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Efficacy and safety of transscleral cyclophotocoagulation in Swedish glaucoma patients

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ABSTRACT.

Purpose: **To retrospectively evaluate the efficacy and safety of all transscleral cyclophotocoagulation (TCP) treatments performed during a 5-year period.**

Methods: **Medical records of all patients, who had undergone TCP treatment between 2010 and 2014 at Umeå University Hospital, Sweden, were evaluated. Clinical data including intraocular pressure (IOP), visual acuity (VA), number of topical glaucoma medications, use of oral acetazolamide, retreatments and complications during a 2-year follow-up were registered. Global success was defined as IOP 6–18 mmHg with or without glaucoma medication.**

Results: **Three hundred patients underwent TCP during the time period. Mean IOP at baseline was 29.3 ± 11.0 (mean ± standard deviation) mmHg (n = 297) with a mean reduction of 11.5 (±12.0) mmHg at 1 year (n = 258; $p < 0.001$) and 12.6 (±12.0) mmHg at 2-year follow-up (n = 245; $p < 0.001$). Global success at 2 years was 64%, achieved by a mean of 1.2 treatments (n = 257). The number of topical glaucoma medications at baseline was 3.1 (±1.0; n = 296) and was reduced by 0.9 (±1.0) medications at 2 years (n = 244; $p < 0.001$). Use of oral acetazolamide decreased from 30% (n = 90) at baseline to 5.3% (n = 13) at 2 years. In eyes with Snellen VA ≥ 0.1, the mean VA at baseline was 0.55 (±0.3) logarithm of the minimum angle of resolution (logMAR; n = 132) and 1.1 (±0.9) logMAR (n = 76) at 2 years ($p < 0.001$). No cases of phthisis bulbi were found.**

Conclusion: **This study displays a substantial and long-term reduction of IOP following TCP with a decrease in topical and oral glaucoma medications. The treatment appears to be safe but the decrease in VA during follow-up is a concern that needs further evaluation.**

Key words: intraocular pressure – laser treatment – open-angle glaucoma – pseudoexfoliation glaucoma – transscleral cyclophotocoagulation

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Introduction

Glaucoma is a progressive ocular disease that leads to damage of the optic nerve and subsequent loss of visual field. Elevated intraocular pressure (IOP) is the main risk factor for glaucoma development and progression (Heijl et al. 2002; Kass et al. 2002; Leske et al. 2003). Elevated IOP is the only treatable risk factor, and it is initially controlled with IOP-lowering eye drops or laser trabeculoplasty. When these treatments are deemed insufficient, the next step is usually invasive glaucoma surgeries followed by transscleral cyclophotocoagulation (TCP) as the last alternative (Huang & Lin 2012).

The TCP method is a well-established cyclodestructive glaucoma treatment. The treatment causes a partial destruction of the ciliary body through transscleral laser application of infrared light (810 nm), which reduces aqueous production and the IOP. There are several studies that report the efficacy of TCP, and many of those studies have been reviewed by Ishida (Ishida 2013). In his review (Ishida 2013), 22 TCP studies were compared, and they displayed a wide range of overall success rates, 37–95%. In these studies, success was defined in most cases as postoperative IOP <21 or 22 mmHg, thereby also including cases of hypotony.

Transscleral cyclophotocoagulation (TCP) is predominantly used in eyes with severe glaucoma that is unresponsive to other interventions and where the visual prognosis is limited at best. This is mainly due to the destructive nature of the method and a general fear of serious complications, which include persistent hypotony, phthisis and a significant decline in visual acuity (VA) (Schuman et al. 1992; Pastor et al. 2001; Ishida 2013). Taken together, these factors have prevented a wider acceptance of TCP in eyes with good residual VA. However, there are a number of studies that have

evaluated TCP as a primary surgical treatment (Egbert et al. 2001; Kramp et al. 2002; Lai et al. 2005; Grueb et al. 2006). There is also some evidence that supports the idea that TCP may be considered safe in eyes with good vision (Egbert et al. 2001; Ansari & Gandhewar 2007; Rotchford et al. 2010; Ghosh et al. 2014).

At present, there is a lack of consensus regarding the appropriate energy administration during TCP and its influence upon the safety of the procedure. It has been suggested by Vernon et al. (2006) that the risk of hypotony and phthisis is related to the amount of energy delivered during a single treatment session of TCP. According to the review by Ishida (Ishida 2013), a treatment protocol resulting in a total energy delivery of 80 J or less has a very low risk of developing hypotony or phthisis after TCP, with the exception of studies which include a high degree of patients with neovascular glaucoma (NVG). Ramli et al. (2012) reported that underlying abnormalities of the eye, rather than energy delivery, pose a higher risk for the development of hypotony.

At our department, TCP treatments have been performed for several years. The eyes selected for TCP usually have a history of substantial glaucoma damage but are also, to some extent, eyes with preserved vision and less optic nerve damage. With this study, we hypothesize that TCP with the standard protocol described in this paper is a safe and efficient therapy to lower IOP in patients with glaucoma in a Scandinavian population.

Patients and Methods

Medical records from all patients with glaucoma who underwent TCP treatment at the Department of Ophthalmology, Umeå University Hospital, Sweden, during a 5-year period between January 2010 and December 2014 were retrospectively reviewed. The investigation was approved by the Regional Ethics Committee and adhered to the tenets of the Declaration of Helsinki. Baseline data including age, type of glaucoma and previous glaucoma surgery were registered. One eye per patient was analysed, and in the case of bilateral treatment, the right eye was chosen for analysis. Preoperative IOP, VA, number of topical glaucoma medications and use of oral acetazolamide were obtained at study baseline and compared with postoperative visits at 1 week, 1, 3, 6, 12 and 24 months or at examinations as close as possible to those dates. Retreatments with TCP or other types of glaucoma surgery that occurred during the 2-year follow-up were registered. Complications were recorded. Treatment success was defined as IOP $\geq$6 and $\leq$18 mmHg, with or without glaucoma medications and retreatments with TCP at the 2-year follow-up. According to the guidelines on designing glaucoma trials outlined by the World Glaucoma Association, definitions of IOP success should include an upper and lower limit, include more than one upper limit or a combination of an upper limit and a percentage reduction (Shaarawy et al. 2009).

Eyes that had undergone any other type of glaucoma surgery during follow-up were considered a failure and were taken into account in the calculation of the success rate.

Treatments with TCP were performed under subtenonal, peribulbar or generalized anaesthesia using the Oculight Sx semiconductor diode 810-nm laser and the contact G-probe (Iris Medical Instruments, Mountain View, CA, USA). In most cases, power was gradually increased from 1800 to 2500 mW. However, the energy range could vary between at lowest 800 mW and up to 2700 mW with 2 seconds duration of each application. In case of an audible 'pop'-sound, energy was usually reduced by 200 mW and the procedure continued. In a standard treatment, 18 applications were distributed over 270° of the circumference unless ocular co-morbidity dictated otherwise, usually sparing the superior nasal quadrant. A standard treatment resulted in a total energy delivery of 84 J. Post-TCP eyes were treated with topical steroids for a minimum of 3 weeks. Topical glaucoma medications were, when possible, reduced according to achieved reduction in IOP. Oral acetazolamide was usually removed directly after TCP treatment and in a few cases re-introduced when assessed as unavoidable. Retreatment with TCP or other glaucoma surgery was performed when the postoperative IOP reduction was considered insufficient.

Statistical methods

Extracted data were analysed using SPSS Statistics version 24 (SPSS Inc, Chicago, IL, USA). Descriptive data are presented as mean and standard deviation unless otherwise stated. Paired-samples *t*-test was used to compare differences in the parameters between baseline and visits throughout the follow-up period.

Independent-samples *t*-test was used to detect and compare differences between groups. $p < 0.05$ was considered significant. Visual acuities were noted as decimal values but converted to the logarithm of the minimum angle of resolution (logMAR) for statistical analyses. For VA analysis, the treated eyes were divided into two groups according to baseline VA: good VA (Snellen VA $\geq$ 0.1) and poor VA (Snellen VA $<$ 0.1).

Results

Patient characteristics

Three hundred eyes of 300 patients who underwent TCP treatment between January 2010 and December 2014 were included in the study. The total number of performed TCP treatments during the time period was 366 since TCP was repeated on several eyes. The patients' clinical characteristics, glaucoma subtypes and previous glaucoma surgeries are outlined in Table 1.

The group referred to as 'Other secondary glaucoma $n = 19$' was dominated by silicone oil-induced glaucoma ($n = 18$), followed by glaucoma secondary to ocular amyloidosis ($n = 7$), uveitis ($n = 6$) and ocular trauma ($n = 4$). In 11 cases (4%), the diagnosis was unknown or could not be comprehended from the medical journal. Thirteen of the patients that had experienced previous glaucoma surgery had received more than one operation. Eighteen patients had undergone previous TCP treatments; of these, 15 patients had one previous TCP and three patients had two TCP prior to study start.

Data regarding baseline topical glaucoma treatment were accessible in 296 cases; in four cases, data could not be extracted from the medical journal.

Out of the 300 patients who received TCP treatment during the 5-year study period, data were not available in 53 cases at 2 years due to the following

Table 1. Baseline characteristics of the patients (n = 300) treated with transscleral cyclophotocoagulation (TCP).

Patient characteristics	
Age (years)	72 (±17)
Sex (% female)	48% (n = 145)
No. of glaucoma medications	3.1 (± 1.0)
Oral acetazolamide	30% (n = 90)
Baseline IOP (mmHg)	29.3 (±11)
Eyes with decimal VA 0.1–1.0	44% (n = 131)
	% (n)
Glaucoma types	
POAG	15 (46)
Pseudoexfoliation glaucoma	40 (120)
Neovascular glaucoma	22 (65)
Other secondary glaucoma	19 (58)
Unknown	4 (11)
Previous glaucoma surgery	
None	74 (222)
Trabeculectomy	17 (51)
Deep sclerectomy	3.7 (11)
TCP	6.0 (18)
Shunt/tube	2.7 (8)
Cyklokryoablation	0.7 (2)

Data are presented as mean ± standard deviation unless otherwise stated.
IOP = intraocular pressure, POAG = primary open-angle glaucoma, TCP = transscleral cyclophotocoagulation, VA = visual acuity.

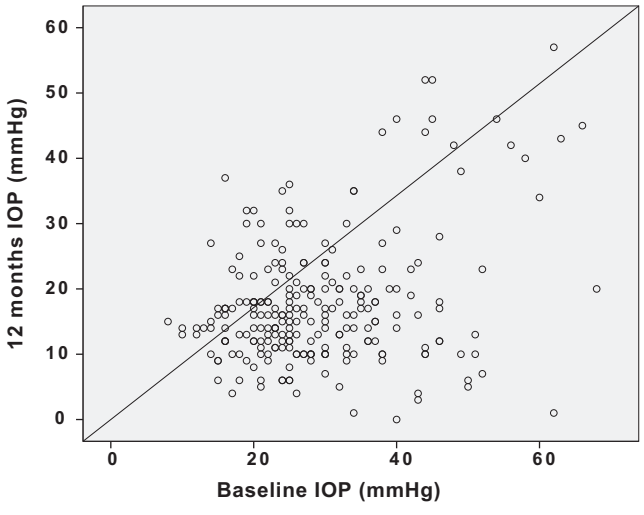

Fig. 1. A scatterplot of the distribution of IOP measurements at baseline and 12 months. All circles below the solid line represent eyes with lower IOP at 12 months than at baseline. IOP = intraocular pressure.

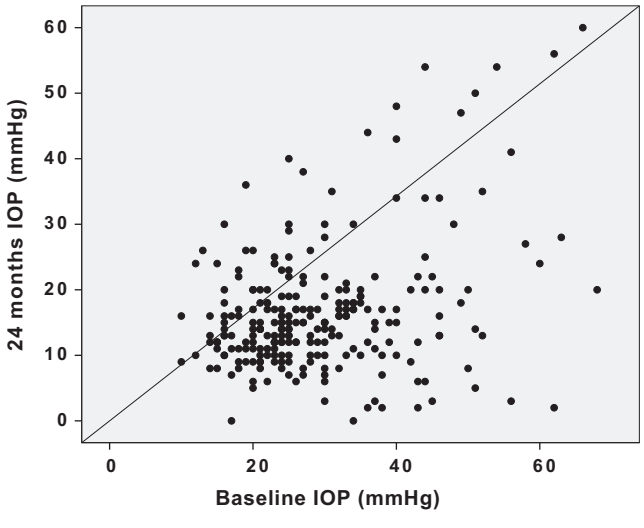

Fig. 2. A scatterplot of the distribution of IOP measurements at baseline and 24 months. All circles below the solid line represent eyes with lower IOP at 24 months than at baseline. IOP = intraocular pressure.

reasons: deceased (n = 22), glaucoma surgery other than TCP (n = 10), no follow-up due to blindness (n = 6), co-morbidity hindering examination (n = 7), moved to other location (n = 6) and unclear reason (n = 2). Two of the three subjects lacking IOP data at baseline presented data at the 2-year follow-up which explains the discrepancy in number of subjects between the paired analysis and total number of observations at that time-point (n = 245 and n = 247 respectively).

IOP and success rate

Mean IOP at baseline was 29.3 (±11.0) mmHg (n = 297). Following TCP treatment, IOP was significantly reduced by a mean of 11.5 (±12.0) mmHg at 1 year (n = 258; $p < 0.001$, paired t-test) and 12.6 (±12.0) mmHg at 2 years (n = 245; $p < 0.001$). The distribution of IOP measurements at baseline and 12 and 24 months, respectively, is shown in Figs 1 and 2.

The IOP values at baseline and during follow-up are presented in Figs 3 and 4.

If the effect of only one TCP treatment was calculated, the IOP was reduced by a mean of 10.7 (±11.3) mmHg at 1 year (n = 214; $p < 0.001$) and 11.8 (±11.5) mmHg at 2 years (n = 195; $p < 0.001$), respectively.

In the group with primary open-angle glaucoma (POAG), mean baseline IOP was 25.6 (±10) mmHg (n = 46), and the mean IOP reduction after 2 years was 10.7 (±10.0) mmHg (n = 38; $p < 0.001$). In the pseudoexfoliation glaucoma (PEXG) group (n = 119), the corresponding figures were 27.2 (±9) and 11.3 (±11) mmHg (n = 102), respectively ($p < 0.001$). The NVG group displayed the highest mean baseline IOP 35.3 mmHg (±12; n = 65), and also the greatest mean IOP reduction after 2 years with 16.6 (±16) mmHg (n = 51; $p < 0.001$). In the group with other secondary glaucoma types, the mean preoperative IOP was 29.6 (±11) mmHg (n = 57) and the mean IOP reduction at 2 years was 13.0 (±11.0) mmHg (n = 47; $p < 0.001$). The IOP reduction was similar after removal of the data from the eyes that had undergone previous TCP.

Global success at 2 years was 64% (n = 257), achieved by a mean of 1.2 treatments where the 10 patients that

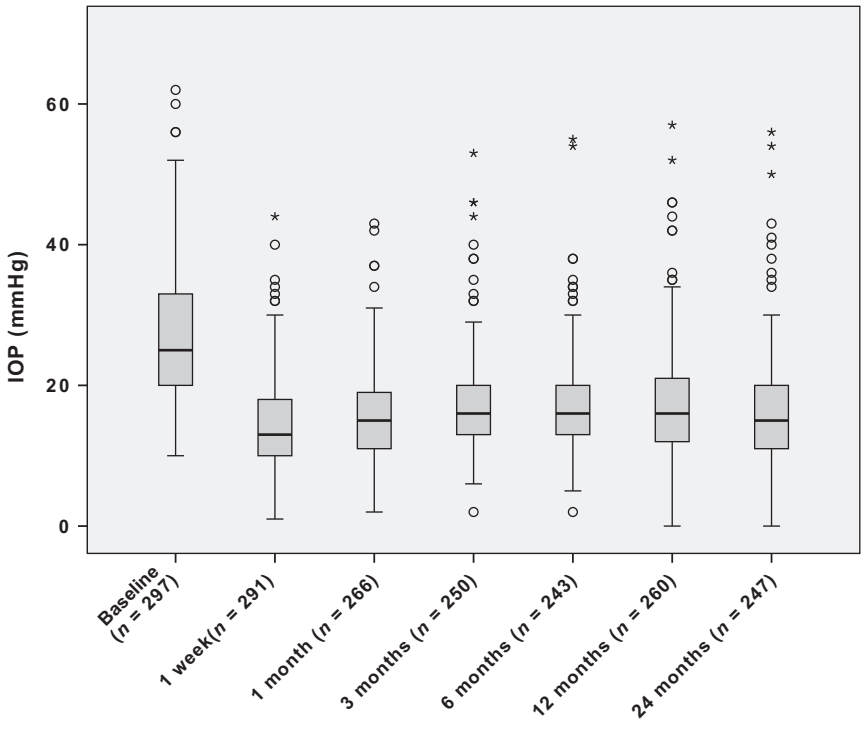

Fig. 3. Box-plot representation of IOP distribution during 24 months of follow-up after TCP. IOP = intraocular pressure, TCP = transscleral cyclophotocoagulation, ° = outlier, * = extreme outlier.

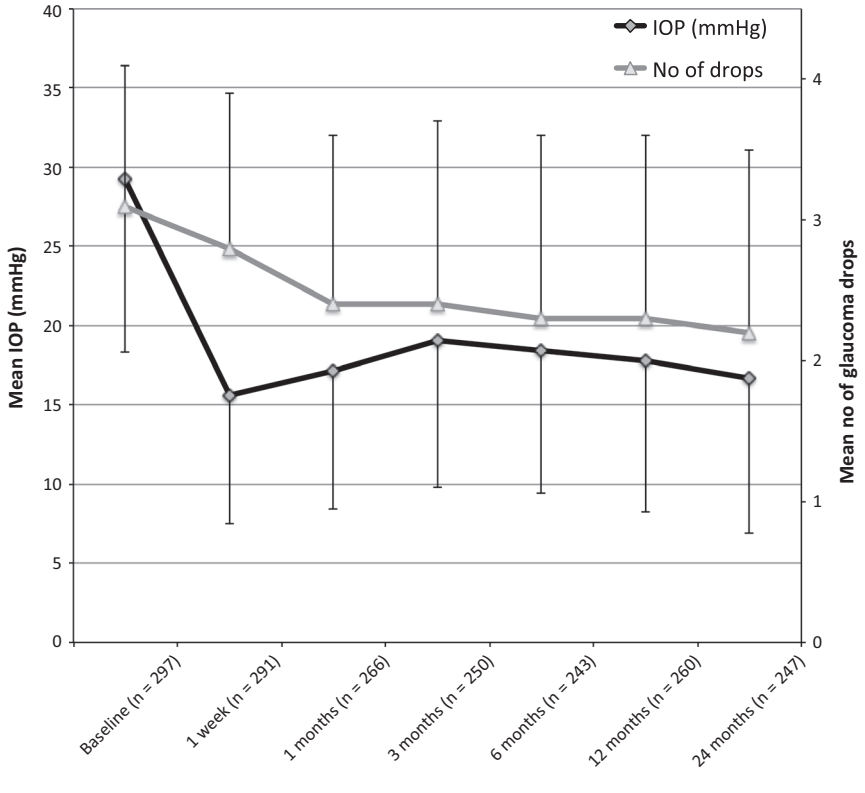

Fig. 4. Mean values (including 1 standard deviation) of intraocular pressure (IOP) and number of glaucoma drops during follow-up.

received other glaucoma surgery than TCP during the period were considered failures. Table 2 shows the number of patients reaching success rates with different upper limits at 12 and 24 months.

Table 2. The number of cases reaching success with different upper IOP limits at 12 and 24 months.

IOP (mmHg)	12 months *n* (%)	24 months *n* (%)
≥ 6 to ≤15	113 (42)	124 (48)
≥ 6 to ≤18	162 (60)	164 (64)
≥ 6 to ≤21	185 (69)	186 (72)

IOP = intraocular pressure.

Global success rates (≥6 to ≤18) at 24 months in the subgroups were 76% in POAG ($n = 38$), 71% in PEXG ($n = 106$), 46% in NVG ($n = 54$) and 62% ($n = 52$) in the group with other patients with secondary glaucoma.

Assessing retreatments with TCP, 19% of the patients ($n = 58$) had more than one TCP during the 2-year follow-up. About 17% of the patients ($n = 52$) had one retreatment, 1.3% ($n = 4$) had two retreatments, and 0.6% ($n = 2$) had three retreatments during the follow-up. Excluding the 18 cases that had undergone TCP prior to study start from the analysis did not significantly change the IOP outcome at any time-point. Fourteen per cent of the retreated patients had POAG ($n = 8$), 40% had PEXG ($n = 23$), 22% had NVG ($n = 13$), and 24% had other glaucoma types ($n = 14$).

IOP-lowering medications

At baseline, the mean number of topical glaucoma medications was 3.1 (±1.0) substances ($n = 296$). This number was decreased by 0.9 (±1.0; $p < 0.001$) substances at the 2-year follow-up ($n = 244$). The mean number of glaucoma medications at the different time-points is outlined in Fig. 4.

Thirty per cent ($n = 90$) of the patients were treated with oral acetazolamide prior to TCP treatment, and this number was reduced to 5.3% ($n = 13$) at 2 years. Excluding the patients who had undergone TCP prior to the study start did not significantly change the outcome in number of glaucoma medications.

Visual acuity analysis

In the group of eyes with better VA, the mean logMAR VA was 0.55 (±0.3) at baseline ($n = 131$). For the eyes that had a VA registered at 2 years, the mean logMAR VA was similar

(0.55 ± 0.3) at baseline and 1.1 (±0.9) at 2 years ($n = 76$; $p < 0.001$). Four patients had a decrease in VA to light perception or less. One was a patient with secondary glaucoma that had a relapse of retinal detachment, and three patients had uncontrolled glaucoma with fluctuating IOP levels despite treatment.

At 2 years, 55% ($n = 44$) had a VA loss of ≥2 lines on the Snellen chart. In this group, there were two cases of persistent corneal oedema that was first described at the 1-week follow-up examination and one patient suffered from a central venous occlusion, which led to a decline in VA. In many cases, the cause of VA decline was not commented or further explained in the medical records. There were no significant differences in the degree of VA decline at 2 years between the different glaucoma types.

The VA at 2 years in the group with poorer VA ($n = 83$) was maintained or improved in 56% ($n = 49$) and decreased in 41% ($n = 34$).

Complications

In this study population, there was no case of phthisis bulbi or persistent hypotony. About 1.7% of the patients ($n = 5$) displayed a late hypotony that appeared after more than a year post-TCP treatment. There was no description of anatomic signs of hypotony such as shallow anterior chamber or choroidal detachment in these patients. In all five cases, the eyes suffered from severe glaucoma damage prior to treatment. Three of these eyes had secondary glaucoma and two PEXG. Four of the eyes were amaurotic, and one had a VA of counting fingers preoperatively.

One per cent of the patients ($n = 3$) had dislocated intraocular lenses (IOL) following treatment. In one of the cases, the IOL had been previously sutured to the sclera, and in the other two cases, there had been signs of IOL instability prior to TCP. One per cent had signs of postoperative cystic macular oedema ($n = 3$). All of the cases resolved within 18 months. Two per cent of the patients ($n = 6$) displayed persistent corneal erosions, two of which required amnion transplantation and one that developed a fungal keratitis. The latter eye had a history of blepharoconjunctivitis and bandkeratopathy prior to treatment. Corneal oedema that presented during the first week post-treatment was described in 2% of the patients ($n = 6$). One patient presented with a perioperative scleral burn but this caused no harm to the patient.

Discussion

In our study, we found an overall substantial IOP-lowering effect following TCP treatment. There was also a significant reduction of both topical and oral glaucoma medications during follow-up. The efficacy of TCP was considerable in all the different subtypes of glaucoma. The overall success rate, defined as IOP 6–18 mmHg with or without glaucoma medications, was 64% achieved by a mean of 1.2 TCP treatments at 2 years. Most of the patients who were treated with oral acetazolamide at baseline could discontinue this treatment during follow-up, which may be of great importance considering the potential side-effects and in some cases itself a treatment goal.

Our results are in line with previous studies. In the review by Ishida (2013), most studies evaluated with the definition of success of 5–21 mmHg had an overall success rate of 54 – 79.5% with 1.16 – 1.86 treatments per eye (Schlote et al. 2001; Murphy et al. 2003; Kaushik et al. 2008; Ramli et al. 2012). There are studies that have reported higher success rates (Gupta & Agarwal 2000; Hauber & Scherer 2002; Lai et al. 2005; Ghosh et al. 2014), but in these, the definition of success only included an upper IOP boundary and not a lower IOP limit, consequently including patients with potential hypotony in the reported success rates. An exception is Rotchford et al. (2010) who presented a success rate of 89.8% with 1.73 treatments per eye with a definition of success as IOP 6–21 mmHg.

In our material, nineteen per cent of the eyes were retreated with TCP during follow-up. Our energy protocol varied somewhat but mean energy per session was in most cases 80–90 J.

Ishida (2013) reported retreatment rates that varied between 0% and 59.6%. The studies with higher retreatment rates (Schlote et al. 2001; Pucci et al. 2003; Vernon et al. 2006) had in common a modest mean energy per session protocol (43.6–56 J) and low reported complication rates. The success rates in these studies were overall high (74.2–88.1%). In studies reporting a low retreatment rate (Mistlberger et al. 2001; Lai et al. 2005; Yildirim et al. 2009), the mean energy per session varied greatly (48–116 J) in the different studies. In the study by Yildirim et al. (2009), there was a rate of hypotony in 9.1% of the eyes (consisting solely of NVG) but otherwise the complication rate was low. The overall success rates were similar to the high retreatment group (63.6–92%). Hence, the impact of retreatments in terms of energy delivery, efficacy and safety remains rather puzzling.

Our study group ($n = 300$) is unique for several reasons. Firstly, it is the largest population evaluated regarding efficacy and safety of TCP. Secondly, it is the first study to evaluate TCP treatment in a Scandinavian population. Finally, since 40% ($n = 120$) of the patients were diagnosed with PEXG, this study includes the largest number of patients with PEXG of published studies evaluating TCP treatment. The high proportion of PEXG is not surprising since PEX syndrome is common in northern Scandinavia (Ringvold 1999; Astrom & Linden 2007; Ekstrom & Alm 2008) and particularly in our county where Astrom & Linden (2007) have followed a cohort for over two decades. Their study revealed a prevalence of PEX in one or both eyes in 23% of 66-year-old subjects, which had increased to 61% by the time they turned 87 years (Astrom et al. 2007).

In a recent review article by Sandhu & Damji (2018), TCP was proposed as a reasonable option for treatment of refractory PEX glaucoma. It has been suggested that excessive exfoliation material on the zonules can hinder laser uptake in endoscopic cyclophotocoagulation (Francis et al. 2014). It remains unclear if such a hindrance may also be the case in TCP. The results of Grueb et al. (2006) evaluated 24 eyes with refractory PEXG that underwent TCP as primary or secondary treatment. They found that only 25% of the patients were successful after 12 months, which could support the hypothesis. The success rate in that study was defined as an IOP 4–18 and at least 20% IOP reduction and

the absence of major complications. However, the success rate of PEXG in our material, with a quite similar definition of success, was considerably higher at 71% even though the energy amount per treatment session was similar. Thus, our results support the use of TCP in patients with PEXG.

Many surgeons consider TCP treatment solely as an option for refractory glaucoma (Ishida 2013) or when filtration surgery or tubes have failed or are not feasible (European Glaucoma Society, 2017). It is therefore interesting that 44% of the patients in our study had a baseline Snellen VA of ≥0.1, indicating that TCP has not been used exclusively as a last resort for eyes suffering from severe glaucoma damage. Although most published studies on TCP include refractory glaucoma, exceptions exist. Rotchford et al. (2010) and Ghosh et al. (2014) both studied patients with Snellen VA ≥ 0.3 and showed high success rates although their definition of success differed from ours as previously discussed.

Despite promising IOP reduction, a concern in our study is that VA diminished over time. We found a significant decrease in VA at the end of the 2-year follow-up when more than half of the treated patients with measured VA at 2 years had lost ≥2 lines of Snellen VA. In comparison with other glaucoma surgery, the Tube versus Trab study found a similar VA decline in 33% of the patients after 1 year (Gedde et al. 2007). The observed decline in VA in our study seems to occur mainly during the first 6 months, and hence, we cannot fully dismiss the possibility that the treatment itself can be partly responsible. However, it is difficult to draw any firm conclusions about the effect of TCP on VA from our material due to several limitations linked to the retrospective study design. These include lack of systematic registration of VA and evaluation of co-morbidities that could cause VA decline. Furthermore, since many of the patients had refractory glaucoma, only IOP was registered at many controls. One should bear in mind that this group of patients display a high degree of co-morbidity with other ocular diseases that affect VA such as age-related macular degeneration, diabetic retinopathy and cataract. This co-morbidity, in addition to the natural course of an advanced glaucoma, has to be taken into account when interpreting the decline in VA.

Decline in VA after TCP treatment has been seen in other studies (Malik et al. 2006; Vernon et al. 2006; Ansari & Gandhewar 2007; Rotchford et al. 2010) where the portion of patients who lost ≥2 lines of Snellen VA ranged between 30 and 55%. However, studies exist where no significant change in VA was noted (Egbert et al. 2001; Zhekov et al. 2013). Common denominators of these studies were that TCP was performed as a primary treatment, that is no previous glaucoma surgery had been performed, and there was a high portion of POAG among their patients (Egbert et al. 2001; Zhekov et al. 2013). Thus, the low portion of POAG in our study could partly explain the higher number of cases with declining VA. Furthermore, Egbert et al. (2001) discussed the possibility that patients with good preoperative VA had better VA outcomes than patients with poor initial VA. This was not supported by Ghosh et al. (2014) or by our data.

Phthisis bulbi is a feared complication of TCP that has been reported in several studies (Gupta & Agarwal 2000; Kramp et al. 2002; Murphy et al. 2003; Nabili & Kirkness 2004; Goldenberg-Cohen et al. 2005; Iliev & Gerber 2007) although this is not always the case in studies evaluating TCP (Egbert et al. 2001; Schlote et al. 2001; Hauber & Scherer 2002; Lai et al. 2005; Grueb et al. 2006; Noureddin et al. 2006; Vernon et al. 2006; Ansari & Gandhewar 2007; Yildirim et al. 2009; Frezzotti et al. 2010). Given the large number of patients in the current study, some cases of phthisis bulbi could have been expected but surprisingly, we did not find a single case. A high percentage of NVG seems to be a similar factor in all studies reporting phthisis bulbi. However, this is not always the case since studies with both many NVG and no cases of phthisis bulbi exist (Ansari & Gandhewar 2007; Pokroy et al. 2008; Yildirim et al. 2009). Ramli et al. (2012) retrospectively evaluated 90 eyes of 90 patients with glaucoma who were treated with TCP with similar energy levels as in the current study but a higher incidence of hypotony (17.7%). Their results showed that a preoperative diagnosis of NVG is associated with an increased risk of developing hypotony after TCP by a factor of 9. Those authors suggested that the combination of severely impaired outflow (due to fibrovascular tissue) and untitratable damage to ciliary body aqueous production might cause the hypotony in NVG eyes after TCP, and they conclude that energy levels should not be too high in the treatment of NVG (Ramli et al. 2012). Murphy et al. (2003) reported phthisis in 5.3% and hypotony in 9.5% of their retrospective study patients in which 46% of the treated eyes had NVG. The association between NVG and the risk for hypotony was not supported in their data. It is notable, however, that further analysis of their NVG cases revealed that all hypotony cases in their data set had very poor VA preoperatively (Murphy et al. 2003). This is in line with our findings that the few patients with hypotony (1.7%; $n = 5$) that presented at a late stage (1–2 years after the event of TCP treatment) all had severely damaged eyes with poor visual potential. In our study, three of the five patients with late hypotony had a diagnosis of NVG.

A weakness of our study is its retrospective nature, which makes it impossible to adjust for underlying confounders due to the lack of a control group. The retrospective design also makes VA comparison preoperatively and postoperatively difficult since VA was measured in decimals and not in logMAR, which would have been preferred. The IOP values, including baseline IOP, are based on one measurement. This poses a risk of regression to the mean which represents a possible bias to better results. Furthermore, information on several parameters was lacking which made interpretation of the results more difficult and diminishes the strength of our observations, especially at the 2-year follow-up.

In conclusion, our study supports that TCP is an efficient option for IOP reduction in patients with various types of glaucoma. Serious adverse events are uncommon. The procedure is fast and easily accessible and does not require frequent follow-up examinations. Thus, the procedure can be a suitable option for many patients with glaucoma.

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