Micropulse transscleral diode laser cyclophotocoagulation as a treatment modality for glaucoma patients

Aim
To evaluate how micropulse transscleral diode laser cyclophotocoagulation (MP-TSCPC) is a safe and effective procedure, in reducing intraocular pressure (IOP) in different glaucoma patients among the Egyptian population.

Study design
Prospective, noncomparative interventional study.

Patients and methods
This study assessed the effect of MP-TSCPC laser on patients with different types of glaucoma. Forty eyes of 40 patients were included in our study. Patients were recruited from Benha University Hospital and Egyptian Eye Academy, and the procedure was done during the period between January 2020 and July 2021.

Results
The mean±SD baseline IOP was 27.72±8.6 mmHg, which showed significant reduction at postsurgical month 6, becoming 16.28±6.38 mmHg (P=0.001). The mean number of IOP-lowering agents was 2.35±1.03 preoperatively, which dropped significantly to 1.50±1.24 at 6 months. Postoperative logMAR best-corrected visual acuity was not significantly reduced from baseline. There was no development of significant postoperative complications.

Conclusion
MP-TSCPC is an efficient, safe, and simple technique with promising results in lowering IOP and can be used in patients with different types of glaucoma.

Keywords:
glaucoma, intraocular pressure, micropulse-transscleral cyclophotocoagulation

Introduction
Micropulse transscleral cyclophotocoagulation (MP-TSCPC) is a relatively new laser delivery system, considered as an alternate procedure to the traditional continuous wave transscleral cyclophotocoagulation (CW-TSCPC). It divides the laser emission into repetitive short pulses with pauses in between [1,2]. The advantage of this mode of laser is achieving lesser tissue destruction, with minimal thermal damage to the surrounding ocular structures, thus decreasing the critical side effects of the CW-TSCPC, like loss of vision, long-standing hypotony, intraocular inflammation, corneal edema, and phthisis bulbi [3,4].

There are many assumed mechanisms explaining the action of MP-TSCPC and how it reduces intraocular pressure (IOP). Animal studies suggest that cyclophotocoagulation of the pigmented ciliary epithelium results in a reduction of aqueous formation. It is also thought that the lower energy of the micropulse laser boosts outflow through the uveoscleral way through remodeling mechanisms. Also, contraction of longitudinal ciliary muscle fibers displaces scleral spur, which increases outflow through the trabecular meshwork. Furthermore, IOP lowering may be attributed to the resultant inflammation in the ciliary body which causes decreased aqueous production [5–7].

Many studies have been published emphasizing the effectiveness and safety of MP-TSCPC in reducing IOP, but to our knowledge, a limited number of studies have been conducted among the Egyptian population [8,9]. So, the aim of our study was to investigate the success of this relatively novel technique in patients with different types of glaucoma.

Patients and methods
This prospective, noncomparative interventional study assessed the effect of MP-TSCPC laser on different glaucoma types. Forty eyes of 40 patients had undergone the procedure.
Patients were recruited from Benha University Hospital and Egyptian Eye Academy, and the procedure was done at the Egyptian Eye Academy during the period between January 2020 and July 2021. The Ethics Committee of Benha Faculty of Medicine approved the study. Informed consent was obtained, and the confidentiality of whole participants was confirmed.

This trial was retrospectively registered on clinical trials.gov (Identifier, NCT05299281).

Our trial included patients with uncontrolled glaucoma despite maximal tolerated IOP-lowering agents, patients who were unable to maintain compliance with the prescribed topical medications, patients who needed filtering glaucoma surgery for controlling IOP but were not generally fit for the surgery, and patients who refused incisional procedures like sub scleral trabeculectomy.

Different types of glaucoma were included in our trial as shown in Table 1.

Preoperatively, complete history was taken from all participants. A full ophthalmological examination was done, and different aspects of treatment were discussed with the patients including success/failure and the number of medicines that may be needed after treatment.

IOP was measured using Goldmann applanation tonometers (Haag-Streit International, Koeniz, Switzerland).

Three successive readings were taken, and the average reading was recorded. For cases with corneal irregularities or scarring, IOP was measured using Tono-Pen (Tono-pen-Avia; Reichert, Depew, New York, USA).

We measured the best-corrected visual acuity (BCVA) using the Snellen chart and converted it into LogMAR for statistical analysis.

Intraoperatively, Peri-bulbar anesthesia of 2% lidocaine hydrochloride was given before the procedure; we used inhalational general anesthesia for pediatric and uncooperative patients.

In this study, we used the CYCLO G6 micropulse laser system combined with the specific P3 probe (IRIDEX Corporation, Mountain View, California, USA) (Figs 1 and 2).

Our laser settings were 2000 mW of 810 nm diode laser, set on the micropulse mode, delivered over 160 s (80 s for each hemisphere), with 10 s dwell time, and a duty cycle of 31.3%.

The procedure was performed by a single surgeon (G. H.A.Y.) after complete sterilization of the field. A viscous interface (methylcellulose) was applied over the area of the treatment to ensure proper energy distribution. The notched side of the probe was placed at the surgical limbus with the probe directed to the center of the globe, adequate pressure was applied, and treatment started with sweeping the probe over the sclera in a continuous ‘painting’ motion. We avoided the application of treatment to the 3 and 9 o’clock positions to preclude any injury to the ciliary nerves.

Postoperatively, topical weak steroids (fluorometholone) and topical NSAIDs eye drops were prescribed. Patients were instructed to stop oral acetazolamide after the procedure if it was used preoperatively and other topical IOP-lowering drops were continued and then slowly tapered depending on the IOP level.

Follow-up was done at 1 day, 2 weeks, 1 month, 3, and 6 months following the procedure. For every visit, we recorded IOP, visual acuity, number of topical IOP-lowering agents, the need for acetazolamide, and any abnormal findings. After 1 month of the procedure, we started to consider retreatment if there was no sufficient reduction in baseline IOP, measured on two successive visits with 1 week apart.

<table>
<thead>
<tr>
<th>Type of glaucoma</th>
<th>n (%)</th>
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<tbody>
<tr>
<td>Primary glaucoma</td>
<td></td>
</tr>
<tr>
<td>Primary open angle</td>
<td>12 (30)</td>
</tr>
<tr>
<td>Chronic angle closure</td>
<td>1 (2.5)</td>
</tr>
<tr>
<td>Secondary glaucoma</td>
<td></td>
</tr>
<tr>
<td>Post-PKP</td>
<td>10 (25)</td>
</tr>
<tr>
<td>Silicone oil induced (post-PPV)</td>
<td>6 (15)</td>
</tr>
<tr>
<td>Congenital</td>
<td>4 (10)</td>
</tr>
<tr>
<td>Juvenile</td>
<td>2 (5)</td>
</tr>
<tr>
<td>Steroid induced</td>
<td>2 (5)</td>
</tr>
<tr>
<td>Uveitic</td>
<td>1 (2.5)</td>
</tr>
<tr>
<td>NVG</td>
<td>1 (2.5)</td>
</tr>
<tr>
<td>Aphakic</td>
<td>1 (2.5)</td>
</tr>
</tbody>
</table>

NVG, neovascular glaucoma; PKP, penetrating keratoplasty; PPV, pars plana vitrectomy.
In this trial, the primary outcomes were a significant decrease in IOP and any change in BCVA, while secondary outcomes included complication rate, decrease in the total amount of IOP-lowering agents, and rate of laser retreatment.

The overall success was defined as ‘attaining postoperative IOP between 6 and 21 mmHg or a decrease of at least 20% of IOP from the baseline value with or without medications’ [10].

The data was collected and managed by the Statistical Package for the Social Sciences SPSS software (SPSS Inc., Chicago, IL, USA).

Statistical significance was used and a $P$ value of less than or equal to 0.05 indicated...
statistically significant results at 95% level of confidence.

**Results**

All our 40 patients who underwent the procedure were followed up for 6 months.

Table 2 summarizes the baseline data of all participants.

In the study, 82.5% of eyes had no previous history of any glaucoma surgery, while 17.5% of eyes had a prior history of one or more glaucoma surgical procedures; six eyes had subscleral trabeculectomy and three eyes had Ahmed valve drainage device implantation.

Baseline and postoperative BCVA were compared, and frequency of vision change was estimated using the paired \( t \) test. There was no significant change in logMAR BCVA from baseline (1.86±1.47) to postsurgical month 6 (1.80±1.50) as shown in Fig. 3.

Figure 4 illustrates the mean IOP at baseline and at each follow-up visit. The mean IOP was significantly dropped from 27.72 mmHg (20.0–44.0 mmHg), at baseline, to 16.28 mmHg (6.0–31.0 mmHg) at postoperative month 6 (\( P=0.001 \)). There was no significant correlation between the percentage of IOP decrease and the type of glaucoma, the age of the patient, or previous exposure to ocular surgery (\( P=0.64, 0.55, \) and 0.28, respectively).

Our trial showed a significant decrease in the number of topical preoperative IOP-lowering agents, using the paired \( t \) test. The mean baseline number was 2.35 ±1.03, while the mean postoperative number was 1.50±1.24 (\( P=0.001 \)) at the final follow-up visit. Also, 37.5% (15/40) of our patients were maintained on oral acetazolamide before the procedure, this ratio dropped to 12.5% (5/40) postoperatively.

Eight eyes needed further laser treatment to control IOP adequately. The mean interval from the initial MP-TSCPC procedure to the retreatment session was 2.5 months. Three of the eyes that required further treatment had glaucoma secondary to penetrating keratoplasty, three had congenital glaucoma, one had uveitic glaucoma, and one had primary open-angle glaucoma. One patient required two more MP-TSCPC sessions (a patient with post-penetrating keratoplasty glaucoma), while the other patients had only one retreatment session.

Complications of the procedure noted in our patients are listed in Table 3.

Of the eyes, 28 (70%) eyes did not show any postoperative complications. Nine eyes demonstrated dilated pupils with loss of accommodation in the early postoperative period, which resolved spontaneously after 1 month; hyphema was noticed in the neovascular glaucoma patient, hypotony occurred in one eye, and one eye had neurotrophic keratitis (NK).

Figure 5 shows the overall success rates at each follow-up visit. We reached our goal in about 60% or more of the cases at each follow-up visit. At our last follow-up (month 6), the overall success was 73.5%.

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Demographics and baseline data of the patients</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Variables</strong></td>
<td><strong>Statistics</strong></td>
</tr>
<tr>
<td>Total eyes number</td>
<td>40</td>
</tr>
<tr>
<td>Total patients’ number</td>
<td>40</td>
</tr>
<tr>
<td>Age (years)</td>
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<tr>
<td>Mean±SD</td>
<td>43.75±21.99</td>
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<tr>
<td>Median</td>
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</tr>
<tr>
<td>Range</td>
<td>3–70</td>
</tr>
<tr>
<td>Sex [n (%)]</td>
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<tr>
<td>Females</td>
<td>19 (47.5)</td>
</tr>
<tr>
<td>Males</td>
<td>21 (52.5)</td>
</tr>
</tbody>
</table>

Figure 3

Preoperative and postoperative logMAR BCVA. BCVA, best-corrected visual acuity.
Discussion

CW-TSCPC had been widely used in treating advanced cases of glaucoma, but due to its potential vision-threatening complications [3,4], there was a new trend toward using a less destructive procedure with lesser side effects, a technique known as MP-TSCPC.

The objective of this cohort was to estimate the effectiveness and safety of MP-TSCPC as an option for controlling IOP in different types of glaucoma among the Egyptian population.

In our study, the overall surgical success rate of MP-TSCPC was 67.5, 67.5, 60.5, and 73.5% in the 2nd week, 1st, 3rd, and 6th months, respectively.

Success rates vary in the literature with Williams et al. [2] showing a success of 75% at 3 months and 66% at 6 months; in addition, Yelenskiy et al. [11] showed an overall success of 71% and Nguyen et al. [12] revealed a total success of 76.8%, both at 12 months.

On the other side, some authors showed higher success rates like Tan et al. [13], who reported a success rate of 81.4% at 6 months, and Al Habash and AlAhmadi [14], who showed a success rate of 95.7% at 6 months. Al Habash and AlAhmadi reported using laser parameters of 2200 mW for 120 s for each 180-degree arc, while our parameters were 2000 mW delivered over 80 s for each hemisphere. This difference in laser parameters may explain the higher success rate in the aforementioned study.

It is noteworthy that IOP in our patients was significantly decreased by 40.75% at 6 months. This supports previous studies of MP-TSCPC.

Kuchar et al. [15] revealed a decrease in mean IOP of 40.1% at 6 months; Garcia et al. [16] showed 31.1% reduction in baseline IOP at 6 months; and Zaarour et al. [17] showed a 29.3% reduction rate of baseline IOP at the 6-month follow-up. Emanuel et al. [18] found slightly higher IOP reduction, from baseline 27.7 to 13.0 mmHg (representing 53% reduction of baseline IOP) at 6 months postoperatively.

Our trial showed a significant reduction in topical IOP-lowering agents. Their mean number was decreased from a mean of 2.35 before the procedure...
to 1.5 at 6 months postoperatively, which correlates with other studies in the literature.

Kuchar et al. [15] showed a decrease in the mean number of topical IOP-lowering agents from 2.6 preoperatively to 1.9 postoperatively. Emanuel et al. [18] demonstrated a reduction in baseline medications from 3.3 to 2.3 at 6 months postoperatively and de Crom et al. [19] showed decreased medication number from 3.3 to 2.6 at 6 months follow-up.

Also, it is important to emphasize that oral acetazolamide was less needed after the procedure with only 12.5% (5/40) of patients needing it, compared with 37.5% (15/40) preoperatively.

These results are quiet similar to Zaarour et al. [17], who demonstrated a significant reduction in the percentage of eyes kept on oral acetazolamide following the laser therapy.

We did not find any significant change in visual acuity. However, BCVA change following the MP-TSCPC is widely variable across the literature. For example, Emanuel et al. [18] found a decrease in BCVA in 41% of eyes postoperatively, while others showed no significant visual loss [12].

Our cohort further ensures the safety of MP-TSCPC. We did not notice major complications like those reported during using CW-TSCPC [3]. However, we observed nine eyes developing postoperative dilated pupils with accommodation loss that was improved 1 month later. Hyphema was noticed in the neovascular glaucoma patient, hypotony occurred in one eye, and one eye had NK. In previous reports, Zaarour et al. [17] and Tekeli and Köse [20] had no serious complications, while Williams et al. [2] who conducted his study on 79 eyes demonstrated a higher rate of complications. They reported phthisis in 2%, hypotony in 8.8%, corneal edema in 2%, and prolonged anterior chamber reaction of more than 3 months in 26%. Also, Emmanuel et al. [18] who conducted his study on 84 eyes reported ‘46% of postoperative inflammation at the 3 months’ follow-up visit and loss of more than two Snellen lines in 26.2% of patients.’

Several studies have reported tonic pupil following the MP-TSCPC procedure, which resolved spontaneously at variable durations. The mechanism is not well understood, but the culprit could be multifactorial. Dorairaj et al. [21] reported that four of 349 patients developing dilated fixed pupil following MP-TSCPC with a higher incidence in myopic females with brown irides.

NK following micropulse cyclophotocoagulation is not common, with Kim et al. [22] reporting one case. Also, Perez et al. [23] recorded two cases. Both were diabetics, one had a history of pars plana vitrectomy, the other had previous history of Ahmed valve implantation. In the present study, one case had developed NK, she was 5 years old with a history of multiple incisional glaucoma surgeries. She developed a 3 mm horizontal epithelial defect in the lower half of the cornea with decreased corneal sensation. There was not any corneal infiltration. The history of multiple previous ocular surgeries and chronic use of topical IOP-lowering agents may have contributed to the development of the neurotrophic state in that patient. Also, corneal exposure during the procedure may acted as an additional risk factor. The epithelial defect healed after 2 weeks with excessive topical preservative-free lubricants and prophylactic antimicrobial eye drops. Another explanation of NK following MP-TSCPC may be inadvertent thermal damage to the ciliary nerves at 3 and 6 o’clock positions during the procedure.

We also found that eight (20%) eyes needed additional laser treatment for reasonable IOP control. Zaarour et al. [17] found that 8% of total 75 eyes needed retreatment after 6 months. Tekeli and Köse [20] showed that 23.9% of total 96 eyes required further laser retreatment. The highest retreatment rate was reported by Aquino et al. [24] with a retreatment rate of 46% of his 48 patients.

To conclude, MP-TSCPC is a powerful easy technique with promising results. It could be used in different types of glaucoma, could be considered an alternative therapy for patients who are noncompliant to medications or medically unfit for surgery, those with high surgical risks (hypotony, bleeding, infection, fixation loss), patients needing additional IOP lowering with or without prior glaucoma surgeries, or as a temporizing measure before incisional glaucoma surgery.

It needs less postoperative activity restriction. It also showed a good safety profile.

So, our results support the growing evidence of using MP-TSCPC as a safe effective treatment in different types of glaucoma patients.

Our study may be limited by the short follow-up period, small sample size, and wide range of
participants’ age. We encourage further research to study the exact durability of the MP-TSCPC laser, comparisons of efficacy between different subgroups of glaucoma, and any other probable complications.

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Nil.

Conflicts of interest
There are no conflicts of interest.

References