One-Year Follow-up of Pars Plicata Versus Pars Plana Application of Transscleral Micropulse Cyclophotocoagulation

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Purpose: To compare the efficacy and safety of micropulse transscleral cyclophotocoagulation applied at the level of the pars plicata transscleral micropulse cyclophotocoagulation (PLI-MPC) versus the pars plana transscleral micropulse cyclophotocoagulation (PLA-MPC).

Methods: This prospective interventional case series included 44 eyes of 31 medically treated primary open-angle glaucoma patients scheduled for micropulse transscleral cyclophotocoagulation to achieve further intraocular pressure (IOP) reduction. In total, 22 eyes underwent PLI-MPC and PLA-MPC each. Primary endpoints were the reduction of 24-hour mean diurnal IOP (mean of 6 measurements), diurnal IOP fluctuations, and peak IOP, after 3 and 12 months. Secondary outcomes were postoperative complications, a possible deterioration in visual acuity and field, factors influencing IOP reduction, and the number of dropouts.

Results: In the PLI-MPC group, IOP was reduced from 15.9 ± 3.4 mm Hg to 13.6 ± 3.1 mm Hg (n = 16; $P < 0.001$) and 12.9 ± 3.7 mm Hg (n = 13; $P < 0.001$) at 3 and 12-month follow-up. In the PLA-MPC group, IOP decreased from 16.4 ± 3.5 mm Hg to 12.3 ± 2.6 mm Hg (n = 15; $P < 0.001$) and 11.8 ± 2.2 mm Hg (n = 14; $P < 0.001$), respectively. At 12 months, 59% of the PLI-MPC and 63% of the PLA-MPC group had a sufficient IOP reduction to reach the individual target pressure. No complications were seen in either group. A higher preoperative IOP was recognized as the only factor influencing the postoperative IOP reduction.

Conclusions: PLI-MPC and PLA-MPC seem to be safe and effective in further lowering the IOP in about 60% of patients with primary open-angle glaucoma who did not reach target pressure despite maximally tolerated IOP-lowering medication. Although the IOP-lowering effect was not statistically significantly different between groups the pars plicata application was superior and easier to perform and should be recommended as the preferred method of application.

Key Words: transscleral micropulse cyclophotocoagulation, cyclodestruction, primary open-angle glaucoma, diurnal intraocular pressure

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Cyclodestructive procedures to lower aqueous humor production and as a consequence intraocular pressure (IOP), have been used in the management of glaucoma since the 1930s. Transscleral cyclophotocoagulation (TSCPC) is a cyclodestructive procedure where a semiconductor diode laser emits light at 810 nm, targeting the melanin in the pigmented ciliary body epithelium at the level of the pars plicata in order to reduce the rate of aqueous humor production. It can be performed using either a continuous wave mode (CW-TSCPC), or the more recent approach of a micropulse mode (MP-TSCPC). CW-TSCPC has been shown to cause significant collateral damage to adjacent structures including the ciliary stroma and ciliary muscle in part because of the nonspecific nature of the technique. Therefore, it has been mainly reserved for refractory glaucoma with poor visual prognosis because of the risk of developing serious postoperative complications such as persistent hypotony, prolonged ocular inflammation, hyphema, visual deterioration, cystoid macular edema, and phthisis bulbi.

As a new and noncontinuous delivery mode, MP-TSCPC is thought to more selectively target the ciliary body epithelium. Laser energy is delivered in on and off cycles, thereby allowing the tissues to cool down and to minimize collateral tissue damage, inflammation, and side effects.

Studies have reported promising results with this new FDA-approved MP-TSCPC laser system with a good efficacy and fewer side effects than those reported with CW-TSCPC. Therefore, it could possibly be offered earlier in the management of glaucoma. Usually, cyclophotocoagulation is applied at the level of the pars plicata of the ciliary body, after visualization by transillumination.

The purpose of the current study was to compare the efficacy of the transillumination-aided treatment of the pars plicata transscleral micropulse cyclophotocoagulation (PLI-MPC) to the treatment of the pars plana transscleral micropulse cyclophotocoagulation (PLA-MPC) by probe positioning. Moreover, to evaluate the efficacy and safety of MP-TSCPC at 3 and 12 months after treatment, to analyze postoperative complications, the number of dropouts, and the identification of factors influencing the IOP-lowering success.

METHODS

In this prospective interventional case series, we consecutively recruited patients with open-angle glaucoma assigned for MP-TSCPC who did not reach target pressure or showed repeated IOP fluctuations despite maximally tolerated topical IOP-lowering medication. Patients were recruited from a tertiary care referral center; they were of Caucasian origin and suffered from high-pressure glaucoma (HPG) and normal-pressure glaucoma. HPG was...
defined as primary open-angle glaucoma (POAG) with a history of untreated IOPs >21 mm Hg, damage to the inner layers of the retina on optical coherence tomography, a glaucomatous optic disc with diffuse or focal thinning of the neuroretinal rim with corresponding visual field (VF) defects but no other ocular or systemic diseases that might cause VF defects. Normal-pressure glaucoma was defined as POAG with a history of untreated IOPs ≤ 21 mm Hg, otherwise, the same criteria applied as for HPG.

Patients with previous filtration or cyclodestructive surgery, axial length ≤ 22 mm or ≥ 26 mm, anterior chamber depth <2 mm, or being unable to keep their follow-up appointments were excluded from the study.

Primary endpoints were the reduction of 24-hour mean diurnal IOP (mean of 6 measurements), diurnal IOP fluctuations, and peak IOP 3 and 12 months after treatment. Secondary outcomes were the occurrence of postoperative complications, a possible decrease in visual acuity and VF progression, the identification of factors influencing IOP reduction, and the number of dropouts.

Baseline characteristics included age, sex, number of IOP-lowering medications, previous surgeries, and a full ophthalmic examination and glaucoma work-up: best-corrected visual acuity (BCVA), slit-lamp examination, funduscopy, VF testing with automated perimetry (Swedish interactive threshold algorithm standard 30-2 + 10-2 program, where applicable; Carl Zeiss Meditec, Dublin, CA), confocal scanning laser ophthalmoscopy (HRT II; Heidelberg Engineering Inc., Heidelberg, Germany), scanning laser polarimetry (Nerve Fibre Analyzer GDxPRO; Carl Zeiss Meditec), Pachymetry (Pachymeter SP-3000; Tomey Corporation, Nagoya, Japan), axial length was measured with optical biometry (IOL-Master; Carl Zeiss Meditec AG), and for objective analysis of the anterior segment the Pentacam HR 3 (Oculus, Wetzlar, Germany), a rotating Scheimpflug camera was used. Measurements of 24-hour diurnal IOP were taken at 1, 4, 7, and 10 PM in a sitting position at the slit-lamp with a Goldmann tonometer, at midnight in a supine position using a Perkins tonometer and at 7 AM again in a sitting position at the slit-lamp. In order to determine the diurnal IOP fluctuation preoperatively and during the follow-up period, the mean difference between the lowest and highest IOP value was calculated.

Follow-up visits took place 1, 3, and 12 months later. At 1 month, BCVA was taken followed by a slit-lamp examination and funduscopy. IOP was measured at the slit-lamp with a Goldmann tonometer between 2 and 4 PM. This was a short-term follow-up to exclude short-term postoperative complications. Follow-ups at 3 and 12 months included a full ophthalmic examination and glaucoma work-up, as well as diurnal IOP measurements as described above and the recording of medications and complications. In-between, patients were followed by their ophthalmologists.

Success was defined as eyes that reached the individual target IOP without any change in glaucoma medication and with no retreatment, other cyclodestructive procedures, or penetrating glaucoma surgery while attaining an IOP no <6 mm Hg. In accordance with the Guidelines of the European Glaucoma Society,14 target IOP was individually set as the upper limit of the IOP estimated to slow progression in such a way that vision-related quality of life in the expected lifetime of the patient, is maintained.

Failure was defined as eyes not reaching target IOP or showing progression and requiring another IOP-lowering intervention during the study period. Data were excluded from analysis at the time of further IOP-lowering procedures.

All MP-TSCPC procedures were performed by a single glaucoma surgeon (K.R.P.) and carried out under parabulbar block and topical Xylocain Gel 2% (Lidocainhydrochlorid 1 H2O; Aspen Germany GmbH, Munich, Germany). The surgeon was neither involved in collecting, nor evaluating the data.

PLI-MPC was performed using the CYCLO G6 transscleral diode laser with a P3 probe (IRIDEX, CYCLO G6; Glaucoma Laser System, Mountain View, CA) with a standardized preset power of 2000 mW and a duty cycle of 31.3%. After visualization of the pars plicata by transillumination (Supplement, Supplemental Digital Content, http://links.lww.com/IJG/A513), the probe’s fiber-optic tip was placed at the pars plicata region of the ciliary body and moved with steady pressure in a continuous sliding arc from 9:30 to 2:30 clock positions in the superior and 3:30 to 8:30 clock positions in the inferior hemifield for 80 seconds each. The 3 and 9 o’ clock positions were left untreated to avoid ciliary neurovascular structures.

In the case of PLA-MPC the same probe and laser setting as in the case of PLI-MPC was used. The probe was also moved in a continuous sliding motion in the upper and lower hemisphere for 80 seconds, avoiding the 3 and 9 o’ clock positions. It was held perpendicular to the surface of the globe, with the edge of the probe directly on the limbus at all times to permit accurate positioning of the fiber-optic tip at 3 mm posterior to the limbus in the pars plana region of the ciliary body.

Postoperative treatment included topical steroid eye drops, Lotemax (5 mg/ml loteprednol etabonate; Bausch + Lomb, Germany) 3 times daily for 2 weeks. Topical anti-glaucomatous therapy was continued and not changed during follow-up.

The study was approved by the ethics committee of the Medical Faculty Carl Gustav Carus of the Technische Universität Dresden, Germany, and followed the tenets of the Declaration of Helsinki. All participants signed a written informed consent.

Statistical analysis was performed with SPSS Version 25 (IBM Statistics, New York, NY). Normal distribution was proven by Shapiro-Wilk test and Q-Q graphs. P-values <0.05 were considered statistically significant. Preoperative and postoperative IOP differences between the 2 treatment groups were carried out using a linear mixed model. The linear mixed model also allows taking data from both eyes without increasing statistical power. In order to identify factors influencing the postoperative IOP reduction, multivariate regression analyses were conducted.

RESULTS

In total, 44 eyes of 31 patients, 22 eyes of 15 patients in the PLI-MPC group (mean age, 72.4 ± 8.3 y), and 22 eyes of 16 patients in the PLA-MPC group (mean age, 71.9 ± 7.9 y), were included in this study. The study group consisted mainly of advanced POAG patients (MD, ≤ −12 dB; 70.5%) receiving maximally tolerated medical therapy. The mean number of substances per day was 3.86 ± 0.89 in the PLI-MPC and 3.77 ± 0.81 in the PLA-MPC group without being statistically significantly different (P = 0.725). Demographic data are shown in Table 1. Cataract surgery and selective laser trabeculoplasty at least 6 months before study inclusion were the only previous ocular surgeries in both study groups.

The preoperative mean diurnal IOP was 15.9 ± 3.4 mm Hg in the PLI-MPC group and 16.4 ± 3.5 mm Hg in the PLA-MPC
group, showing no statistically significant difference between the 2 groups (P = 0.584). Table 2 and Figures 1 and 2 summarize the IOP changes of mean diurnal IOP, as well as the 20% mean diurnal IOP reduction, mean diurnal IOP fluctuation, and mean diurnal peak IOP at baseline, and at the 3 and 12-month follow-up. A statistically significant reduction in mean diurnal IOP was observed 3 and 12 months after a single PLI-MPC (P < 0.001) and PLA-MPC (P < 0.001), respectively. The average difference in mean diurnal IOP reduction between the 2 methods was not statistically significantly different at the 3 and 12-month follow-up (P = 0.114 and P = 0.415).

Postoperative diurnal IOP fluctuations decreased statistically significantly at 3 (P < 0.001) and 12 months (P < 0.001) in the PLA-MPC; however, in the PLI-MPC group, only at 3 months (P = 0.027; Table 2). Mean peak IOP decreased statistically significantly at 3 and 12 months in both groups (all P ≤ 0.001) and was not statistically different between both groups at 12 months (P = 0.294; Table 2).

IOP-lowering medication did not change during follow-up. The 16 patients reaching the 3 months follow-up of the PLA-MPC group were on 3.6 ± 0.9 and the 15 patients of the PLI-MPC group on 3.3 ± 1.6 medications without being statistically significantly different between groups (P = 0.522). At 12 months, the 13 patients of the PLI-MPC group were on 4.2 ± 0.8 and the 14 patients of the PLI-MPC group on 3.3 ± 1.6 medications. This was not statistically significantly different between groups as well (P = 0.080).

Six eyes (27%) in the PLI-MPC and 8 eyes (36%) in the PLA-MPC group showed an IOP reduction of > 20%, 12 months after a single treatment without being statistically different between groups (P = 0.568). In total, 12 (54%) of the PLI-MPC and 14 eyes (63%) of the PLA-MPC group had a mean diurnal IOP between 6 and 18 mm Hg.

No severe complications such as prolonged inflammation, hyptonony, development of macular or corneal edema, severe pain, vision loss, or development of phthisis bulbi were noticed.

Mean visual acuity was not statistically different (P = 0.551) between the PLI-MPC (0.4 ± 0.5 logMAR) and PLA-MPC group (0.4 ± 0.3 logMAR) at baseline and did not change significantly at any follow-up. At 12 months it was 0.6 ± 0.7 logMAR in the PLI-MPC and 0.5 ± 0.6 logMAR in the PLA-MPC.

### TABLE 1. Baseline Characteristics of Participants

|                        | Total (n = 44) | PLI-MPC (n = 22) | PLA-MPC (n = 22) | P     |
|------------------------|---------------|------------------|------------------|-------|
| Age, mean years ± SD (range) | 72.2 ± 8.0 (51-85) | 72.4 ± 8.3 (51-85) | 71.9 ± 7.9 (57-83) | 0.839 |
| Sex, n (%)             |                |                  |                  |       |
| Female                 | 17 (38.6)      | 15 (68.2)        | 2 (9.1)          | <0.001|
| Male                   | 27 (61.4)      | 7 (31.8)         | 20 (90.9)        |       |
| BCVA (mean logMAR ± SD) | 0.41 ± 0.44    | 0.44 ± 0.52      | 0.37 ± 0.33      | 0.551 |
| mean IOP (mm Hg)       | 16.1 ± 3.4     | 15.9 ± 3.4       | 16.4 ± 3.5       | 0.603 |
| MD (mean db ± SD)      | −16.8 ± 9.9    | −15.4 ± 10.6     | −18.1 ± 9.1      | 0.374 |
| Glaucoma medications (mean ± SD) | 3.6 ± 0.15 | 3.7 ± 0.15       | 2.2 ± 0.57       | 0.294 |
| Previous ocular surgery, n (%) | 16 (36.4) | 12 (54.5)        | 4 (18.2)         | 0.014 |
| SLT                    | 32 (72.7)      | 16 (72.7)        | 16 (72.7)        | 1.0   |
| Cataract surgery       | 27 (61.4)      | 13 (59.1)        | 14 (63.6)        | 0.756 |
| Type of glaucoma, n (%) |                |                  |                  |       |
| HPG                    | 33 (75)        | 13 (59.1)        | 20 (90.9)        | 0.014 |
| NPG                    | 11 (25)        | 9 (40.9)         | 2 (9.1)          |       |
| Sex, n (%)             |                |                  |                  |       |
| Male                   | 27 (61.4)      | 7 (31.8)         | 20 (90.9)        |       |
| Female                 | 17 (38.6)      | 15 (68.2)        | 2 (9.1)          | <0.001|

**Bold indicate significant P values.**

BCVA indicates best-corrected visual acuity; HPG, high-pressure glaucoma; MD, mean deviation, tested with Swedish interactive threshold algorithm standard 30-2 program; mdIOP, mean diurnal intraocular pressure; NPG, normal-pressure glaucoma; PLA-MPC, pars plana transscleral micropulse cyclocyclophotocoagulation; PLI-MPC, pars plicata transscleral micropulse cyclophotocoagulation; SLT, selective laser trabeculoplasty.

### TABLE 2. mdIOP Reduction, ≥20% mdIOP Reduction, Mean Fluctuation of dIOP, and Mean Peak dIOP at Baseline and at the 3 and 12-Month Follow-up

| Pretreatment | After 3 mo | After 12 mo |
|--------------|------------|-------------|
|               | PLI-MPC    | PLA-MPC    | PLI-MPC | PLA-MPC | PLI-MPC | PLA-MPC |
| Eyes (n)      | 22         | 22         | 16      | 15      | 13      | 14      |
| mdIOP (mm Hg) |            |            |         |         |         |         |
| Pretreatment  | 15.9 ± 3.4 | 16.4 ± 3.5 | 13.6 ± 3.1 | 12.3 ± 2.6 | 12.9 ± 3.7 | 11.8 ± 2.2 |
| After 3 mo    | <0.001     | <0.001     | <0.001  | <0.001  | <0.001  | <0.001  |
| After 12 mo   | <0.001     | <0.001     | <0.001  | <0.001  | <0.001  | <0.001  |
| mdIOP reduction (mm Hg) |            |            |         |         |         |         |
| Pretreatment  | −2.3 ± 2.9 | −4.1 ± 2.6 | −3.0 ± 3.9 | −4.6 ± 3.3 |         |         |
| After 3 mo    | <0.001     | <0.001     | <0.001  | <0.001  | <0.001  | <0.001  |
| After 12 mo   | <0.001     | <0.001     | <0.001  | <0.001  | <0.001  | <0.001  |
| %             | <0.001     | <0.001     | <0.001  | <0.001  | <0.001  | <0.001  |
| n (%) of eyes with ≥20% mdIOP reduction |            |            |         |         |         |         |
| Mean fluctuation of dIOP (mm Hg) |            |            |         |         |         |         |
| Pretreatment  | 8.6 ± 3.3  | 9.1 ± 4.6  | 6.1 ± 2.6 | 5.1 ± 2.1 | 6.4 ± 2.8 | 5.3 ± 1.6 |
| After 3 mo    | <0.001     | 0.001      | 0.094   | 0.001   | 0.001   |         |
| After 12 mo   | <0.001     | <0.001     | <0.001  | <0.001  | <0.001  | <0.001  |
| Mean peak of dIOP (mm Hg) |            |            |         |         |         |         |
| Pretreatment  | 20.3 ± 4.6 | 21.2 ± 5.2 | 16.6 ± 3.6 | 14.8 ± 3.3 | 16.1 ± 4.6 | 14.5 ± 2.5 |
| After 3 mo    | <0.001     | <0.001     | <0.001  | <0.001  | <0.001  | <0.001  |
| After 12 mo   | <0.001     | <0.001     | <0.001  | <0.001  | <0.001  | <0.001  |

**Bold indicate significant P < 0.05.**

dIOP indicates diurnal intraocular pressure; mdIOP, mean diurnal intraocular pressure; PLA-MPC, pars plana transscleral micropulse cyclophotocoagulation; PLI-MPC, pars plicata transscleral micropulse cyclophotocoagulation.
group, which was not statistically different compared with baseline (PLI-MPC, \( P = 0.090 \); PLA-MPC, \( P = 0.177 \)) or between groups (\( P = 0.775 \)).

MD of VFs was not statistically different (\( P = 0.374 \)) between the groups at baseline and did not change significantly at any follow-up. At 12 months MD was \(-12.1 \pm 11.5 \) dB in the PLI-MPC and \(-16.1 \pm 10.1 \) dB in the PLA-MPC group, which was not statistically different compared with baseline (PLI-MPC, \( P = 1.0 \); PLA-MPC, \( P = 1.0 \)) or between groups (\( P = 0.365 \)).

A higher preoperative mean diurnal IOP was recognized as the only factor influencing the postoperative mean diurnal IOP reduction after PLI-MPC and PLA-MPC (\( P = 0.008 \) and \( P = 0.001 \), respectively). There was no correlation between the treatment site of the cyclodestructive procedure and efficacy.

The Kaplan-Meier survival curve indicates that 59% in the PLI-MPC group and 63.6% in the PLA-MPC group did not need secondary IOP-lowering surgical interventions at 12 months postoperatively, showing no statistically significant difference between the 2 groups (\( P = 0.655 \); Fig. 3). Nine eyes (41%) in the PLI-MPC (5 MP-TSCPC retreatments, 1 selective laser trabeculoplasty, 1 cyclocryocoagulation, 2 trabeculectomies) and 8 eyes (36.4%) in the PLA-MPC (2 MP-TSCPC retreatments, 3 selective laser trabeculoplasties, 2 cyclocryocoagulations, 1 trabeculectomy) needed further IOP-lowering surgical interventions during the study period. The Pearson-\( \chi^2 \)-Quadrat test showed no statistically significant difference between rates or surgery types of additional interventions between groups (\( P = 0.498 \)).
DISCUSSION

This study compares the efficacy and safety of MP-TSCPC applied at the level of the pars plicata versus the pars plana in patients with mostly advanced POAG and already receiving maximally tolerated topical IOP-lowering therapy. Neither treatment protocol showed significantly different mean diurnal IOP lowering at 12 months although the IOP-lowering effect of PLA-MPC tended to be superior. The same was found for mean diurnal IOP fluctuations and peak IOP. There was also no statistically significant difference regarding the number of dropouts needing further IOP-lowering surgical interventions. However, the PLA-MPC group tended to be superior in all these aspects and should be the preferred method of application.

The mechanism of MP-TSCPC is not fully understood yet. A recent study compared the macroscopic and microscopic histologic changes with single or double MP-TSCPC treatments versus CW-TSCPC, and controls in adult cadaver eyes. Full-thickness destruction of the ciliary epithelium, coagulation of collagen, and destruction of ciliary stroma leading to decreased production of aqueous humor was only seen in CW-TSCPC. This finding is in accordance with previous studies. Between single and double MP-TSCPC–treated sections and control sections, no significant histologic changes were seen. This confirms the good safety profile clinically seen in the current and other studies. Further, the study provides evidence that an extended treatment time to reach better efficacy might still be safe. Because MP-TSCPC does not destroy the ciliary processes, there may be an IOP-lowering mechanism independent from reducing aqueous production. This might include displacement of the scleral spur with subsequent opening of the anterior chamber angle, thereby increasing trabecular outflow and enlarging Schlemm canal, similar to the effects caused by pilocarpine. The latter mechanism might be more prominent in the PLA-MPC application mode explaining its superiority over PLI-MCP treatment.

There are large variations of the IOP reducing effect described in the current literature on MP-TSCPC. One reason is the different treatment protocols using different energies (2000 to 2500 mW) or longer application times per hemisphere (80 to 120 s). In addition, some studies allowed retreatments or change in IOP-lowering medications. Different baseline characteristics and follow-up times also contribute to the difficulty of comparing studies. Furthermore, most of the studies only record and compare single IOP measurements, often not even taken at the same time of day. It is an important strength of the current study, that the mean of 24-hour diurnal IOP measurements was used, including a measurement in the supine position.

The current study found an IOP reduction of ≥20% in 27% of the PLI-MPC and in 36% of the PLA-MPC group at 12-month follow-up with only 1 MP-TSCPC treatment and no change in IOP-lowering medication. de Crom et al used similar treatment parameters and found an IOP reduction of ≥20% in 60% of patients after 2-year follow-up. These evaluations, however, only included eyes that reached the 2-year follow-up, however. Considering that only 30 eyes of 141 at baseline reached this goal, only about 21% of the patients included at baseline had a ≥20% IOP reduction after 2-year follow-up. This is closer to the findings of the present study. The study of Zaarour et al used standardized treatment parameters as well and found success rates, defined as IOP between 6 and 21 mm Hg or an IOP reduction of ≥20% from baseline, of 73.3% and 66% after 12 and 15 months, respectively. Again, these evaluations only included eyes that reached the individual follow-ups. The percentage of patients with a 20% IOP decrease at 12 months was about 45%. This is much higher compared with our findings and probably because of the higher baseline IOP of 26.0 ± 7.9 mm Hg compared with the mean diurnal baseline IOP in the cohort of the current study (15.9 ± 3.4 mm Hg in the PLI-MPC and 16.4 ± 3.5 mm Hg in the PLA-MPC group, respectively). A higher preoperative mean diurnal IOP was found to be the only factor influencing the postoperative mean diurnal IOP reduction after PLI-MPC and PLA-MPC (P = 0.008 and P = 0.001, respectively). In a retrospective study by Sarrafpour et al, where they had used different power settings on the basis of BCVA, 76% of patients obtained at least 20% IOP reduction at 1 year. Again, the average initial IOP was much higher (25.5 ± 9.4 mm Hg) and

FIGURE 3. Kaplan-Meyer plot showing the cumulative survival without the need for a secondary intraocular pressure-lowering procedure within 12-month follow-up, in both groups. PLA-MPC indicates pars plana transscleral micropulse cyclophotocoagulation; PLI-MPC, pars plicata transscleral micropulse cyclophotocoagulation.
the study did not account for the dropouts and thereby overestimated the IOP-lowering success. The same is the case in the study by Varikuti et al,\(^\text{10}\) where about 86% had an IOP reduction of \(\geq 20\%\) at 12 months. Baseline IOP was much higher (25.69 \(\pm\) 5.63 mm Hg) and they did not take the dropouts into account.

Only limited data of diurnal IOP parameters like IOP fluctuation or peak IOP after cyclodestratc procedures exist. Asrani et al\(^\text{19}\) found that large fluctuations in diurnal IOP are a significant risk factor for glaucoma progression. Diurnal IOP fluctuations were lower after incisional surgery compared with medically treated, advanced glaucoma cases in a study by Konstas et al.\(^\text{30}\) The Advanced Glaucoma Intervention Study (AGIS)\(^\text{22}\) clearly showed that a greater long-term IOP fluctuation has been consistently associated with VF progression in advanced glaucoma cases. In the present study, both treatment arms showed a reduction of diurnal IOP fluctuation and peak IOP with the PLA-MPC group being superior to the PLI-MPC group.

Although the current study found an IOP reduction of \(\geq 20\%\) in only about 30% of patients, it has to be emphasized that the preoperative IOP was already quite low, compared with other studies. 60% of patients showed sufficient IOP reduction to reach their individual target IOP, with less IOP fluctuations, and lower-peak IOPs. The findings of the Early Manifest Glaucoma Trial showed that an IOP reduction of even 1 mm Hg slows down progression by 10\%.\(^\text{32}\) Considering the good safety profile and the rather fast and painless procedure, it can definitely be recommended for wider application.

Secondary outcomes were the occurrence of complications, the course of visual acuity and VFs, the identification of possible factors influencing IOP-lowering success, and the number of dropouts.

Similarly to the study of Zaarour,\(^\text{12}\) we did not observe severe complications like persistent hypotony or phthisis bulbi during the 12-month follow-up in either group. Studies showing higher complication rates after MP-TSCPC used more intense treatment protocols. Emanuel et al\(^\text{13}\) and Williams et al\(^\text{24}\) reported an average treatment time of 300 and 319 seconds, respectively.

BCVA stayed stable during the 12-month follow-up. A stable BCVA was also found in the study by Varikuti et al.\(^\text{10}\) They only treated patients with good visual potential at baseline. Zaarour et al\(^\text{12}\) observed a significant decrease in BCVA in the early follow-up up to 1 month, whereas at the remaining follow-ups BCVA stayed stable. The study of de Crom et al\(^\text{11}\) recognized a decrease in BCVA in about 25% of patients at 1 and 2 years follow-up. They treated a rather heterogeneous group of patients and related this finding to retinal disease, worsening of cataract, or glaucoma progression. In the study by Sarrafpour et al\(^\text{13}\) 18.8% experienced persistent VA loss of 2 or more lines. Their interpretation was a possible fluctuating corneal edema or VA in patients with advanced disease. Although most of the patients in the current study suffered from advanced glaucoma, BCVA did not deteriorate throughout the course of 1 year.

In contrast to the study by de Crom et al,\(^\text{11}\) preoperative IOP was the only parameter correlating with IOP-lowering success after treatment. Sarrafpour et al\(^\text{13}\) also found IOP reduction to be associated with preoperative IOP as well as with the used laser power.

During the 12-month follow-up about 60% in both treatment groups showed sufficient additional IOP lowering after only a single treatment with MP-TSCPC, whereas VFs and BCVA remained stable. Considering the low complication rate and easy to perform the procedure, this novel noninvasive treatment option seems to be a good alternative before planning incisional glaucoma surgery. Especially in patients with only central VFs left, scarred, or very thin conjunctival tissue, and to avoid a wipe-out phenomenon.

Limitations of the current study include its relatively small sample size and the short follow-up time of 12 months. Important strengths of the study are the evaluation of standardized diurnal IOP measurements, the homogeneity of patients, and the exclusion from analysis at the time of further IOP-lowering procedures like repeated MP-TSCPCs.

In conclusion, MP-TSCPC is an effective noninvasive, easy to perform, and safe treatment option, that allows about 60% of POAG patients already applying maximally tolerated IOP-lowering medication to reach their individual mean diurnal target IOP with lower-peak IOPs and less IOP fluctuations. This might be especially important in advanced cases where incisional glaucoma surgery has the risk of a wipe-out. However, the good safety and efficacy profile reported in our and in other recent studies, render MP-TSCPC a potential treatment option also for early glaucoma cases with good visual acuity.\(^\text{10}\) The application site at the pars plana seems to be superior to the pars plicata application. In addition, it is easier and faster to perform and therefore should be the preferred method of application.

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