Long-term results of deep sclerectomy with collagen implant

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Purpose: To study prospectively the success rate and complications of deep sclerectomy with collagen implant (DSCI).

Setting: Glaucoma Unit, Department of Ophthalmology, Hôpital Ophtalmique Jules Gonin, University of Lausanne, Lausanne, Switzerland.

Methods: This nonrandomized prospective trial comprised 105 eyes of 105 patients with medically uncontrolled primary and secondary open-angle glaucoma. Visual acuity, intraocular pressure (IOP), and slitlamp examinations were performed before surgery and after surgery at 1 and 7 days, and 1, 3, 6, 9, 12, 18, 24, 30, 36, 48, 54, 60, 66, 72, 78, 84, 90, and 96 months. Visual field examinations were repeated every 6 months.

Results: Mean follow-up period was 64 months ± 26.6 (SD). Mean preoperative IOP was 26.8 ± 7.7 mm Hg, and mean postoperative IOP was 5.2 ± 3.35 mm Hg at day 1 and 12 ± 3 mm Hg at month 78. At 96 months, the qualified success rate (ie, patients who achieved IOP <21 mm Hg with and without medication) was 91%, and the complete success rate (ie, IOP <21 mm Hg without medication) was 57%. At 96 months, 34% of patients had an IOP <21 mm Hg with medication. Fifty-one patients (49%) achieved an IOP ≤15 mm Hg without medication. Neodymium:YAG goniopuncture was performed in 54 patients (51%); mean time of goniopuncture performance was 21 months, and mean IOP before goniopuncture was 20 mm Hg, dropping to 11 mm Hg after goniopuncture. No shallow or flat anterior chamber, endophthalmitis, or surgery-induced cataract was observed. However, 26 patients (25%) showed a progression of preexisting senile cataract (mean time 26 months; range 18 to 37 months). Injections of 5-fluorouracil were administered to 25 patients (23%) who underwent DSCI to salvage encysted blebs. Mean number of medications per patient was reduced from 2.3 ± 0.7 to 0.5 ± 0.7 (signed rank $P<.0001$).

Conclusion: Deep sclerectomy with collagen implant appears to provide stable and reasonable control of IOP at long-term follow-up with few immediate postoperative complications.

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Deep sclerectomy with collagen implant (DSCI) is a filtration procedure for the surgical treatment of medically uncontrolled open-angle glaucoma. The more common trabeculectomy procedure, with or without antimetabolites, has a well-documented complication rate.[1] The DSCI procedure was designed to lower the incidence of such complications without compromising the success rate and intraocular pressure (IOP) reduction achieved with trabeculectomy.[2,3]

This report documents experience with the procedure in a prospective nonrandomized (consecutive) study of 105 patients who had DSCI between May

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Table 1. Patient data (N = 105).

Parameter	Result
Mean age, ± SD (y)	75 ± 13.1
Male/female	46/59
White race/other	105/0
Preoperative IOP (mm Hg)	
Mean ± SD	26.8 ± 7.7
Range	19–50
Follow up ± SD (mo)	64 ± 26.6
Mean preoperative medications ± SD	2.3 ± 0.7
Number of preoperative medications, n (%)	
Two	64 (62)
Three	35 (33)
Four	6 (5)
Diagnosis	
POAG	53
PEXG	26
PSPHG	14
NPG	5
Aphakia	2
Other	5

IOP = intraocular pressure; POAG = primary open-angle glaucoma; PEXG = pseudoexfoliative glaucoma; PSPHG = pseudophakic glaucoma; NPG = normal tension glaucoma; Aphakia = aphakic glaucoma

1994 and early 1996 and who were followed up for up to 96 months.

Patients and Methods

Case Selection

One hundred five eyes of 105 white patients (Table 1) with medically uncontrolled primary and secondary open-angle glaucoma underwent DSCI at the Glaucoma Unit of the Ophthalmology Department, University of Lausanne, Switzerland. After obtaining approval from the Ethical Committee of the University of Lausanne, the patients were enrolled consecutively. Informed consent was obtained from all participants. Patients selected had medically uncontrolled glaucoma with maximal medical therapy. Uncontrolled glaucoma was defined as well-documented progression of glaucomatous visual field defects and optic nerve morphology under maximal tolerable medical treatment (2 or more antiglaucoma medications).

Exclusion criteria were unwillingness to participate, single eyes, known allergy to collagen, advanced lens opacities, and previous eye surgery or laser trabeculoplasty fewer than 6 months before enrollment in the study. All patients in the series had bilateral glaucomatous visual field defects, and none had previous laser trabeculoplasties.

Data Recorded Preoperatively

On the day before surgery, patients underwent best corrected visual acuity (BCVA) assessment (Snellen chart at 5 m) and IOP was measured using a Haag-Streit Goldmann applanation tonometer mounted on a slitlamp. Patients also underwent biomicroscopy, gonioscopy, visual field testing using the G1 program of the Octopus 101 (Interzeag), and fundus biomicroscopy.

Postoperative Follow-up

After surgery, all previously mentioned examinations, with the exception of visual field assessment, were conducted on the first and the seventh day and at 1, 3, 6, 9, 12, 18, 24, 30, 36, 48, 54, 60, 66, 72, 78, 84, 90, and 96 months. Visual field examination was repeated every 6 months. If complications occurred, follow-up was intensified.

Complications were defined as follows: Hyphema was considered present when erythrocytes were seen in the anterior chamber. Hypotony was defined as a postoperative IOP of 4 mm Hg or higher for more than 2 weeks. Anterior chamber depth was clinically assessed in comparison with the fellow eye and was considered shallow when there was an iridocorneal touch in the periphery and flat when there was a lens–corneal touch as seen with biomicroscopy. Anterior chamber inflammation was considered present when flare could be seen with biomicroscopy. Choroidal detachment was considered present when seen in the peripheral retina using an indirect ophthalmoscope. In postoperative follow-up, cataract was either observed as a direct consequence of filtration surgery, considered surgery-related cataract, or appeared progressively and was therefore considered cataract progression. Surgery-related cataract has been defined by a rapid (1 month) decrease in visual acuity and the development of cortical opacity; cataract progression was defined as slow, progressive decrease in visual acuity of more than 2 Snellen lines because of lens opacification, primarily nuclear sclerosis.

Surgical Procedures

All surgeries were performed by a single experienced surgeon using retrobulbar anesthesia consisting of 2 to 4 mL bupivacaine 0.75%, lidocaine hydrochloride 4% (Xylocaine®), and hyaluronidase 50 U. The surgical procedure has been described elsewhere.[4,5] Figures 1 through 5 document the surgical procedure.

Surgery was considered a complete success when IOP was ≤21 mm Hg without glaucoma medication and a qualified success when IOP was ≤21 mm Hg with glaucoma medication. It was considered a failure when IOP was >21 mm Hg with or without glaucoma medication or when an eye required further glaucoma drainage surgery, developed

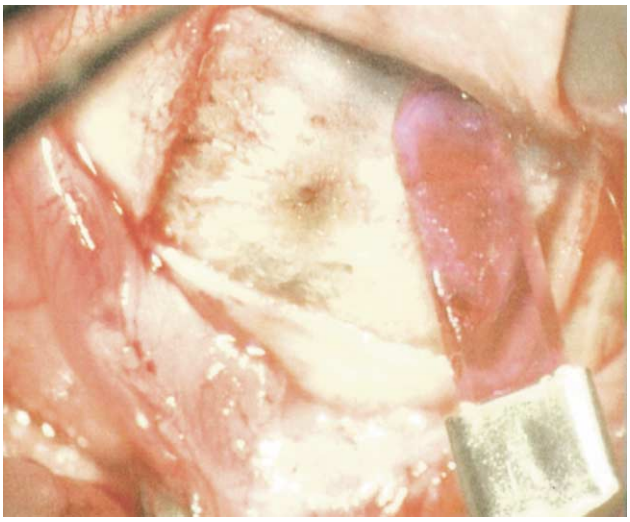

Figure 1. (Shaarawy) A one-third scleral thickness limbus-based scleral flap measuring 5 mm × 5 mm was dissected.

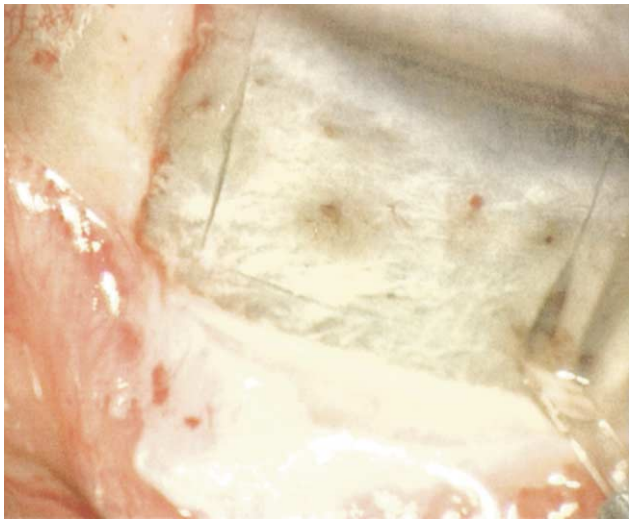

Figure 2. (Shaarawy) A rectangle of deeper scleral tissue was dissected.

phthisis bulbi, or lost light perception. Three measures of IOP were performed to determine the mean IOP (once every 5 minutes for 15 minutes); when mean IOP was >21 mm Hg, the operation was considered a failure.

When the filtering bleb at any postoperative visit was encysted or showed signs of fibrosis, subconjunctival injections of 5 mg of 5-fluorouracil (5-FU) were administered in the lower quadrant, opposite the DSCI. The subconjunctival injections consisted of 0.1 mL of a 50 mg/mL solution of 5-FU (250 mg/5 mL Fluoro-Uracil®). Subconjunctival 5-FU injections were repeated up to 7 times, if necessary.

Goniopuncture with a neodymium:YAG (Nd:YAG) laser (Microruptor II, Lasag) was performed when the target IOP range for each patient was not achieved because of insufficient filtration through the trabeculo-Descemet's membrane (TDM). The procedure for goniopuncture has been previously reported.[5]

Glaucoma Collagen Implant

The cylindrical collagen implant measured 2.5 mm in length and 1.0 mm in diameter. It was processed from lyophilized porcine scleral collagen, which is sterilized using a radiation procedure. This cross-linked, collagen-based, biocompatible material does not induce a systematic immunologic reaction.[6] The water content of the hydrated device is 99%. Chiou et al.[7,8] reported ultrasonic biomicroscopy (UBM) findings consistent with IOP lowering by aqueous filtration through the thin, remaining TDM to an area under

Figure 3. (Shaarawy) The rectangle was removed, leaving a thin layer of deep sclera, unroofed Schlemm's canal, and Descemet's membrane.

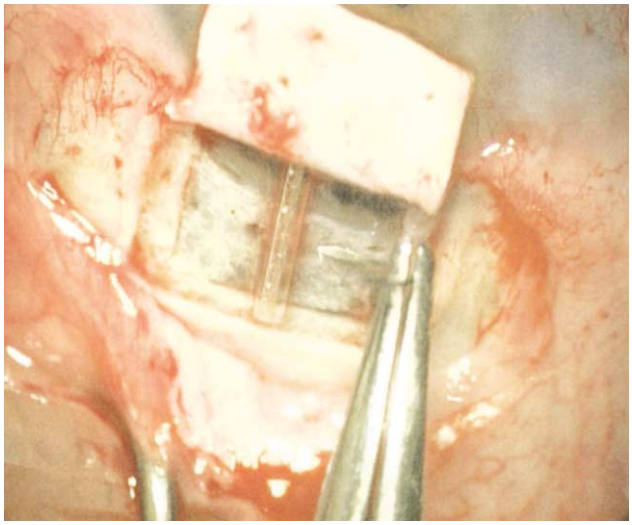

Figure 4. (Shaarawy) The collagen implant was placed radially and secured with a single 10-0 nylon suture.

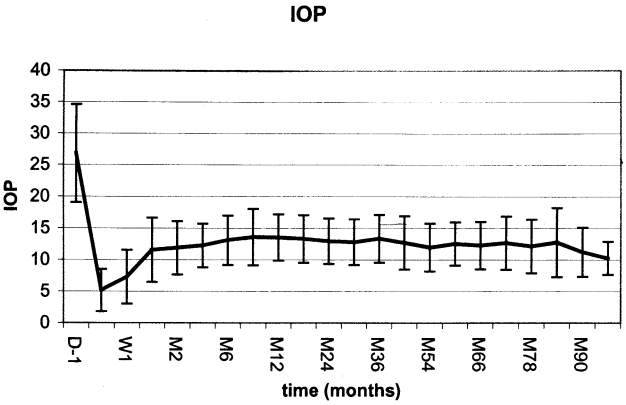

Figure 5. (Shaarawy) Intraocular pressure before and after DSCI.

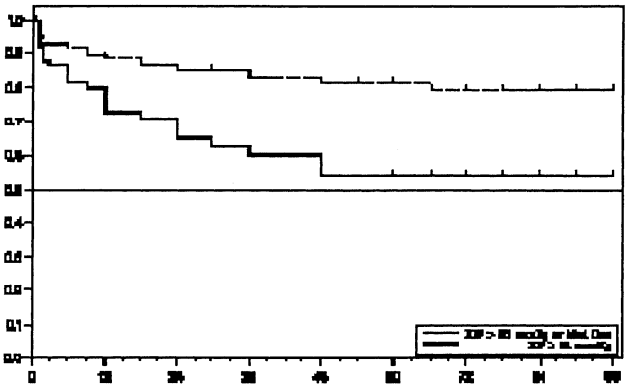

Figure 6. (Shaarawy) Long-term cumulative qualified and complete success of DSCI using Kaplan-Meier life table analysis.

the scleral flap, which the collagen implant hypothetically kept open. Other available implants are the reticulated hyaluronic acid implant[9,10] and the hydrophilic acrylic nonabsorbable implant (Elie Dahan, MD, personal communication, 2002).

Statistical Analysis

Results were analyzed using the Student *t* test for comparison of means, chi-square analysis for 2 × 2 tables, and Kaplan-Meier survival curves for long-term success rate analysis. For comparison between groups, the Wilcoxon test was used.

Results

Mean follow-up time was 64 months ± 26.63 (SD). Mean preoperative IOP was 26.8 ± 7.77 mm Hg; and mean postoperative IOP was 5.2 ± 3.35 mm Hg at day 1 and 12 ± 3 mm Hg at month 78 (Figure 5).

Complete success, defined as IOP lower than 21 mm Hg without medication, was 57% at 96 months (Figure 6). Patients who achieved IOP below 21 mm Hg with and without medication (91% at 96 months) were considered a qualified success. Patients with an IOP lower than 21 mm Hg with medication were 34% at 96 months. The mean number of medications per patient was reduced from 2.3 ± 0.7 to 0.5 ± 0.7 after DSCI.

Of the 105 eyes in which DSCI was performed, IOP was uncontrolled (mean IOP 26.6 mm Hg) in 9 (9%) cases and required reoperation (trabeculectomy or another DSCI with mitomycin I-C intraoperative application). The BCVA dropped on the first postoperative day from 0.73 (preoperatively) to 0.53. Visual acuity returned to preoperative levels 1 week after surgery and remained stable over the next 96 months, achieving a mean BCVA of 0.7 at 66 months and 0.7 at 96 months (Figure 7).

The stability of visual fields in the complete success group was evaluated using the Brusini glaucoma staging system.[11] Of the complete success group, 78% of the patients maintained stable visual fields (within the same preoperative stage) and 22% showed deterioration despite an IOP ≤15 mm Hg, pointing to pressure-independent factors.

There were no significant operative complications recorded in this series. Postoperative complications are shown in Figure 8. No shallow or flat anterior chamber, bleb-related endophthalmitis, or surgery-induced cataract was observed; however, 26 patients (25%) showed either a progression of preexisting senile cataract or developed cataract postoperatively (mean time 26 months; range 18 to 37 months). Bleb fibrosis and

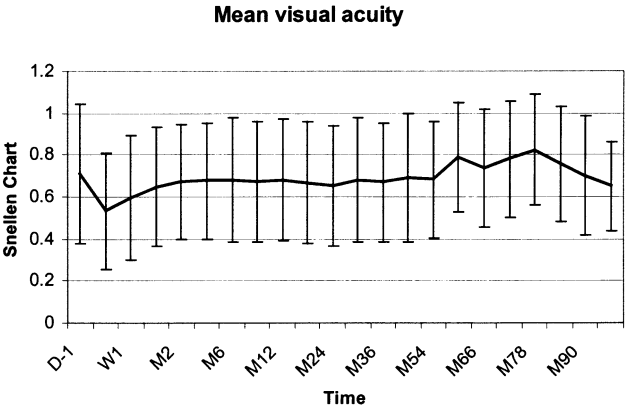

Figure 7. (Shaarawy) Mean BCVA before and after DSCI.

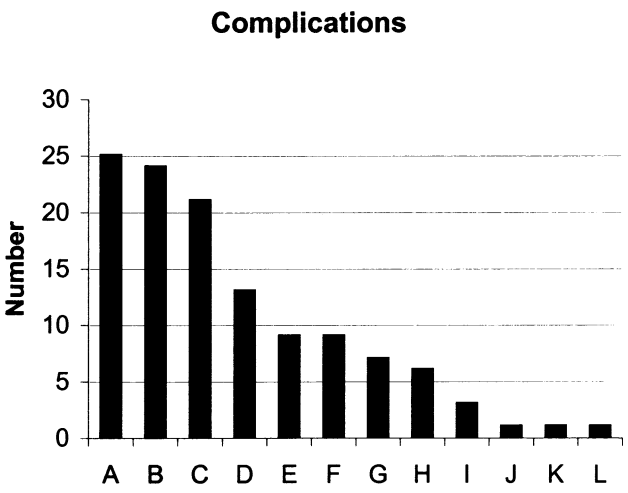

Figure 8. (Shaarawy) Postoperative complications. A = 5-fluorouracil injections; B = cataract progression; C = blebencapsulation; D = bleb fibrosis; E = hyphaema; F = wound leak; G = choroidal detached; H = dellen; I = needling; J = corneal abrasion; K = malignant glaucoma; L = hypotony.

encapsulation were treated with 5-FU subconjunctival injections. Injections of 5-FU were performed in 25 (23%) patients who underwent DSCI. The mean number of injections was 2.9 ± 1.9, and the mean time between operation and 5-FU injection was 1.8 ± 2.6 months.

Goniopuncture with Nd:YAG laser was performed in 54 (51%) patients. Mean time between laser and DSCI was 21 ± 13.0 months, mean IOP before goniopuncture was 20 ± 6.0 mm Hg, and mean IOP after goniopuncture was 11 ± 6.3 mm Hg. This difference was statistically significant ($P<.001$). The results in the 54 patients requiring goniopuncture were further analyzed (mean follow-up 71 ± 18 months). The procedure was successful in dropping pressure to below 18 mm Hg in 3 cases (5%) and below 15 mm Hg in 27 cases (50%) without medication and to below 15 mm Hg with medication in 16 cases (30%). In 8 cases (15%), the procedure failed to lower IOP.

Discussion

The major advantage of DSCI is that it precludes the sudden hypotony that occurs following trabeculectomy by creating progressive filtration of aqueous humor from the anterior chamber to the surgically created intrascleral space through the TDM.[12] Hamard et al.[13] recently showed that the membrane peeled in deep sclerectomy consists of the inner wall of Schlemm's canal and the juxta-canalicular tissue, which conventional wisdom considers to be the site of highest outflow resistance.[14,15] Two studies[16,17] have demonstrated that deep sclerectomy exposes a physiological membrane consisting of the rest of trabecular tissue (after peeling) and the Descemet's membrane. These studies have demonstrated that aqueous percolates at the level of the trabeculum and, to a much lesser extent, at the level of Descemet's membrane. This is in line with studies[18] reporting relatively low permeability of Descemet's membrane. The creation of the TDM dramatically increases facility of outflow but also offers sufficient resistance to prevent the sudden globe decompression that commonly occurs after trabeculectomy.[17]

The concept of occupying the intrascleral space with a space-occupying device has been proved to improve succes rates significantly in deep sclerectomy.[19,20] This is supported by Roters et al.,[21] who correlated IOP control in viscocanalostomy with the presence of intrascleral space, and vice versa. In an earlier study,[5] we reported the 5-year result in the same group of DSCI patients. Comparison between that study and that described here is interesting in that there was no significant drop in success rates or increase in complication rates over the last 2 to 3 years. These results are encouraging markers of the stability of the surgery over longer-term follow-ups.

Except for the first week after surgery, visual acuity was unaffected by DSCI. This phenomenon may be explained by the fact that the eye was not perforated, which avoids inflammation, the need for mydriatics, and sudden hypotony. Furthermore, visual acuity remained stable because no surgery-related cataracts developed after DSCI.

The most common intraoperative complication of this surgery is perforation of the thin TDM during the deep sclerectomy dissection. This was common in the learning phase of deep sclerectomy, occurring in 3 of the first 10 surgeries (30%), but with increased surgical experience, this complication became rare: Only 3 surgeries of the subsequent 101 (2.9%) resulted in perforation. In this study, only the patients with an intact TDM are reported (105 patients). The results of the patients who had perforation of the TDM (6 patients) are not analyzed here because they have already been reported.[22] Postoperative complications and final out-

come in patients with intraoperative perforation of the TDM were similar to those of patients who had undergone standard trabeculectomy.

Early postoperative complications included the presence of subtle hyphaema (unleveled) in 8.5% of our cases. The small amount of blood in the anterior chamber was explained by a probable blood reflux from the scleral bed through the anterior trabeculum or undetected microperforations.

Goniopunctures with the Nd:YAG laser were performed in 51% of patients (54 patients). When goniopuncture was performed shortly after DSCI, it was because there was insufficient percolation of aqueous humor at the TDM, probably because of the lack of surgical dissection. When goniopunctures were required at a later time (more than 9 months after initial surgery), low filtration was probably the result of fibrosis of the TDM because goniopuncture resulted in increased filtration of aqueous humor and decreased IOP. By opening the TDM, however, goniopuncture transformed a nonperforating filtration procedure into a perforating one. This surgery has been repeatedly criticized[23] for being a 2-step penetrating procedure in at least 50% of cases, in contrast to its promise of nonpenetration. In our judgment, this is not a valid point; even if the surgeon does penetrate following the initial procedure, this does not undermine the high safety profile afforded by the lack of intraoperative penetration. Furthermore Nd:YAG goniopuncture penetration at later stages does not compromise the high success rates and the low IOP that can be achieved through DSCI by experienced surgeons compared with trabeculectomy.[24] Laser suturelysis and laser capsulotomy are not traditionally considered to be failure criteria to either trabeculectomy or cataract extraction.

In our series, 23% of patients experienced cataract progression or an onset of cataract after a relatively long postoperative period (mean time 26 months; range 18 to 37 months). There is no definite method to prove that the cataract was not surgically induced during deep sclerectomy, but the relatively advanced age of our patients, the long follow-up, and the mean time and range of cataract incidence seem to indicate this.

The main limitation of our study is that it was a nonrandomized and noncomparative (although consecutive) series. It nonetheless provides an interesting indicator of the long-term results that may be expected of DSCI when performed by experienced surgeons. The procedure is known to have a long learning curve. Furthermore, the comparison of the 5-year and long-term results underscores the stability of the procedure's outcomes.

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