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Ophthalmology Research

Efficacy and Safety of Deep Penetrating Sclerectomy in Advanced Primary Open-Angle Glaucoma: A Prospective Single-Center Study of 91 Cases with 12-Month Follow-Up

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ABSTRACT

Context Primary open-angle glaucoma (POAG) is a major cause of blindness in sub-Saharan Africa, where late diagnosis and follow-up constraints complicate management. In Mauritania, its increasing prevalence requires a rethinking of available surgical options.

Objective: *To evaluate the 12-month results of deep penetrating sclerectomy (DPS) in patients with advanced POAG, by analyzing both its eye pressure efficacy, its impact on drug treatment, and its possible complications.*

Methodology: *Prospective, single-center interventional study including 91 patients with advanced POAG, who underwent surgery using a standardized DPS technique. Intraocular pressure (IOP), topical treatment, complications, and surgical success rate were assessed at regular intervals up to 12 months postoperatively.*

Results: *A significant reduction in IOP was observed (−29.8% at M12), associated with a notable decrease in the number of treatments. The absolute success rate (without eye drops) was 76%, with a favorable safety profile. Some minor complications were observed, mainly transient hypotony and a few cases of cataract. A lower eye pressure response was noted in patients of Black African origin, raising questions about underlying anatomical or genetic factors.*

Conclusion: *In this resource-limited African context, DPS appears to be a realistic and relatively safe surgical alternative. While the 12-month results are encouraging, longer-term monitoring and a comparative study with other techniques remain essential to better define its place in the therapeutic arsenal.*

Keywords

Advanced glaucoma, Filtering surgery, Intraocular pressure, Penetrating sclerectomy.

Introduction

Glaucoma is the leading cause of irreversible blindness worldwide, with an estimated prevalence of 3.5% in people aged 40-80 years [1]. POAG is the most common glaucoma since it represents, depending on the region and diagnostic criteria, 50 to 70% of all glaucomas and is the cause of 6.4 million cases of blindness worldwide [2].

Mauritania, a Sahelian country with 4.5 million inhabitants, presents an alarming epidemiological situation with a prevalence of POAG increasing from 3.1% in 2004 to 13.03% in 2023 according to local studies [3-5].

Although glaucomatous lesions are irreversible, their progression can be slowed by appropriate treatment, based on early diagnosis and good compliance [6].

Since the pioneering work of Fyodorov and Koslov in 1989 [7,8], non-penetrating deep sclerectomy (NPS) has emerged as an alternative to trabeculectomy. It involves removing the internal wall of Schlemm's canal, allowing percolation of aqueous humor through the residual trabeculo-descemetic membrane [9], to a scleral lake located under a superficial scleral flap. This space acts as an internal filtration bubble, with possible additional drainage to the subchoroidal and subconjunctival spaces [10]. Its pressure efficacy remains lower, however, particularly in advanced glaucoma, but it has a better safety profile [11,12].

Deep penetrating sclerectomy (DPS) represents a technical development combining the advantages of DPS with those of trabeculectomy by creating a controlled micro-perforation of the trabeculo-descemetic membrane, thus playing the role of an intraoperative goniopuncture [13]. Although initially described for moderate glaucoma, its application in advanced forms remains poorly documented, particularly in Africa where patients often present at late stages.

This prospective study aims to fill this gap by comprehensively evaluating the outcomes of DPS in a Mauritanian study of advanced POAG, with a standardized 12-month follow-up. We specifically analyze the influence of demographic and ethnic factors on surgical outcomes, a crucial aspect in this multi-ethnic region.

Methodology

Study Design

Prospective single-center interventional study, compliant with CONSORT recommendations and approved by the local ethics committee (ref. CE/FB/2023-01).

Population Studied

Consecutive recruitment of patients with advanced POAG among consultants at the Bouamatou Foundation, a national reference center.

Inclusion Criteria

POAG confirmed by gonioscopy and optic nerve examination, IOP >21 mm Hg under maximum tolerated treatment (≥3 anti-glaucoma drugs), Visual field showing an arcuate or para-central deficit**,** Age ≥15 years old, Signed informed consent.

Exclusion Criteria

Antecedent filtering surgery, secondary or angle-closure glaucoma, severe associated ocular pathology, follow-up impossible to guarantee.

Preoperative Assessments

Measure IOP by Goldmann applanation tonometry (average of 3 measurements), Visual acuity), Fundus examination with assessment of papillary excavation (cup/disc ratio), 4-mirror gonioscopy, Automated visual field, OCT of retinal nerve fibers

Surgical Technique

All patients underwent surgery under laterobulbar anesthesia. After disinfection and placement of a sterile drape, an eyelid retractor was positioned. A corneal traction suture with 6/0 Vicryl suture was performed. The conjunctiva was opened supratemporally to the limbus, and the Tenon capsule was dissected to expose a 5 × 5 mm scleral area. Hemostasis was performed by bipolar diathermy.

Two scleral flaps were created:
A superficial flap of 5 × 5 mm, one third of the scleral thickness, extended 1 mm into the clear cornea, A deep flap of 4 × 4 mm below the previous one, extended 1.5 mm into the cornea.

Schlemm's canal was opened, corneal paracentesis was performed, and a viscoelastic agent was injected into the anterior chamber. The deep flap was excised down to Descemet's membrane. Unlike conventional non-penetrating deep sclerectomy, the anterior chamber was intentionally penetrated through the trabeculo-Descemet's membrane, followed by superior iridectomy. The superficial flap was sutured with 10-0 nylon. Patency was tested by injecting saline under the flap. Conjunctival closure was achieved with 8-0 Vicryl. At the end of the procedure, a subconjunctival injection of gentamicin and dexamethasone was administered.

Postoperative Protocol

Topical antibiotic-steroid (neomycin 0.5%-prednisolone 1%) 4x/day for 6 weeks - Immediate discontinuation of anti-glaucoma drugs, Controls at D1, D7, M1, M3, M6 and M12

Parameters Evaluated

- IOP reduction at 12 months, Number of anti-glaucoma medications, Visual acuity, Early and late complications, Surgical success rate (absolute and relative), Prognostic factors (age, sex, ethnicity).

Statistical Analysis

- IBM SPSS v20 Software، Parametric tests (Student's t), Survival analysis (Kaplan-Meier)، Significance threshold: $p<0.05$

Results

Demographic characteristics

The study included 91 patients (70 men, 21 women) with a mean age of 56.7 ± 12.7 years (range : 16-81 years). The ethnic distribution showed 46 Black African patients (50.55%) and 45 Arab-Berbers (49.45%). The main geographical origins were the Trarza region (18.06%) and Nouakchott (13.89%).

Preoperative Data

- Average duration of glaucoma : 5 ± 6.1 years
- Mean IOP: 22.28 ± 7.03 mm Hg (9-40 mm Hg)
- Average number of anti-glaucoma drugs: 2.24 ± 1.06
- Average papillary excavation: 0.86 ± 0.14
- Preoperative visual acuity:
* PL-: 6%
* PL+: 8.4%
* Finger movement: 9.6%
* Count fingers: 12%
* 1/10 to 3/10: 23.8%
* 4/10 to 10/10: 39.3%

Pressure Results

The evolution of IOP showed a significant reduction ($p<0.001$) at all evaluation times (Figure 1):

-D1: 9.18 ± 7.76 mm Hg (-58.8%)
-D7: 11.45 ± 7.08 mm Hg (-48.6%)
-M1: 14.84 ± 5.91 mm Hg (-33.4%)
-M3: 13.85 ± 5.22 mm Hg (-37.8%)
-M6: 13.63 ± 5.05 mm Hg (-38.8%)
-M12: 15.65 ± 4.24 mm Hg (-29.8%)

Drug Load: Significant reduction ($p<0.001$) of the number of anti-glaucoma drugs (Figure 1):

-Pre-op: 2.24 ± 1.06
-M12: 0.36 ± 0.78

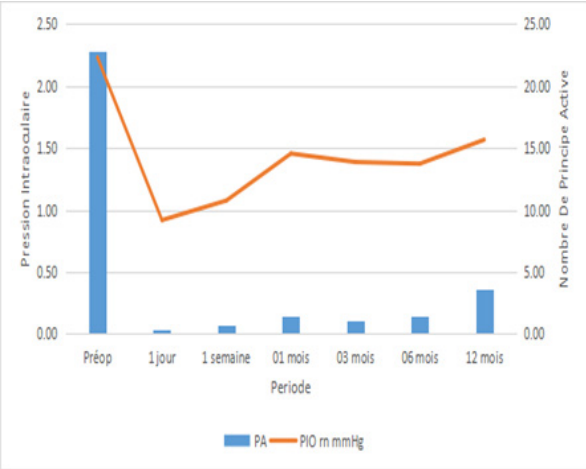

Figure 1: Evolution of IOP and number of active ingredients over time.

Surgical Success

- Relative success (IOP≤21 mm Hg with less medication): 86.9%
- Absolute success (IOP≤21 mm Hg without medication): 76.08%
- Kaplan-Meier survival analysis showing stability of results between M6 and M12 (Figure 2)

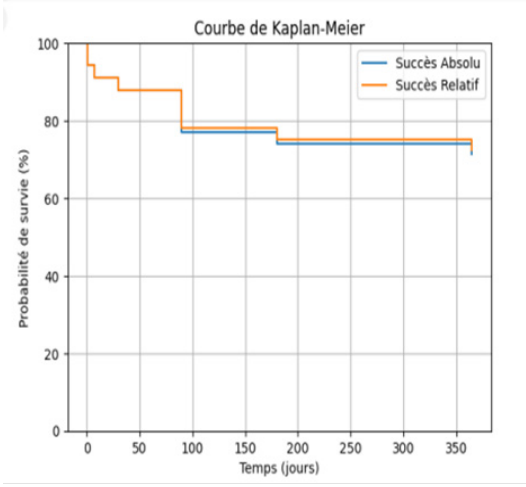

Figure 2: Kaplan-meier curve representing surgical success over time.

	1jour	1semaine	1mois	3mois	6mois	12mois
Athalamie	1,2%	2,4%	1,2 %	0%	0%	0%
Hypothalamie	5,9%	8,5%	0%	0%	0%	0%
PRC	1,2%	0%	0%	0%	0%	0%
Tyndall	1,2%	0%	0%	0%	0%	0%
Hyphéma	3,5%	1,2 %	0%	0%	0%	0%
Synéchies irido-cristalienne	0%	12,2 %	3,6 %	0%	0%	0%
Cataracte	0%	4,7%	4,8%	10,3%	17,3%	17,5%
Décollement de la rétine	0%	0%	1,2 %	1,1%	1,1%	1,1%
Bulle plate	0%	0%	0%	3,3%	1,8 %	3%

Table 1: Les complications.

Prognostic Factors

Multivariate analysis identified:

- Significant pejorative factor: black African ethnicity (+1.74 mm Hg vs. Arab-Berber; p=0.032)
- Non-significant factors: age, sex, duration of glaucoma
- Inverse correlation between preoperative IOP and eye pressure reduction (r=-0.42; p=0.001)

Discussion

Our results show that deep penetrating sclerectomy (DPS) can provide satisfactory eye pressure control in patients with advanced primary open-angle glaucoma (POAG), with a mean IOP reduction of 29.8% at 12 months and an absolute success rate of 76%. These data are close to those reported by Kalala et al. in the Democratic Republic of Congo (40.3% eye pressure reduction) [14], in a comparable African context in terms of resources, diagnostic delay, and follow-up constraints.

On the other hand, our results remain lower than those published by Kozobolis et al. in Greece, who reported a mean reduction of 48.3% [15]. This difference may be explained, at least in part, by the fact that the Greek study included the systematic use of anti-metabolites (such as mitomycin C), which were absent from our protocol. These agents are known to improve the permeability of the filtering bleb by reducing postoperative fibrosis.

The favorable safety profile observed in our study, marked by a low incidence of severe complications, reinforces the interest of deep penetrating sclerectomy (DPS) in African settings with limited resources. The rate of transient hypotony (5.9%) remains significantly lower than the 15–20% reported with trabeculectomy in the African and international literature [16,17]. This difference could be explained by the hydraulic resistance offered by the residual scleral flap, limiting the risk of over-filtration. In addition, no cases of endophthalmitis were observed in our study, whereas African series report rates of 1 to 1.5% after trabeculectomy

[18,19]. Hyphemas (3.5%) and flat bullae (3%) are also lower compared to the rates of 8 to 10% found in classic series [17,20]. Finally, our secondary cataract rate (17.5%) remains lower than the 30 to 40% described after trabeculectomy in several African studies [21].

These results suggest that DPS constitutes an effective and safer surgical alternative, particularly suited to African realities where postoperative monitoring remains difficult.

The significant influence of ethnicity on the results is consistent with that of Seck (Senegal), who reported modest results after trabeculectomy in black African patients, linked to rapid fibrosis of the bleb [22]. Internationally, Kugler et al. and Kanner et al. also observed reduced efficacy of surgery in African American patients [23].

Limitations of the Study

Include the fact that it is monocentric, the absence of a control group and the use of several surgeons (distinct learning curve). A randomized study comparing DPS and trabeculectomy would be desirable to clarify the respective place of these techniques.

Conclusion

After 12 months of follow-up, DPS achieved satisfactory eye pressure control in the majority of cases, with a low complication rate.

These results suggest that it could represent a relevant alternative to trabeculectomy, particularly in African contexts with limited resources.

The technique deserves to be integrated into national strategies to combat glaucomatous blindness, particularly for:
- Young patients requiring long-term preservation of visual capital
- Cases at high risk of post-trabeculectomy complications
- Contexts where postoperative monitoring is difficult

Further research should explore:
The results encourage the continuation of this technique and open the way for future studies to further optimize protocols and improve long-term results.

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