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ORIGINAL ARTICLE

Changes in intraocular pressure during the first 24 h after transscleral cyclophotocoagulation

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Abstract

Aims: To estimate the changes in intraocular pressure (IOP) during the first 24 h after transscleral cyclophotocoagulation (TCP).

Methods: A prospective single-centre study, where patients with glaucoma destined for treatment with TCP were asked for participation. The IOP was measured prior to TCP and at 1, 2, 4, 6 and 24 h post-TCP. An IOP spike was defined as an elevation of IOP of ≥5 mmHg compared with baseline. The visual acuity (VA) was examined at baseline and after 24 h.

Results: The mean IOP prior to TCP in 58 eyes of 58 patients was 26.2 (±8.9 SD) mmHg. Twenty-three eyes (40%) experienced an IOP spike at some examination timepoint during the first 24 h. The mean value of the IOP spike was 12.1 (±6.9) mmHg. Fifty-six per cent of the eyes with pseudoexfoliation glaucoma (PEXG) experienced an IOP spike, and 16% had an IOP spike ≥20 mmHg. The IOP was significantly reduced at the 24 h examination by 8.1 (±7.8) mmHg ($n = 58$). The VA 24 h after TCP was unchanged compared with baseline.

Conclusion: Clinically significant IOP spikes were common in the first 24 h post-TCP. Almost one in five eyes had an increase of 10 mmHg and in almost one in 10 eyes, the IOP increase was 20 mmHg or higher. Eyes with PEXG had a higher occurrence of IOP spikes and displayed a greater magnitude of IOP elevation. Prophylactic post-operative IOP-lowering medication should be considered to prevent further glaucoma damage.

KEYWORDS
glaucoma, glaucoma treatment, intraocular pressure, laser treatment, prospective study, transscleral cyclophotocoagulation

1 | INTRODUCTION

Transscleral cyclophotocoagulation (TCP) is a well-established method used to reduce the intraocular pressure (IOP) in eyes with advanced glaucoma (Beckman et al., 1972; Murphy et al., 2003; Rotchford et al., 2010; Schlote et al., 2001; Vernon et al., 2006). TCP is often used when the IOP remains uncontrolled despite maximal medical therapy or filtrating glaucoma surgery. TCP comprises transscleral treatment using an 810-nm diode laser that targets and coagulates the pigmented epithelium of the ciliary body. The destruction caused by the laser leads to a reduced production of aqueous humour which in turn decreases the IOP.

Many studies have investigated the long-term efficacy and potential complications of TCP (Egbert et al., 2001; Rasmuson et al., 2019; Schlote et al., 2001; Vernon et al., 2006). However, knowledge of the short-term consequences of TCP is limited with few prospective studies (Razeghinejad et al., 2017; Uppal et al., 2015), and little is known of the immediate IOP changes that occur post-operatively.

A temporary elevation of IOP, also referred to as an 'IOP spike', is a known post-operative complication after TCP. Since TCP is predominantly used in sensitive eyes that are already compromised due to severe glaucoma, the treated eyes are especially vulnerable to such an IOP elevation as it might further damage the optic nerve. A few studies have reported IOP

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spikes after TCP (Contreras et al., 2004; Razeghinejad et al., 2017; Uppal et al., 2015). However, these studies only investigated the post-operative IOP results up to 3 h after treatment, hence it is unknown if there are IOP fluctuations during the remaining hours of the first post-operative day.

In this prospective study, we aimed to evaluate the post-laser IOP levels during the first 24 h after TCP in order to detect possible IOP spikes. A secondary aim was to investigate whether pre-operative factors could determine the risk of IOP spikes.

2 | METHODS

2.1 | Subjects

Glaucoma patients from Northern Sweden who were referred for TCP to the Department of Ophthalmology, University Hospital of Umeå, between April 2016 and June 2022, were offered participation in the study. Information was given orally, and written informed consent was obtained. Patients with glaucoma and age 18 years or above were eligible for the study. Exclusion criteria were amaurosis in the other eye and inability to provide informed consent. All levels of IOP and all stages of glaucomatous damage were allowed for inclusion. Baseline data including type of glaucoma, eye drops (IOP-lowering and anti-inflammatory drops), previous glaucoma surgery or laser treatment (including laser trabeculoplasty and TCP), and other ocular surgery and ocular co-morbidities were registered. If patients were treated with oral acetazolamide, the treatment was discontinued at a minimum of 24 h prior to TCP.

2.2 | Procedures

All TCP procedures were performed by the same surgeon (GJ) under sub-tenon anaesthesia (Carbocain 20 mg/mL) using the Oculight Sx semiconductor diode 810-nm laser and the contact G-probe (Iris Medical Instruments, Mountain View, CA USA). The TCP was performed according to a standard treatment protocol in which power was gradually increased from 1800 to 2500 mW with 2 s duration of each application. In case of an audible 'pop' sound, energy was reduced by 200 mW before continuation of treatment. This procedure was repeated in case of additional 'pop' sounds. According to the standard treatment protocol, 18 applications were evenly distributed over 270°, leaving one quadrant untreated, in most cases, the superior nasal quadrant. Post-operative treatment included topical antibiotic drops (Fucithalmic) for 4 days and steroid drops (Isopto-maxidex or Dexafree) for a minimum of 3 weeks.

The IOP was measured with both Goldmann applanation tonometry (GAT) (Haag-Streit, Bern, Switzerland) prior to TCP and 1, 2, 4, 6 and 24 h post-TCP. Measurements with rebound tonometry, that is, iCare (Icare Finland Oy, Vantaa, Finland) were also performed as a backup data source as it is a more objective measurement than GAT. The IOP measurements with GAT were used for analyses (the mean of three IOP measurements at each time point). Treatment with topical glaucoma medications was maintained unchanged throughout the 24-hour study. Treatment with oral acetazolamide was resumed after the 6-h control in a few cases of high IOP and advanced levels of glaucoma damage ($n=3$). An IOP spike was defined as an IOP elevation ≥5 mmHg compared with baseline.

Visual acuity was determined as the total number of correctly read letters on the Early Treatment Diabetic Retinopathy Study (ETDRS) chart at baseline and 24 h post-TCP, described as the logarithm of the minimum angle of resolution (logMAR). Eyes with vision less than 1.0 logMAR (0.1 Snellen acuity) were described as counting fingers, hand movements, light perception or amaurosis. Only one eye per patient and the first TCP treatment of that eye was used for analyses.

2.3 | Statistical Methods

Descriptive data were presented as mean and standard deviation (SD) unless otherwise stated. Paired-samples t-test was used to compare differences between IOP at baseline and IOP measurements at different timepoints. One-way ANOVA and linear regression were used for the analysis of differences in baseline factors influencing the IOP change. $p<0.05$ was considered significant. Data were analysed using SPSS Statistics version 28.0 (SPSS Inc, Chicago, IL, USA).

3 | RESULTS

Fifty-eight eyes of 58 patients receiving TCP were analysed; 8 (14%) had primary open-angle glaucoma (POAG), 25 (43%) pseudoexfoliation glaucoma (PEXG), 15 (26%) neovascular glaucoma (NVG) and 10 (17%) other types of secondary glaucoma (OSG). The baseline characteristics of the treated patients are shown in Table 1. The group with OSG included glaucoma secondary to amotio with silicon oil ($n=5$), ocular amyloidosis ($n=2$), uveitis ($n=1$), ocular trauma ($n=1$) and pigment glaucoma ($n=1$).

TCP treatments were performed with a mean number of laser effects of 17.8 (±1.0). The total delivered energy for each treatment was 80.8 (±8.2) mW and the number of pop sounds was 0.6 (±1.1) per treatment. The mean volume of administered sub-tenon anaesthesia was 1.9 (±0.6) mL.

3.1 | Intraocular pressure

The mean IOP and the mean IOP change in all eyes are shown in Table 2a. Table 2b and Figure 1 show the mean IOP and IOP change at the different time points for each of the glaucoma subgroups. Only IOP measurements with GAT are reported as there was no statistical difference between the IOP measured with the two tonometry methods at any time point.

The mean IOP change compared to baseline IOP at the 6-hour examination was significantly different between the glaucoma types ($p=0.008$). Post hoc analysis revealed a difference in 6-hour IOP change between eyes with PEXG and eyes with NVG ($p=0.04$). Gender, age, previous TCP, number of audible pops, total energy delivered, volume of distributed anaesthetics and previous glaucoma surgery did not significantly influence the 6-hour IOP change.

3.2 | IOP spikes

Twenty-three eyes (40%) experienced an IOP spike at some examination point during the first 24 h after TCP. The mean value of the IOP spike was 12.1 (±6.9) mmHg ranging from 5.0 to 28.6 mmHg. Eleven eyes (19%) displayed an IOP elevation ≥10 mmHg compared with baseline. Furthermore, five eyes (9%) had an IOP elevation of ≥20 mmHg (range of IOP increase 20.4–28.6 mmHg). Two of these eyes had been previously treated with TCP.

Among all eyes with PEXG included in the study ($n=25$), 56% got an IOP spike after TCP. The corresponding figures were 25% in POAG, 33% in NVG and 20% in OSG. Twenty eight percent of all eyes with PEXG got an IOP spike ≥10 mmHg, and 16% got an IOP spike ≥20 mmHg.

TABLE 1 Baseline characteristics of the 58 eyes of the 58 patients.

	n (%)	Mean	SD	Range
Age (years)	58	75.4	8.9	47–92
Female	21 (36)	–	–	–
Number of drops		3.5	1.1	1–5
Previous LTP	18 (31)			
Previous filtration surgery	19 (33)	–	–	–
Previous TCP	16 (28)			
Pseudophakia	40 (69)			
Other ocular surgery	17 (29)			
Baseline IOP (mmHg)	58	26.2	8.9	12–49
Baseline VA (logMAR)	24[a] (41)	0.6[b]	0.3	0.1–1.0

Abbreviations: IOP, intraocular pressure; logMAR, logarithm of the minimal angle resolution; LTP, laser trabeculoplasty, *N*, number; SD, standard deviation; TCP, transscleral cyclophotocoagulation; VA, visual acuity.

[a]Number of eyes where a visual acuity measurement with the ETDRS chart could be performed.

[b]Equal to 0.3 Snellen acuity.

3.3 | Visual acuity

The visual acuity (VA) was measured in all eyes. The ETDRS visual acuity chart was used in 24 of the patients (41%). In this group, the mean visual acuity was 0.64 (±0.3) logMAR (equals 0.3 Snellen acuity) just before the TCP treatment and 0.66 (±0.4) logMAR at the 24-hour examination (p=0.87). The remaining 34 eyes had a baseline visual acuity of counting fingers ($n=11$), hand movements ($n=13$), light perception ($n=4$) or were amaurotic ($n=6$). When excluding the six blind eyes, the VA in this group was unchanged in 75% ($n=21$) of the eyes, reduced in 11% ($n=3$) and improved in 14% ($n=4$).

4 | DISCUSSION

In this study of 58 eyes, we found considerable IOP fluctuations in a large proportion of the patients during the first 24 h post-TCP. IOP spikes, defined as an IOP elevation of ≥5 mmHg compared to baseline, were seen in 40% of the eyes at some point during the first 24 h. Furthermore, almost one in five eyes displayed an IOP spike ≥10 mmHg and almost 1 in 10 eyes increased by 20 mmHg or more compared with baseline IOP. Eyes with a diagnosis of PEXG were over-represented in the eyes that experienced an IOP spike, especially in the group with the highest spikes.

Studies investigating the IOP behaviour in the first hours following TCP are scarce (Contreras et al., 2004; Razeghinejad et al., 2017; Uppal et al., 2015). Uppal et al. prospectively examined the occurrence of IOP spikes in 53 eyes after TCP. In their study, 34% had an elevation ≥33 mmHg and 17% had an elevation of ≥10 mmHg during the first 3 h after TCP treatment (Uppal et al., 2015). In our study, eyes with PEXG showed a significant increase in IOP compared with baseline 6 h after TCP. The IOP development during the hours after the 6-hour examination but before 24 h remains unknown, but the IOP levels were significantly reduced in all glaucoma types at the 24-hour examination. In the prospective study by Uppal et al. only two cases of PEXG (4%) were included, compared with 43% in our study (Uppal et al., 2015). The frequency of IOP spikes was slightly higher in the current study, which may be explained by the higher proportion of PEXG and the fact that the peak post-operative IOP was at 6 h, a timepoint not investigated by Uppal et al.

Razeghinejad et al. studied 10 eyes in sedated glaucoma patients and showed a significant IOP elevation in almost all eyes just after TCP (Razeghinejad et al., 2017).

TABLE 2A Mean IOP change at the different time points after TCP, all eyes.

	Mean IOP	SD	Range	*n*	Change in IOP	SD	Range	*p*
Baseline	26.2	8.9	11.7–48.7	58	–	–	–	–
1 h	23.1	8.9	9.7–46.7	58	−3.0	7.5	−18 to +26	0.003
2 h	22.3	7.3	9.3–44.0	58	−3.8	6.9	−19 to +16	<0.001
4 h	23.9	9.0	7.3–48.7	58	−2.2	10.1	−25 to +24	0.099
6 h	25.8	9.0	9.0–49.3	58	−0.4	10.9	−24 to +29	0.792
24 h	18.0	7.6	6.7–40.3	58	−8.1	7.8	−25 to +8	<0.001

Abbreviations: IOP, intraocular pressure; n, number of eyes; *p*, *p*-value; TCP, transscleral cyclophotocoagulation.

TABLE 2B Mean IOP change during the 24-hour follow-up in the different glaucoma types.

	POAG						PEXG					
	n	Mean IOP	SD	Change in IOP	SD	*p*	*n*	Mean IOP	SD	Change in IOP	SD	*p*
Baseline	8	25.0	9.3	–	–	–	25	22.6	6.3	–	–	–
1 h	8	18.8	7.5	−6.2	7.8	0.059	25	21.8	7.1	−0.8	6.8	0.558
2 h	8	20.6	6.2	−4.4	9.6	0.234	25	20.9	5.4	−1.7	5.2	0.121
4 h	8	20.3	6.1	−4.7	11.9	0.303	25	25.0	9.1	+2.5	8.5	0.160
6 h	8	19.6	5.9	−5.4	11.9	0.241	25	27.7	9.4	+5.1	9.7	0.015
24 h	8	16.0	7.0	−9.0	10.2	0.040	25	16.5	6.7	−6.1	7.3	<0.001
	NVG						OSG					
	n	Mean IOP	SD	Change in IOP	SD	*p*	*n*	Mean IOP	SD	Change in IOP	SD	*p*
Baseline	15	32.0	11.1	–	–	–	10	27.2	6.2	–	–	–
1 h	15	28.4	11.7	−3.6	9.6	0.171	10	22.0	6.5	−5.2	3.6	0.001
2 h	15	26.4	9.3	−5.7	8.3	0.019	10	21.1	7.9	−6.2	4.9	0.003
4 h	15	25.5	8.5	−6.5	10.5	0.030	10	21.7	11.2	−5.6	8.1	0.058
6 h	15	27.8	7.8	−4.2	11.1	0.163	10	23.0	10.1	−4.3	7.5	0.103
24 h	15	22.1	9.4	−9.9	8.2	<0.001	10	17.5	5.7	−9.8	5.6	<0.001

Abbreviations: IOP, intraocular pressure; *n*, number of eyes; NVG, neovascular glaucoma; OSG, other type of secondary glaucoma; *p*, *p*-value; PEXG, pseudoexfoliation glaucoma; POAG, primary open-angle glaucoma.

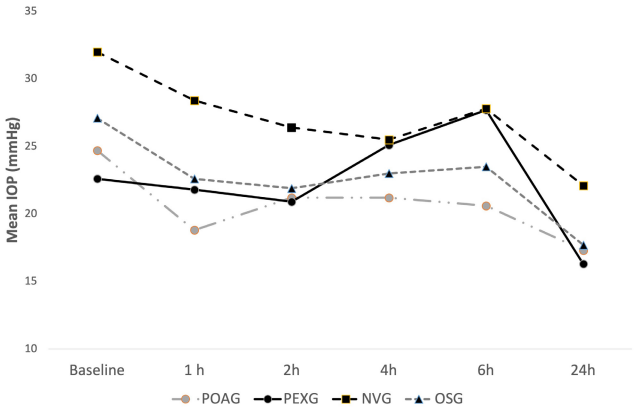

FIGURE 1 Mean IOP in the different types of glaucoma at different timepoints. IOP, intraocular pressure; NVG, neovascular glaucoma; OSG, other secondary glaucoma; PEXG, pseudoexfoliation glaucoma; POAG, primary open-angle glaucoma.

The glaucoma in these eyes was defined as refractory, but no further details regarding the glaucoma type were provided. IOP measurements in that study were made with Tono-pen, compared with GAT in the current study. Furthermore, a retrospective study of 116 eyes showed an IOP spike (defined as IOP ≥5 mmHg) in 11% of the eyes 1 h after TCP (Contreras et al., 2004).

We found that the type of glaucoma significantly influenced the IOP change at 6 h post-TCP, where PEXG was associated with the highest IOP elevation. In the material by Contreras et al. (2004), there was a trend towards more frequent spikes in eyes with NVG and after re-treatment with TCP, but this was not confirmed in our data. Similar to our results, no other predictive factors were found by Contreras et al. (2004) or Uppal et al. (2015).

The mechanisms underlying the occurrence of IOP spikes post-laser remain unclear. Ultrasound performed after TCP has demonstrated debris arising from the ciliary body following TCP treatment, which may cause a temporary block of the trabecular meshwork leading to an acute IOP spike (Sii et al., 2007). This possible explanation is of particular interest in PEXG as the delivered laser energy may cause a sudden liberation of exfoliative material. This material could create an increase in IOP and would thus explain the high incidence of IOP spikes in eyes with PEXG in the current study. Several studies report changes in the blood-aqueous barrier in eyes with pseudoexfoliation syndrome (Hardenborg et al., 2009; Küchle et al., 1996; Vazquez & Lee, 2014). This may cause increased flare and inflammation after ocular procedures, which in turn may contribute to an elevated IOP. Furthermore, trabeculitis has been shown histologically in enucleated eyes post-TCP, which may contribute to an impaired aqueous outflow and subsequent rise in IOP (McKelvie & Walland, 2002).

The study had several strengths and limitations. The strengths included the prospective design and that all eyes were treated by the same surgeon. Furthermore, the study group contained a large sample of eyes with PEXG, to date the largest reported in a prospective study after TCP treatment. This provided new information regarding the frequent occurrence of IOP spikes in eyes with PEXG. Limitations include a potential selection bias since the subjects' decisions to participate in the study may have been affected by factors such as co-morbidities and place of residence that often was far away. Furthermore, the fact that all patients were not consecutively asked for participation due to logistical reasons may have introduced a selection bias. In addition, since patients with blindness in the other eye were excluded, this may have excluded some patients with particularly aggressive glaucoma. Corneal oedema is a known complication of TCP, and it is possible that an

early change in corneal properties may have affected the IOP measurement in some cases.

In our clinic, the first routine check-up after TCP is a clinical examination including measurement of IOP approximately 1 week post-laser. This is in accordance with the results from the UK National Cyclodiode Laser Survey where most first post-operative examinations after TCP are scheduled 1–2 weeks after treatment (Agrawal et al., 2011). According to the results of the current study, the examination including IOP measurement needs to be performed at a much earlier timepoint during the first hours following treatment in order to detect an IOP spike. Such a routine would naturally require additional healthcare resources and would probably not be feasible for practical reasons. However, given the risk of IOP spikes shown in the current study, prophylactic treatment with oral acetazolamide during the first 24 h post-laser could be considered since the great majority of the studied eyes had a normalized IOP at that time point.

In conclusion, this short-term study after TCP showed that a considerable proportion of eyes experienced IOP spikes in the hours following treatment. Eyes with PEXG were over-represented, and the highest IOP peak occurred 6 h after laser treatment in this group. A clinical recommendation based on the results could be to consider a prophylactic acetazolamide treatment during the first 24 h following TCP, especially in eyes with PEXG.

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ETHICS STATEMENT

The study was approved by the Regional Ethics Committee, Umeå, Sweden. It adhered to the tenets of the Declaration of Helsinki.

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