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Outcomes of slow coagulation transscleral cyclophotocoagulation in a predominantly African American glaucoma population☆

Zaid Parekh [a], Jessie Wang [b], Mary Qiu [b,*]

[a] The University of Chicago Pritzker School of Medicine, Chicago, IL, USA
[b] Department of Ophthalmology & Visual Sciences, University of Chicago, Chicago, IL, USA

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ABSTRACT

Purpose: To evaluate outcomes of slow coagulation transscleral cyclophotocoagulation (SC-TSCPC) in a primarily African American patient population with glaucoma.

Methods: A retrospective chart review was performed for 104 consecutive cases of SC-TSCPC by a single surgeon between November 6, 2019–September 7, 2023. Power ranged from 1150 to 1500 mW, duration was 4 s, and number of spots ranged from 10 to 25. Exclusion criteria were diagnosis of neovascular glaucoma, prior CPC, visual acuity (VA) of no light perception or unable to be assessed due to patient's mental status, aphakia, or follow-up <3 months. The primary outcome measure was surgical success defined as an intraocular pressure (IOP) of 6–21 mmHg with a ≥20 % reduction from baseline, no glaucoma re-operation, and no loss of light-perception. Secondary outcome measures included VA, glaucoma medication use, and post-surgical complications. Analysis was also stratified by lens status as literature suggests a greater IOP-lowering effect in pseudophakic eyes after CPC.

Results: There were 28 eligible patients (6 phakic, 22 pseudophakic) included in this analysis. Mean follow-up was 11.6 ± 8.3 months, and 14 patients had postoperative year 1 data available. The mean age was 75.2 ± 13.9 years, 42.9 % were female, and 92.9 % were African American, reflective of the demographics of the local community. The cumulative success rate was 68.5 % at 1 year and did not differ significantly between phakic and pseudophakic patients. Mean VA worsened from 20/600 preoperatively to 20/1050 at last follow-up ($P = 0.04$) and was marginally worse in the phakic group ($P = 0.15$). Mean IOP decreased from 31.1 ± 13.2 mmHg on 4.0 ± 1.5 medications preoperatively to 13.8 ± 7.1 mmHg on 2.6 ± 1.5 medications at last follow-up ($P < 0.001$; $P < 0.01$), with a more pronounced effect among pseudophakic patients. 85.7 % of patients had prolonged anterior chamber (AC) inflammation beyond 1 month, which persisted in 10.7 % at last follow-up. The cystoid macular edema (CME) rate was 21.4 %, with 10.7 % persistent at last follow-up.

Conclusions: SC-TSCPC is an effective, non-incisional IOP-lowering procedure in phakic and pseudophakic eyes that may not otherwise be ideal candidates for incisional glaucoma surgery. Pseudophakic eyes may experience larger reductions in IOP, however, laser settings can be titrated on a case-by-case basis depending on individual patients' goals. There was a higher incidence of prolonged AC inflammation and CME in our cohort compared to similar studies which report rates of 12.7 % and 2.7 %, respectively. Although the significance of such complications may differ based on the visual potential of each patient, these findings support existing literature that African American patients can have greater incidence of inflammation and subsequent sequalae after ocular surgery.

1. Background

Glaucoma is the leading cause of irreversible blindness worldwide, and the only currently modifiable risk factor is intraocular pressure (IOP).[1,2] Cyclodestructive procedures lower IOP by reducing aqueous production and were once considered to be a last-resort option in eyes with very low visual potential due to the associated risk of uncontrolled inflammation and phthisis.[1,2] With recent advances in laser probes and

☆ **Institution at which the study was conducted:** University of Chicago Medical Center.

* Corresponding author. 5758 S. Maryland Ave, Suite 1B, Chicago, IL, 60637, USA.
E-mail address: mary.qiu@gmail.com (M. Qiu).

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laser settings, the safety of transscleral cyclodestruction has improved, rendering it a viable non-invasive option for a broader spectrum of patients.[3,4]

Transscleral diode laser cyclophotocoagulation (TSCPC), administers laser energy through the sclera, causing coagulative necrosis in the ciliary body by targeting melanin pigment.[5] Continuous wave (CW) laser energy delivery is the traditional approach, while the newer intermittent micropulse (MP) laser energy delivery has gained interest due to its precise energy control, yet there remains some controversy regarding its success rates and long-term outcomes compared to CW.[6,7] Within CW-TSCPC, there are two different strategies.[8] The conventional "pop" method starts with a laser energy power of around 1750–2000 mW (mW) applied for a relatively short duration of 2 s. The energy is slowly titrated until the minimum power required to produce a "pop" is applied, signifying tissue coagulation and destruction to the ciliary body of the eye.[8] In contrast, slow coagulation (SC) CW-TSCPC utilizes a lower amount of diode laser energy over an extended period, approximately 1250 mW over 4 s.[8,9] Providers may titrate the energy levels up or down to minimize "pops", although the maximum energy is typically capped at a certain value.

Recent studies comparing 'slow coagulation' and conventional CPC settings report lower complications in the slow coagulation group while maintaining similar vision and IOP outcomes, which has contributed to the increased adoption of this technique.[8–10] Although conventional CPC may have previously been reserved for blind painful eyes or eyes which have already failed prior glaucoma surgery, recent literature supports slow coagulation TSCPC (SC-TSCPC) as a reasonable primary option to lower IOP in eyes without prior incisional glaucoma surgery.[5,6] However, there is limited literature on the efficacy of such CPC techniques in different ethnic groups and different lens statuses.[9,11,12] Considering the known racial disparities in glaucoma incidence, treatment outcomes, and re-operation rates, understanding the safety and efficacy of SC-TSCPC within a racial context is essential.[13–15]

More recently, Khodeiry et al. performed a large series at Bascom Palmer Eye Institute evaluating SC-TSCPC outcomes in pseudophakic patients which included 74 total patients: 27 of whom identified as Hispanic, 24 as White, and 20 as Black.[16] Although their overall outcomes were promising, their results were not stratified by racial group and therefore may be overlooking a potential disparity. As we practice in a predominantly Black/African American patient population in South Side Chicago, the purpose of this study is to describe outcomes of SC-TSCPC in a primarily African American patient cohort with various forms of refractory glaucoma, mirroring the methodology of the study published by Khodeiry et al.[16]

2. Methods

This study was conducted in accordance with the Declaration of Helsinki and approved by the Institutional Review Board of the University of Chicago Medicine. Written consent was waived with IRB approval.

A retrospective chart review was performed for patients aged 18 years or older who underwent SC-TSCPC by a single surgeon at the University of Chicago (MQ) from November 6th, 2019, to September 7th, 2023. A total 104 eyes of 100 patients were initially screened. Patients were excluded if the etiology was neovascular glaucoma (n = 39), there was history of a prior cyclodestructive procedure (n = 14), there was less than 3 months of post-operative follow-up data available (n = 9), the visual acuity was no light perception (n = 7) or unable to be assessed due to the patient's mental status (n = 1), or if the eye was aphakic (n = 2). Furthermore, 4 patients received SC-TSCPC on both eyes on the same day, so only their right eye was included. The patients were predominantly African American, representative of the demographics of the local community.

The primary outcome measure was the cumulative rate of surgical success at 12 and 24 months. Failure was defined as IOP >21 mm Hg, reduced by <20 % from baseline, or ≤5 mmHg on two consecutive follow-up visits, loss of light perception vision, or re-operation for glaucoma within the first 24 months which is similar to the criteria implemented in other studies on TSCPC.[5,16] Additional subsequent TSCPC treatments in the same eye were not considered as reoperation or failures as TSCPC is sometimes performed in a titratable manner per surgeon discretion.[5,16] Secondary outcome measures included visual acuity (VA), IOP, number of IOP-lowering medications, and post-operative complications.

Data was collected regarding demographic and clinical characteristics, including preoperative and postoperative best-corrected VA, IOP, and number of IOP-lowering medications at postoperative month (POM) 1, 3, 6, 12, 18, and 24. Baseline visual field mean deviation values were also collected when available. Data was collected regarding complications including conjunctival scarring, corneal decompensation, anterior chamber (AC) inflammation (any degree of cell or flare), pupillary changes, hypotony maculopathy (IOP ≤5 mm Hg with fundus abnormalities on physical exam), cystoid macular edema (CME) (detected using optical coherence tomography), and loss of light perception.[5,16] In accordance with previous literature, prolonged inflammation was defined as any degree of cell or flare documented at visits >1 months after surgery, or that which required increased topical steroid dosing at a post-operative visit.[16] In patients who underwent reoperation for IOP-lowering, data regarding the date and type of surgery were collected.

2.1. Surgical technique

SC-TSCPC procedures were performed as described by Khodeiry et al. with the following modifications.[16] G-Probe (Iri-dex Corp, Mountain View, California, USA) was used with power settings ranging from 1150 to 1500 mW over a fixed duration of 4 s. All patients received 10 mg of periocular dexamethasone at time of surgery (**Video 1**), except one patient who could not since his procedure was performed in the clinic instead of the operating room during the COVID pandemic. At that time, the operating room was closed due to the pandemic and there was no dexamethasone available in the clinic. The number of laser applications ranged from 10 to 25 for all patients. Postoperatively, prednisolone acetate 1 % drops were started at 6–8 times a day for ≥1 week and then tapered slowly on a biweekly basis for an average of 3 months. The one patient who underwent the procedure in the clinic without periocular dexamethasone was able to use topical difluprednate instead of topical prednisolone acetatate postoperatively. Variations to this regimen were made at the surgeon's discretion based on the patient's response to treatment, including the use of sub-Tenon depot Kenalog at time of surgery (n = 6).

2.2. Statistical analysis

Statistical analysis employed XLSTAT 2023; significance was set at $P < 0.05$. Subjects were categorized by lens status (phakic versus pseudophakic), as some literature found pseudophakic eyes to be associated with greater SC-TSCPC success rates.[5,16] Snellen VA measurements were converted to logarithm of the minimum angle of resolution (logMAR) VA for standardized intervals. Low vision categories counting fingers (CF), hand motion (HM), and light perception (LP) were substituted with 1.90, 2.30, and 2.70 logMAR, respectively, following established conventions.[17] Continuous variable differences used independent t-tests; Fisher's exact test analyzed categorical variables. Paired t-tests compared preoperative and postoperative IOP and medication values. When calculating the number of baseline IOP-lowering medications, oral carbonic anhydrase inhibitor counted as one IOP-lowering medication in addition to topical glaucoma medications. Kaplan-Meier survival analysis assessed success, with the log-rank test for intergroup comparisons. If an eye experienced multiple failure events, the time to first failure was used for analysis.

3. Results

3.1. Baseline characteristics

There were 28 eyes from 28 patients (mean age 75, 42.9 % female, 92.9 % Black/African American) that met inclusion criteria to be included in this analysis. The mean follow-up duration was 11.6 months (range 3–24, median 11.5). Baseline characteristics are shown in Table 1. Mean logMAR VA was 1.49 ± 0.8 (~20/600 Snellen VA), and mean baseline IOP was 31.1 ± 13.2 mmHg on 4.0 ± 1.5 IOP-lowering medications. The most prevalent glaucoma diagnosis was primary open-angle glaucoma (42.8 %). Of the 28 patients, 20 (71.4 %) had undergone one or more prior glaucoma procedures, with trabeculectomy being the most common surgery. Twenty-one patients (75.0 %) had CPC performed in their worse eye, while 7 patients (25.0 %) had the procedure done in their better eye – of which it was the only seeing eye for 3 of these patients.

Patients were also grouped by lens status, with 6 phakic eyes (21.4 %) and 22 pseudophakic eyes (78.6 %). Between cohorts, the pseudophakic group was older (P < 0.01) and had better baseline VA compared to the phakic group. Mean LogMAR VA was 2.15 ± 0.4 (~20/2800 Snellen VA) in the phakic group compared to 1.31 ± 0.8 (~20/400 Snellen VA) in the pseudophakic group (P = 0.02). The phakic and pseudophakic groups otherwise did not have any statistically significant differences in any other baseline demographic or clinical characteristic (Table 1). Baseline IOP in the phakic group was 29.3 ± 15.9 mmHg on 3.5 ± 2.7 medications compared to 31.6 ± 12.8 mmHg on 4.1 ± 0.9 medications in the pseudophakic group (P = .72; P = .39).

On average, treated patients received 19.2 laser spots (range 10–25, median 20) and completed their post-operative steroid taper over an average of 3.0 ± 1.1 months.

Table 2 compares clinical parameters at baseline and the last follow-up visit. Among the entire cohort of 28 patients, the mean logMAR VA worsened from 1.49 ± 0.82 (~20/600 Snellen VA) at baseline to 1.72 ± 0.83 (~20/1050 Snellen VA) at the most recent follow-up ($P = 0.04$). No significant difference in the change of logMAR VA at last follow-up was observed between the two groups ($P = 0.24$; Table 2). Improvements from baseline VA was recorded in 6 eyes (21.4 %), 8 eyes (28.6 %) experienced no change from baseline VA, 3 eyes (10.7 %) had slight decrease in VA (≤2 lines), and 10 eyes (35.7 %) had logMAR VA decreased by ≥ 2 lines at the last follow-up. Causes of decreased VA in

Table 1
Baseline clinical characteristics and prior procedures.

Characteristic	Total	Phakic	Pseudophakic	P value
Eyes (n)	28	6	22	n/a
Age (years)				<0.01[Δ]
Mean ± SD	75.2 ± 13.9	62.2 ± 16.9	78.7 ± 10.9	
Median (range)	81.0 (42–92)	61.5 (42–86)	82.0 (58–92)	
Sex, n (%)				1.00[Ω]
Male	16 (57.1)	3 (50.0)	13 (59.1)	
Female	12 (42.9)	3 (50.0)	9 (40.9)	
Race, n (%)				1.00[Ω]
Black	26 (92.9)	6 (100.0)	20 (90.9)	
Non-Hispanic White	1 (3.6)	0 (0.0)	1 (4.5)	
Hispanic	1 (3.6)	0 (0.0)	1 (4.5)	
Laterality: right, n (%)	16 (57.1)	2 (33.3)	14 (63.6)	0.35[Ω]
IOP (mm Hg)				0.72[Δ]
Mean ± SD	31.1 ± 13.2	29.3 ± 15.9	31.6 ± 12.8	
Range	11–60	16–60	11–57	
Glaucoma Medications (n)				0.39[Δ]
Mean ± SD	4.0 ± 1.5	3.5 ± 2.7	4.1 ± 0.9	
Range	0.0–6.0	0.0–6.0	2.0–6.0	
VA (Categories), n (%)				0.21[Ω]
20/20 – 20/50	4 (14.3)	0 (0.0)	4 (18.2)	
20/80 – 20/150	5 (17.8)	0 (0.0)	5 (22.7)	
20/200 – 20/600	7 (25.0)	1 (16.7)	6 (27.3)	
Low Vision (CF, HM, LP)	12 (42.9)	5 (83.3)	7 (31.8)	
VA (logMAR)				0.02[Δ]
Mean ± SD	1.49 ± 0.8	2.15 ± 0.4	1.31 ± 0.8	
Median	1.48	2.3	1.20	
Range	0–2.7	1.40–2.7	0–2.7	
Glaucoma subtype, n (%)				0.65[Ω]
POAG	12 (42.8)	2 (33.3)	10 (45.5)	
CACG	2 (7.1)	1 (16.7)	1 (4.5)	
Traumatic	6 (21.4)	1 (16.7)	5 (22.7)	
*Hyphema**	2 (7.1)	1 (16.7)	1 (4.5)	
Mixed Mechanism	5 (17.9)	1 (16.7)	4 (18.2)	
PACG	1 (3.6)	0 (0.0)	1 (4.5)	
Prior Procedure[†], n (%)	20 (71.4)	3 (50)	17 (77.3)	0.32[Ω]
Trabeculectomy	8 (28.6)	1 (16.7)	7 (31.8)	
Ahmed Valve	1 (3.6)	0 (0.0)	1 (4.5)	
BGI-350	1 (3.6)	0 (0.0)	1 (4.5)	
GATT	2 (7.1)	0 (0.0)	2 (9.0)	
Goniotomy	4 (14.2)	0 (0.0)	4 (18.2)	
iStent®	3 (10.7)	0 (0.0)	3 (13.6)	
SLT	5 (17.9)	2 (33.3)	3 (13.6)	
LPI	2 (7.1)	0 (0.0)	2 (9.0)	

BGI-350 = baerveldt-350 implant; CACG = chronic angle-closure glaucoma; CF = counting fingers; GATT = gonioscopy-assisted transluminal trabeculotomy; HM = hand motion; IOP = intraocular pressure; iStent® = trabecular micro-bypass stent; logMAR = logarithm of the minimum angle of resolution; LP = light perception; LPI = laser peripheral iridotomy; n/a = not applicable; PACG = primary angle-closure glaucoma; POAG = primary open-angle glaucoma; SLT = selective laser trabeculoplasty; SD = standard deviation; VA = visual acuity. * Due to hemolytic glaucoma. Both eyes in this "hyphema" group had very poor visual potential, high IOP, hyphema and vitreous hemorrhage in the setting of proliferative diabetic retinopathy and recent pars plana vitrectomy for tractional retinal detachment; of note, these two cases did not have traumatic hyphemas. [Δ] Student's t-test. [Ω]Fisher's Exact Test. [†]Some patients had more than one prior IOP lowering procedure. Percentage is calculated out of the whole group.3.2-Visual acuity.

Table 2
Clinical outcomes at last follow-up visit after transscleral cyclophotocoagulation.

Eyes (n)	Total	Phakic	Pseudophakic	P value
	28	6	22	n/a
Follow-up (months)*	11.6 ± 8.3	11.3 ± 8.1	11.7 ± 8.5	0.92[Δ]
IOP (mmHg)*				
Baseline	31.1 ± 13.2	29.3 ± 15.9	31.6 ± 12.8	0.72[Δ]
Last follow-up	13.8 ± 7.1	14.8 ± 3.8	13.6 ± 7.8	0.80[Δ]
Change	−17.3 ± 16.4	−14.5 ± 17.9	−18.0 ± 16.4	0.65[Δ]
Eyes with ≥ 20 % decrease in IOP[†]	24 (85.7)	5 (83.3)	19 (86.4)	1.0[Ω]
Eyes with final IOP ≤ 21 mmHg[†]	24 (85.7)	6 (83.3)	18 (81.2)	0.55[Ω]
Retreatments[†]	2 (7.1)	0 (0.0)	2 (9.1)	1[Ω]
Glaucoma Medications*				
Baseline	4.0 ± 1.5	3.5 ± 2.7	4.1 ± 0.9	0.39[Δ]
Last follow-up	2.6 ± 1.5	3.3 ± 0.8	2.5 ± 1.7	0.22[Δ]
Change	−1.3 ± 2.3	−0.2 ± 2.4	−1.6 ± 2.0	0.11[Δ]
VA (logMAR)*				
Baseline	1.49 ± 0.82	2.15 ± 0.45	1.31 ± 0.81	0.02[Δ]
Last follow-up	1.72 ± 0.83	2.16 ± 0.49	1.61 ± 0.87	0.15[Δ]
Change	0.25 ± 0.55	0.01 ± 0.26	0.32 ± 0.60	0.24[Δ]

IOP = intraocular pressure; logMAR = logarithm of the minimum angle of resolution; n/a = not applicable; VA = visual acuity. *Data presented as mean ± standard deviation. [†]Data presented as n (%). [Δ] Student's t-test. [Ω]Fisher's Exact Test.

those 13 eyes were attributable to glaucoma in 5 eyes, retinal vascular disease in 5 eyes, corneal disease in 2 eyes, and neurological factors in 1 eye. The neurological factor limiting VA in this patient was ischemic neuropathy of the right eye following a cerebrovascular accident. Humphrey Visual Fields (HVF) data was only available for 5 patients at baseline, because the others had vision too poor to do a visual field test in their operative eye. HVF mean deviations (MD) for these 5 patients was −16.09 dB (dB) (range −2.18 to −29.51 dB). Of note, CPC was performed on the patient with MD of −2.18 dB due to initial patient refusal for incisional surgery. The next lowest MD available was −9.02 dB.

3.3. IOP and medications changes

Table 3 presents IOP measurements and the number of medications for the overall cohort and the two groups at various time points, including baseline, 1-week post-operation, and 1, 3, 6, 12, 18, and 24 months of follow-up. Missed visits or re-operations for glaucoma were the primary reasons for the decrease in the number of patients at follow-up time points. To avoid confounding, clinical parameters of patients who underwent additional glaucoma surgery were excluded from the analysis after glaucoma reoperation.

In the overall cohort, IOP measurements showed significant reductions compared to baseline at all follow-up time points ($P < 0.02$). The mean reduction at last follow-up was 17.3 ± 16.4 mmHg ($P < 0.001$) with 24 eyes (85.7 %) achieving a ≥20 % reduction in baseline IOP and no significant differences between the two groups ($P = 1.0$, Table 2). In the pseudophakic group, IOP was significantly reduced from baseline at all postoperative visits ($P < 0.001$ for all visits, except for $P = 0.03$ at 18 months, $P = 0.04$ at 24 months; Fig. 1). The phakic group also showed postoperative IOP reduction at all visits, however, statistical significance was variable and could not accurately be detected between each visit due to low power. The mean IOP reduction at last follow-up compared to baseline was 18.0 ± 16.4 mmHg in the pseudophakic group ($P < 0.001$) compared to 14.5 ± 17.9 mmHg in the phakic group ($P = 0.1$), with no significant difference in absolute reduction between the two groups ($P = 0.65$, Table 2).

Only two eyes (7.1 %) required additional TSCPC, with both achieving a ≥20 % reduction in IOP from baseline after retreatment. No difference in retreatment rates was observed between the two groups ($P = 1.0$).

All participants experienced a decrease in the number of medications from 4.0 ± 1.5 at baseline to 2.6 ± 1.5 at the last follow-up visit ($P < 0.01$). This reduction was statistically significant at 1 week, and 1-, 3-, and 6-month follow-up ($P < 0.01$, $P = 0.01$, $P < 0.001$, $P = 0.02$, respectively). Throughout the follow-up period, both groups required, on average, fewer medications compared to baseline.

3.4. Surgical success

The overall cumulative probability of success was 68.5 % at the one-year visit and remained consistent for the remainder of the follow-up period (Fig. 2). In the phakic group, the cumulative success rate was 55.5 % at the 1- and 2-year intervals while the pseudophakic group demonstrated a 72.2 % success rate at both time points ($P = 0.62$, log-rank test; Fig. 3).

Two patients in the phakic group and five patients in the pseudophakic group experienced treatment failure (Table 4). The most common reasons for failure across both groups were inadequate reduction in intraocular pressure (IOP >21 mm Hg and/or a reduction of <20 % from baseline IOP on two consecutive visits) and hypotony (IOP ≤5 mm Hg on two consecutive follow-up visits). Additionally, one phakic patient initially underwent bilateral SC-TSCPC due to refusal of all incisional surgery, but subsequently had to undergo cataract surgery, goniosynechialysis, and goniotomy in both eyes for a combination of visually significant cataract, IOP reduction, and medication reduction. Baseline demographics and clinical features, including age, race, and gender, were not found to be significantly associated with time to treatment failure or outcome using Cox survival regression analysis ($P = 0.60$).

Table 3
Intraocular pressure and medical therapy outcomes at baseline and follow-up visits after transscleral cyclophotocoagulation.

Characteristic	Total	Phakic	Pseudophakic	P-Value
Baseline				
Patients with follow-up (n)	28	6	22	
*IOP (mmHg)**	31.1 ± 13.2	29.3 ± 15.9	31.6 ± 12.8	0.72
*No. of glaucoma medications**	4.0 ± 1.5	3.5 ± 2.7	4.1 ± 0.9	0.39
1 Week				
Patients with follow-up (n)	27	6	21	
*IOP (mmHg)**	11.7 ± 8.2	9.2 ± 6.4	12.9 ± 8.4	0.33
*No. of glaucoma medications**	3.0 ± 1.8	3.5 ± 1.4	2.8 ± 1.9	0.41
1 month				
Patients with follow-up (n)	25	6	19	
*IOP (mmHg) **	11.8 ± 6.1	12.8 ± 7.1	11.5 ± 6.0	0.66
*No. of glaucoma medications**	2.9 ± 1.8	3.3 ± 2.0	2.8 ± 1.7	0.50
3 months				
Patients with follow-up (n)	24	5	19	
*IOP (mmHg) **	13.3 ± 7.3	15.2 ± 5.5	12.8 ± 7.7	0.53
*No. of glaucoma medications**	2.6 ± 1.7	2.6 ± 1.9	2.6 ± 1.7	0.96
6 months				
Patients with follow-up (n)	17	5	12	
*IOP (mmHg) **	13.5 ± 5.6	15.2 ± 5.4	12.8 ± 5.7	0.43
*No. of glaucoma medications**	2.9 ± 1.5	3.8 ± 0.4	2.5 ± 1.7	0.12
12 months				
Patients with follow-up (n)	14	2	12	
*IOP (mmHg)**	11.1 ± 4.3	16.0 ± 4.2	10.3 ± 3.9	0.08
*No. of glaucoma medications**	3.3 ± 2.9	2.6 ± 1.5	3.25 ± 3.2	0.92
18 months				
Patients with follow-up (n)	7	2	5	
*IOP (mmHg)**	15.4 ± 5.7	10.5 ± 6.4	17.4 ± 4.7	0.16
No. of glaucoma medications[a]	3.1 ± 0.9	3.5 ± 0.7	3.0 ± 1.0	0.56
24 months				
Patients with follow-up (n)	6	1	5	
*IOP (mmHg)**	14.7 ± 6.9	11[Δ]	15.4 ± 7.5	n/a[Ω]
*No. of glaucoma medications**	3.7 ± 1.4	4[Δ]	3.6 ± 1.5	n/a[Ω]

IOP = intraocular pressure. *Data presented as mean ± standard deviation. [Δ]Standard deviation is inapplicable because there is only one observation for this subgroup. [Ω]T-test is inapplicable because there is only one observation in one subgroup.

3.5. Postoperative complications

A total of 24 patients (85.7 %) had anterior chamber inflammation at the 1-month visit which persisted in 3 patients (10.7 %) at last follow-up (POM 3; Table 5). Additionally, one patient demonstrated rebound iritis

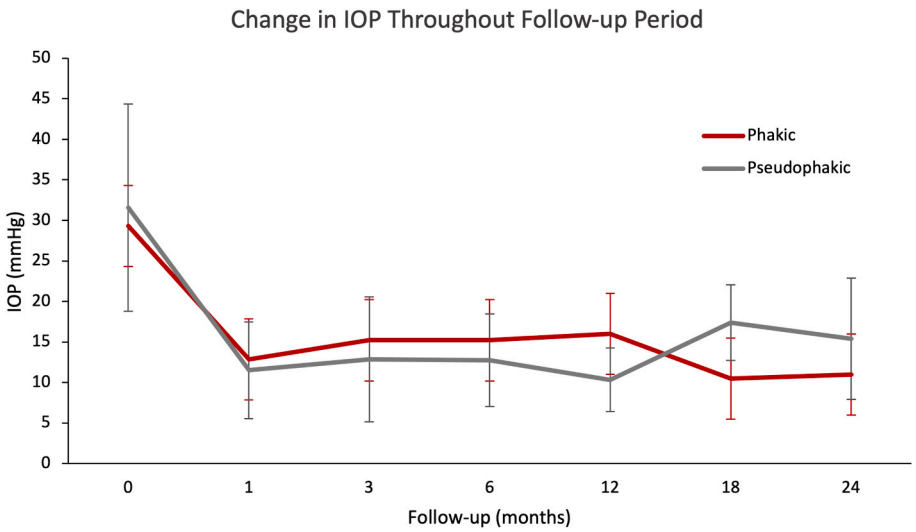

Fig. 1. Graph showing intraocular pressure (IOP) at baseline and follow-up in the phakic and pseudophakic groups. Data presented as mean and standard error of the mean and is censored after a reoperation for glaucoma.

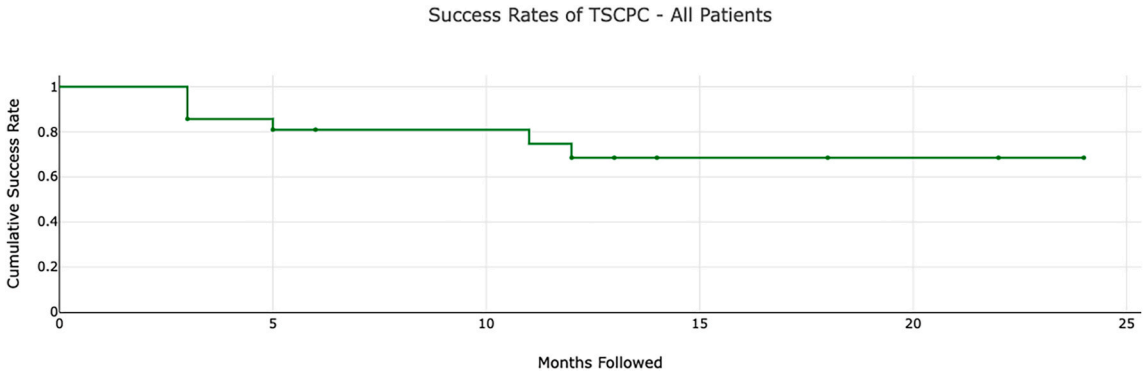

Fig. 2. Kaplan-Meier curve for the cumulative success rates of the overall cohort after transscleral cyclophotocoagulation.

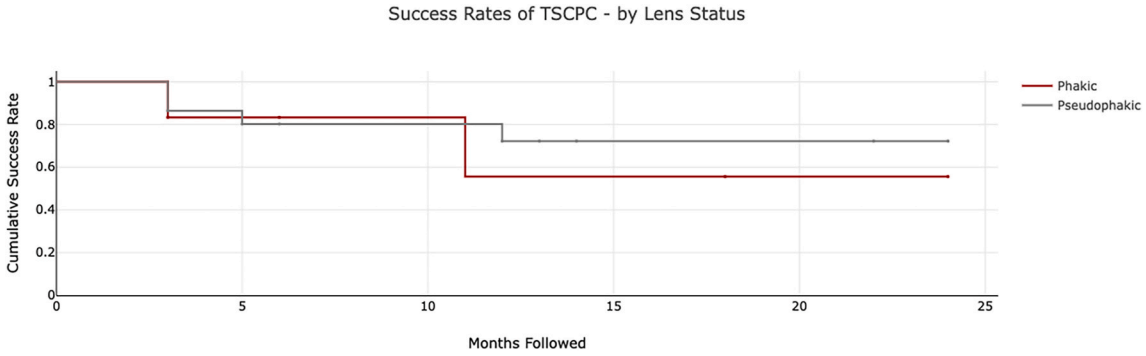

Fig. 3. Kaplan-Meier curves showing the cumulative success rates of phakic and pseudophakic groups after transscleral cyclophotocoagulation.

twice at POM12 and POM20 but was resolved upon completion of steroid taper both times. CME was observed in 6 patients (21.4 %) and was persistent in 3 patients (10.7 %) at last follow-up (post-operative months 3, 5, and 12 respectively). One patient (3.6 %) developed postoperative hyphema that resolved within 3 months. No cases of loss of light perception, hypotony maculopathy (indicated by the presence of folds), choroidal effusion, corneal decompensation, pupillary abnormalities, conjunctival scarring, sympathetic ophthalmia, or phthisis bulbi were observed within the 24-month post-operative follow-up period.

4. Discussion

In this study, we analyzed the clinical outcomes of slow coagulation CW-TSCPC in a predominately African American patient population with medically uncontrolled glaucoma or those who were refractory to prior surgeries. Our data shows that, regardless of lens status, SC-TSCPC is efficient and acceptably safe when used as an alternative glaucoma intervention in this demographic.

While most patients either had vision improvement or maintained baseline VA, ten (35.7 %) patients lost ≥2 lines of Snellen VA. This is

Table 4
Reasons for failure.

Reason	Total	Phakic	Pseudophakic
Inadequate IOP reduction*	3 (42.9)	1 (50.0)	2 (40.0)
Reoperation for glaucoma	1 (14.3)	1 (50.0)	0 (0.0)
Persistent hypotony†	3 (42.9)	0 (0.0)	3 (60.0)
Loss of LP	0 (0.0)	0 (0.0)	0 (0.0)
Total (n)	7	2	5

Data are presented as no. (%), unless otherwise indicated. Patients are categorized according to the first-occurring reason for treatment failure. *Intraocular pressure of more than 21 mmHg or reduced by less than 20 % from baseline on 2 consecutive follow-up visits. †Intraocular pressure of ≤5 mmHg on 2 consecutive follow-up visits. IOP = intraocular pressure; LP = light perception.

Table 5
Postoperative complications within 24 month follow-up period.

Complications	Total	Phakic	Pseudophakic
Anterior chamber inflammation	24 (85.7)	5 (83.3)	19 (86.4)
Cystoid macular edema	6 (21.4)	0 (0.0)	6 (27.3)
Hyphema	1 (3.6)	0 (0.0)	1 (4.5)
Hypotony maculopathy	0 (0.0)	0 (0.0)	0 (0.0)
Loss of Light Perception	0 (0.0)	0 (0.0)	0 (0.0)
Pupillary abnormalities	0 (0.0)	0 (0.0)	0 (0.0)
Conjunctival burn	0 (0.0)	0 (0.0)	0 (0.0)
Choroidal effusion	0 (0.0)	0 (0.0)	0 (0.0)
Corneal decompensation	0 (0.0)	0 (0.0)	0 (0.0)
Persistent complication at last follow-up			
Anterior chamber inflammation	3 (10.7)	0 (0.0)	3 (13.6)
Cystoid macular edema	3 (10.7)	0 (0.0)	3 (13.6)

Data presented as n (%). Two cases of prolonged anterior chamber inflammation and one case of persistent inflammation with subsequent cystoid macular edema was a result of noncompliance to post-operative steroid dosing. Four cases of cystoid macular edema were in eyes with underlying diabetes or retinal vein occlusions.

comparable to the range of 15–60 % reported in previous studies evaluating both standard and SC-TSCPC.[8,18] Despite maintaining a better overall VA than the phakic cohort, nine pseudophakic eyes (40.1 %) experienced a significant loss of VA compared to only one phakic eye (16.7 %). One possible explanation for this discrepancy between groups is that more phakic patients started and remained at low vision categories (*CF, HM, and LP*) at last follow-up, whereas pseudophakic patients were distributed more evenly across various VA ranges at all time points. Such low vision categories are often highly subjective and difficult to measure, therefore making it hard to determine true significant vision loss and leading to inaccurate converted logMAR values and a blunted change in VA.[17]

This study also sought to compare clinical outcomes of our pseudophakic cohort specifically with those reported by the slow coagulation techniques of Khodeiry and associates.[16] Among the nine pseudophakic patients who experienced significant loss in VA in our cohort, four cases (18.8 %) were primarily due to glaucoma compared to the 5.4 % of pseudophakic patients in their group, with the others reported to either be partially or fully limited by other underlying retinal or corneal diseases.[16] One possible explanation for this difference is that vision loss due to glaucoma in our cohort was primarily related to disease progression as end-stage cases, whereas their study reported on cases in which SC-TSCPC served as a primary intervention. Furthermore, surgical discretion may have also contributed to this difference. Of the ten total patients experiencing significant vision loss, nine (90.0 %) had CPC performed in their worse eye with VA in the alternate eye ranging from 20/25–20/100. Since almost all these eyes were being treated palliatively, we prioritized comfort over function which may have negatively impacted measured visual outcomes. Only one of these patients had CPC done in their better, only-seeing eye, and this was indicated due to a thin conjunctiva, recurrent erosions, and unprovoked infections of previous tubes. Even then, reduced vision in this patient was related to a cloudy corneal graft and not progression of glaucoma.

Our cumulative success rate of 68.5 % was comparable to rates of 35–85 % reported in both standard and slow coagulation TSCPC procedures among patients with medically and surgically refractory glaucoma.[10,19,20] Among pseudophakic patients receiving slow-coagulation TSCPC, Khodeiry et al. reported a cumulative success rate of 60.6 % at 12-months and 58.5 % at 24-months compared to 72.2 % among our pseudophakic patients at both time periods in this study.[16] The stability of success rates between 12- and 24-months may be explained by reports that eyes treated with CPC tend to fail earlier than glaucoma drainage devices, but have relatively few late failures after the first year.[21] Additionally, only two pseudophakic eyes (9.1 %) in our study underwent additional TSCPC retreatment which is lower than 14.9 % of eyes in Khodeiry et al. and the range of 20–60 % reported in current literature of standard TSCPC treatment.[16,22,23] It is important to note that although failure was defined specifically for the purposes of the study parameter, clinically speaking, the criteria for success or failure was patient dependent and may not been confined strictly to these guidelines.

The mean IOP decreased significantly at all follow-up visits. Compared to baseline, significant reductions ranging between 18.5 and 96.5 % at last follow-up visit were observed in our cohort with 85.7 % of the patients having an IOP reduction of ≥20 %. The hypotensive effect of slow coagulation CW-TSCPC in our study was higher than, or comparable to, previous studies evaluating the efficiency of the standard "pop" technique of CW-TSCPC for refractory glaucoma.[24–27] In one study of standard TSCPC conducted by Grueb and associates on patients with progression of glaucoma refractory to ocular surgery and maximal medical therapy, the mean IOP reduction was 23.8 % after 12 months.[24] Stanca et al. utilized slow-coagulation techniques among a similar patient population, and reported a decrease in mean IOP from 47.6 ± 6.2 mmHg to 18.0 ± 4.1 mmHg after 6 months.[19] This is compared to a mean reduction of 43.9 % (31.1 ± 13.2 mmHg to 13.8 ± 7.1 mmHg) over a mean follow-up of 11.6 months in our study. Additionally, 86.4 % of our pseudophakic patients achieved a ≥20 % decrease in IOP compared to 75.7 % of patients in Khodeiry et al.[16]

Furthermore, in the present study, the absolute IOP-lowering effect of SC-TSCPC was found to be slightly greater in pseudophakic patients compared to phakic patients, yet not significantly so. We reported a mean reduction of 18.0 ± 16.4 mmHg in the pseudophakic group vs. 14.5 ± 17.9 mmHg in the phakic group (P = 0.65) with 86.4 % and 83.3 % of eyes achieving a ≥20 % decrease in IOP, respectively (P = 1.0). Similarly, no statistical difference between the cumulative probability of success rates was observed (P = 0.62). These findings differ from previous studies which suggest that lens status might be a prognostic factor for the absolute reduction of IOP after primary slow-coagulation TSCPC.[5,16] However, while the absolute value of IOP reduction was not significant between the groups, more profound effects were observed *within* the pseudophakic group. Compared to their respective baseline values, the pseudophakic patients experienced a greater significance in IOP reduction at last follow-up than the phakic group (P < 0.001 vs P = 0.1; Paired *t*-test). Although the relationship between pseudophakia and IOP reduction has been studied in glaucomatous and non-glaucomatous patients alike, the exact mechanisms of this process are neither clear nor conclusive and have been linked to a variety of pre-operative statuses such as lens placement, angle parameters, and glaucoma diagnosis.[28,29] This observed difference in significance may also be due to the greater power of pseudophakic patients, which allows for more accurate comparison within the cohort.

In addition to IOP reduction, the average number of medications at all follow-up visits were lower than baseline with no significant difference between our phakic and pseudophakic cohorts (P = 0.11). Among pseudophakic patients specifically, the mean number of glaucoma medications decreased from 4.1 ± 0.9 at baseline to 2.5 ± 1.7 at last follow-up visit. This mean reduction of 1.6 glaucoma medications is

greater than the reduction of 1.3 medications found with the standard TSCPC technique of Winkler and associates, and 0.9 medications reported by Khodeiry and associates utilizing similar slow-coagulation techniques.[16,30] The mean IOP and number of medications continued to be lower than baseline values throughout 11.7 ± 8.5 months of follow-up, suggesting the persistence of IOP-lowering and decrease in medications dependence effects of SC-TSCPC even up to the first year. Studies with longer follow-up periods would be required to confirm the long-term efficiency of SC-TSCPC on these outcomes.

Most reported complications in this study were mild and transient, comparable to existing literature utilizing similar slow coagulation techniques.[5,16] TSCPC causes destruction of the ciliary body tissues, making irreversible hypotony a concern.[27] Current literature suggests that the risks of hypotony and phthisis may be directly proportional to the dosage of laser energy delivered in a treatment session, which is lower in the slow-coagulation technique applied in our study compared with the standard-coagulation technique.[8,20] The incidence of hypotony in our study was low, with only three eyes (10.7 %) showing persistent hypotony (defined as IOP ≤5 mmHg on 2 consecutive follow-up visits). However, none of these eyes demonstrated associated clinical complications from hypotony such as maculopathy or choroidal effusion upon physical exam. This is similar to rates seen in other SC-TSCPC studies, but better than studies evaluating standard TSCPC outcomes which report rates of hypotony maculopathy ranging from 1.0 to 25.0 % and phthisis ranging from 0 to 10 %.[5,16,24,31,32] Additionally, in this study no other serious complications typically associated with traditional TSCPC were observed, such as loss of light perception, corneal decompensation, choroidal effusion, or hemorrhage. A single patient (3.6 %) developed transient hyphema during the follow-up period, which is comparable to one patient (1.4 %) reported by Khodeiry et al.[16] None of our patients experienced loss of light perception, which is more favorable than rates of 1.6–4.2 % in similar slow coagulation studies.[5,16]

Prolonged postoperative inflammation and subsequent sequela such as CME are another significant concern after glaucoma surgery, including TSCPC surgery.[33] Overall, our patients experienced high rates of anterior chamber inflammation throughout the study period with no significant difference between phakic and pseudophakic cohorts (P = 1.0; Fisher's Exact Test). 10.7 % of our patients reported persistent inflammation at last follow-up which is comparable to an average of 10 % (range 1.9–20 %) in published reports of standard TSCPC techniques.[34] However, in comparison with other slow-coagulation studies, 86.4 % of our pseudophakic patients experienced prolonged anterior chamber inflammation during the early postoperative follow-up period with 13.6 % persisting at last follow-up, compared to only 12.2 % and 2.7 % reported in Khodeiry et al. respectively.[16]

Despite similar surgical techniques, such differences in inflammation rates may be influenced by a few factors. First, some of these cases may be attributed to poor patient adherence to post-operative drop regimen - which may have also been a contributing factor as to why CPC was chosen instead of incisional surgery initially. Secondly, SC-TSCPC was utilized in many of our patients as a last resort compared to as a primary method of treatment in Khodeiry et al.[16] Failure rates and high complications rates are known to be much more likely in these eyes.[35] Lastly, compared to the 27.0 % of Black/African American pseudophakic patients in their study, 90.9 % of our pseudophakic cohort identified as Black/African American. This is noteworthy as extensive research exists on the relationship of race on rates of inflammation and CME following ocular surgery.[12,36,37] One study measuring rates of uveitis after uncomplicated phacoemulsification cataract extraction, found African Americans to be twice as likely to have continued inflammation at 1 year postoperatively compared to their White counterparts.[36] Similar findings have been reported amongst African American patients receiving phacoemulsification cataract surgery combined with endoscopic cyclophotocoagulation.[12] While studies measuring outcomes of TSCPC across different parts of Africa vary in indications for treatment, sample sizes, and follow-up periods, all of them report postoperative uveitis as the most common complication with peak incidences often higher than comparable studies.[38–40]

Although there is a clear association between post-operative intraocular inflammation and African ancestry, the mechanisms behind such findings are unclear. The present study did not find any association between race and length of surgery; and patients were not reported to have had any perioperative complications that may have contributed to worse outcomes. One explanation that has been discussed in current literature is the increased amount of melanin in African eyes which has previously been shown to augment intraocular inflammation.[41] In addition, injections of bovine ocular melanin were shown to induce an experimental uveitis in certain rat strains.[42] As more pigment can lead to increased absorption of laser energy, it is possible that ciliary body damage might be more likely in individuals with darker pigmentation undergoing CPC.

Another prevalent complication among our cohort was CME, which was observed in six eyes (21.4 %) based on optical coherence tomography (OCT) imaging and was persistent in three eyes (10.7 %) at last follow-up. This is much higher than the 2.7 % of patients with post-operative CME in Khodeiry et al. and above the range of 1–12.5 % reported by other groups utilizing either slow coagulation or standard TSCPC.[5,16,34] Rates of CME were not found to be significantly different between our phakic and pseudophakic cohorts (P = 0.29; Fisher's Exact Test). The three eyes in which CME was persistent showed clinical significance by causing a decrease in VA of ≥2 lines, however this may not have been attributable to the procedure itself. Among these eyes, two developed CME from central retinal vein occlusions at POM6 and POM14 respectively and were treated with intravitreal anti-vascular endothelial growth factor injections leading to improvement of CME and VA after completion. A third eye, with no significant visual loss, also presented with CME due to retinal vein occlusion with edema promptly improving after modifications to post-operative steroid regimen. A fourth eye had underlying diabetes diagnosis which contributed to diabetic macular edema. For these reasons, it is likely that the CME in only two of the six eyes (7.1 % of total patients) may be attributed to TSCPC, which is closer to the rate of 2.7 % (also two eyes) reported by Khodeiry et al.[16]

In addition to racial demographics leading to greater inflammation and subsequent CME among our cohort, the increased CME rate may also simply be the result of an increased detection rate. Although macular (Mac) OCT is typically reserved for patients presenting with unexplained significant worsening vision post-operatively, we routinely conduct them as part of standard post-operative care regardless of VA. In our study, one third of patients found to have CME did not present with any significant visual loss at time of imaging. This suggests part of the increased cases of CME may simply be due to increased surveillance. Awareness of these risks may lead to prompt modifications of post-operative steroid and non-steroidal anti-inflammatory drug (NSAID) regimens in Black/African American patients, with further investigation potentially leading to improved preventative measures.[37]

The purpose of this retrospective analysis was to describe the efficacy and safety of slow coagulation TSCPC for uncontrolled glaucoma in both phakic and pseudophakic patients at a tertiary academic center in South Side Chicago. Primary limitations of this study are its retrospective nature and small sample size. As with all retrospective chart review studies, inherent assumptions and inconsistencies of proper documentation in medical records may have resulted in an underestimation of some adverse events. Additionally, the number of patients at follow-up points after 12 months was relatively low. While comparisons were also made between cohorts, statistically significant differences found within the phakic group specifically may not have accurately been detected due to its small sample size compared to the pseudophakic group. Lastly, the postoperative treatment protocol was not standardized for all patients. Inflammation was treated at the physician's discretion, leading to some variability in the length of steroid treatment, particularly in low-grade inflammation.

In summary, slow coagulation TSCPC has favorable efficacy with minimal serious postoperative complications when used as a surgical glaucoma intervention in patients with medically uncontrolled or surgically refractory glaucoma. Clinical outcomes were better than or comparable to other slow-coagulation studies, and no significant differences were found between phakic and pseudophakic cohorts as other studies may suggest. However, higher rates of post-operative inflammation and CME were present in our subjects compared to current literature which may be a result of a predominant make-up of patients with African ancestry. Our findings support extending the role of SC-TSCPC in glaucoma management regardless of lens status, while also encouraging further research into unique preventative measures and post-operative modifications that can be tailored for Black/African American populations.

5. Patient consent

- Written consent was waived with IRB approval.
- **Video 1** does not contain any personal information that could lead to the identification of the patient.

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CRediT authorship contribution statement

Zaid Parekh: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Jessie Wang:** Writing – review & editing, Validation, Supervision, Methodology, Investigation, Data curation, Conceptualization. **Mary Qiu:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.The authors have no conflict of interest.

Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.ajoc.2024.102072.

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