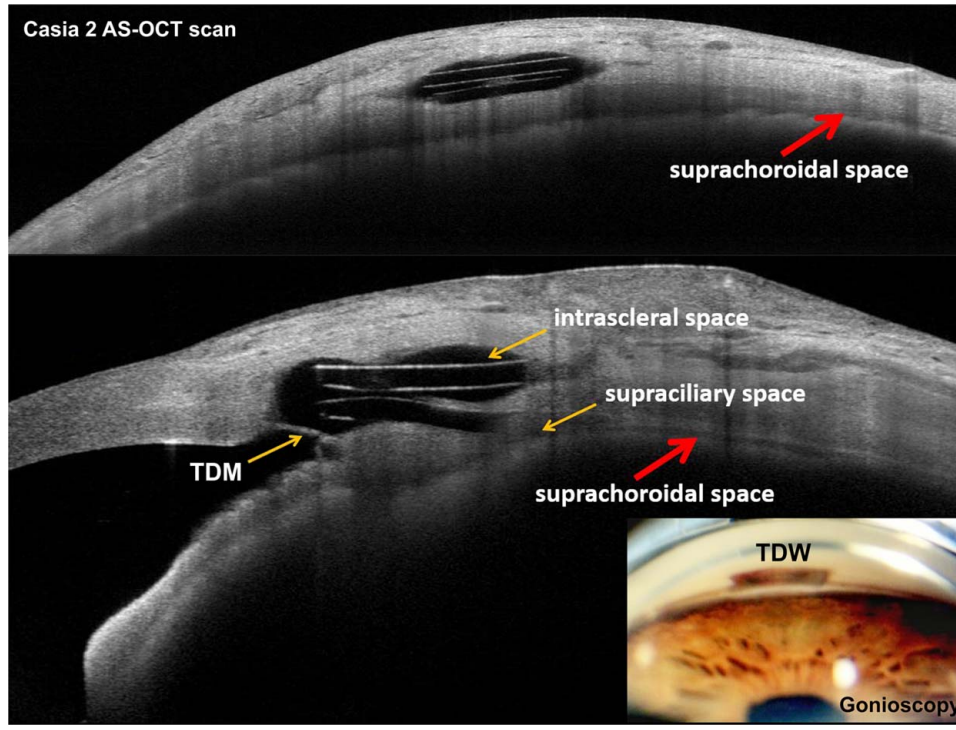


**FIGURE 5.** Photographs of the Esnoper Clip implant with anterior segment OCT (Tomey Casia 2 AS-OCT) and the gonioscopic image of the trabeculo-descemet window with slit-lamp camera module SL 220 (Carl Zeiss Meditec AG). TDM indicates trabeculo-descemet membrane; TDW, trabeculo-descemet window.

the progressive filtration of aqueous humor from the anterior chamber to the subconjunctival space without penetrating the eye.[27–29,44–46] Various studies have shown that although DS is less efficient than TE, it has a superior safety profile.[26,37–40] Its primary drawback is that it is not as widely undertaken by surgeons due to the difficulty of the technique and the long learning curve it requires.[10,28,38] The safety of the procedure is strengthened by the outflow dynamics through the TDM. Thus, Mermoud and Vaudaux[45] experimentally demonstrated that outflow resistance through the TDM was low but sufficient to avoid over-filtration and postoperative hypotony. The use of implants has been shown to have a positive influence, increasing the efficiency of the surgery and reducing the complication rate. Drainage implants act as flow controllers and space maintainers as well as healing modulators, reducing the risk of scleral fibrosis.[9–21,27–31,44] The suprachoroidal implantation of drainage devices appears to improve DS reducing IOP by decreasing aqueous production due to a certain detachment of the ciliary body or by increasing the choroidal resorption of aqueous humor.[31,35] While the trabecular outflow pathway, which involves a subconjunctival bleb formation, has been studied for several years, lately attention has been directed to the uveoscleral pathway, which involves aqueous bleb-less drainage.[47] This has meant a lower risk of DS failure with uveoscleral implants compared with scleral devices, due to increased aqueous outflow through the suprachoroidal pathway and also due to the lower rate of complications related to the subconjunctival bleb.[33,47] On the other hand, a significant limiting factor in the long-term success of DS with uveoscleral implants is the inflammatory potential of the suprachoroidal region characterized by significant cell infiltration and fibrosis.[33,47,48] This deficiency could be resolved by using materials with better modulation of biological responses, inducing minimal tissue reaction and scarring, especially in the suprachoroidal region.[47] According to Loscos-Arenas et al,[31] another important factor in the success rate for this surgery is implant design. Thus, the avoidance of implants that induce secondary fibrosis or TDM obstruction due to device displacement over the TDM is recommended. In the present study we used the Esnoper Clip, which is a nonabsorbable implant made from HEMA, a nonionic polymer with a low tendency for protein deposits. The implant employs a double-plate design, which simultaneously facilitates both trabecular and uveoscleral drainage and also ensures the maintenance of both spaces, avoiding their collapse over time (Figs. 2, 5). In general, DS success rates vary depending on multiple factors, such as the type of implant, the surgical protocol and the specific criteria used for defining absolute success. As such, the mid-term CS rate of DS using a collagen implant was reported by Demailly et al[46] (ie, IOP $\leq$ 20 mm Hg without medication) to be 83% at 12 months postoperatively. The long-term CS rate of DS with a collagen device was demonstrated by Shaarawy et al[12,28] (ie, IOP $\leq$ 21 mm Hg, IOP $<$ 21 mm Hg without medication) to be favorable at 48 and 96 months after surgery, reaching 63.4% and 57%, respectively; as well as by Bissig et al[29] (ie, IOP $\leq$ 21 mm Hg without medication) reaching 47.7% at 10 years postoperatively. Furthermore, a CS rate (ie, IOP $\leq$ 18 mm Hg without medication) of 85% at the 1-year follow-up in DS using a nonabsorbable T-flux implant was reported by Studeny et al.[13] Romera-Romero et al[32] reported a CS rate for DS using the nonabsorbable implant Esnoper Clip (ie, IOP $\leq$ 18 mm Hg and $\geq$ 20% IOP reduction, without medication) of 68.3% at 12 months and 61.1% at 2 years postoperatively.

Like all surgeries, DS is accompanied by a certain failure rate, which is directly influenced by the level of preoperative IOP.[42] Therefore—and we noticed the same trend in our study—the higher the preoperative IOP, the worse the prognosis for long-term IOP control.

Consistent with the findings of Vieira et al,[30] Loscos-Arenas et al,[31] and Romera-Romero et al,[32] we achieved a statistically significant IOP reduction after DS with the Esnoper Clip implant throughout all postoperative periods. However, the IOP decrease at follow-ups was greater in those studies compared with our results, which can be explained by their perioperative use of MMC. For example, in their study of 5 eyes with uncontrolled open angle glaucoma (OAG) which underwent DS with Esnoper Clip implantation, Vieira et al[30] found that postoperative hypotonia occurred only in 1 patient, in whom MMC was used perioperatively. To our best knowledge, there are no clinical studies available to date proving the superior efficiency of antifibrotic agents (MMC/5-FU or Ologen) used in DS with the Esnoper Clip implant compared with DS with the Esnoper Clip alone. Therefore, in our practice we do not use antimetabolites in DS with the Esnoper Clip as a rule. Also, in our cost-benefit analysis, the side effects and the risk of postoperative hypotonia after using antimetabolites especially in those patients with relatively lower preoperative IOP was too substantial. Moreover, the uniformity of the study subjects was of secondary value. Thus, our study brings useful informations regarding the effectiveness of DS with Esnoper Clip without the use of antifibrotic substances. Also, our results can be informative primarily with regard to patients with relatively low preoperative IOPs and in whom the use of antimetabolites (MMC, 5-FU) or wound healing modulator agents (Ologen) may pose a risk of irreversible and vision-threatening complications induced by a relatively high probability of postoperative hypotonia.

Moreover, in the Romera-Romero et al study,[32] 39% of DSs were combined with phacoemulsification, which may lead to a greater IOP reduction postoperatively.

On the other hand, our study registered lower IOP levels compared with Loscos-Arenas et al[31] and Romera-Romero et al[32] overall, in both preoperative and postoperative periods. This can be explained by the homogeneity of our group of patients with POAG, which is generally characterized by lower IOP values, compared with those in Loscos-Arenas and Romera-Romero studies, which included secondary types of OAG, characterized by potentially higher IOP, in their groups. The most common intraoperative DS complication is TDM perforation and subsequent conversion to TE.[28,41,44] The relatively high degree of difficulty in carrying out this procedure, which requires great skill in lamellar microdissection and also lengthy experience on the surgeon's part, leads to the incidence of this complication.[7,10] Varga and Shaarawy[7] noted that TDM perforation is significantly more common during the learning phase of a surgeon's personal experience with DS, defined as the first 20 DS performed. In our study, we encountered only 3 cases of TDM perforation followed by conversion to TE, and these were automatically excluded from the statistical evaluation. Early postoperative complications such as mild hyphema and transient hypotony occurred in 15.4% of our patients and can be explained by minimal blood reflux from the scleral bed through the anterior trabeculum or TDM microperforations—some possibly undetected. Those unfavorable conditions led to a shallow anterior chamber in 7.7% of the eyes and choroidal detachment in 10.3% of eyes, which caused a mild, temporary decrease in visual acuity for the patients involved. This BCVA decrease was detected only in the early postoperative period. At the end of the follow-up period, we found that DS did not affect the visual acuity of any enrolled patient. Thirty-three percent of our patients required an Nd:YAG goniopuncture. Several goniopunctures were performed 3 months after DS due to insufficient percolation of aqueous humor, likely resulting from a higher TDM thickness (2.5%). Most of these procedures were performed more than 9–12 months after surgery to treat relatively low filtration, likely due to TDM fibrosis. Although the number of antiglaucoma therapies reported by Loscos-Arenas et al[31] and Romera-Romero et al[32] at the 1-year follow-up was similar to that in our results, the number of goniopunctures reported in these studies was significantly higher (44.4% and 61%) than in our group (33.3%).

The difference in goniopuncture rate can be explained by postoperative IOP variation as a result of diverse surgical protocol methodologies, OAG particularities and differences in the postoperative IOP targets.

The primary limitations of our study are the relatively short postoperative follow-up period and the absence of randomization. Further prospective randomized trials with larger samples and longer follow-up periods are required to guarantee the long-term efficacy and safety of DS with a suprachoroidal drainage implant.

In conclusion, the results of the present study demonstrated that DS with the Esnoper Clip implant significantly reduced IOP over a 1-year follow-up period in patients with medically uncontrolled POAG. The incidence of complications was low and visual acuity was not affected by the surgery. The findings of our study suggest that DS with the Esnoper Clip implant can be considered a viable surgical option in patients with uncontrolled POAG.

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