ORIGINAL ARTICLE

Micropulse transscleral laser therapy for glaucoma: a retrospective study

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Abstract

Objective: To evaluate the safety and efficacy of micropulse transscleral laser therapy (MPTLT) in patients with glaucoma at a tertiary eye center in Hong Kong.

Methods: Medical records of patients who underwent MPTLT at Hong Kong Eye Hospital between 1 August 2020 and 31 July 2021 were retrospectively reviewed. Successful treatment was defined as a postoperative intraocular pressure (IOP) between 6 and 21 mmHg or a 20% reduction in IOP from baseline, without an increase in glaucoma medications (topical or oral) or additional glaucoma interventions.

Results: In total, 205 eyes underwent MPTLT either for the first time (n=100) or retreatment (n=105). The mean preoperative visual acuity was 1.6 LogMAR, and 42 (20.5%) eyes had a baseline visual acuity of light perception or worse. The mean preoperative IOP was 27.7 mmHg. All the patients were on the maximum tolerated medical therapy prior to undergoing MPTLT; the mean number of preoperative topical anti-glaucoma medications was 4.1. The mean energy administered was 116.4 J. The overall success rates were 64.9% at 1 month, 51.7% at 3 months, 42.4% at 6 months, 31.2% at 1 year, and 29.3% at 18 months. Success rates were comparable across all time points for both groups. At 18 months or the last visit before additional intervention, the mean IOP reduced 11.3% to 23.3 mmHg (p<0.001), and approximately 23% of patients had an IOP reduction of at least 20%. The mean number of topical anti-glaucoma medications required decreased 5.3% from 4.1 to 3.9 (p=0.003). The decrease was significant in eyes undergoing first-time MPTLT (p=0.004). The percentage of eyes requiring an oral carbonic anhydrase inhibitor also decreased from 72.2% to 44.9% (p<0.001). Patients who received intermediate-energy MPTLT experienced a greater reduction in the number of topical glaucoma medications and in eyes requiring oral carbonic anhydrase inhibitor (acetazolamide) than patients who received low-energy MPTLT. Of 205 eyes, 124 (60.5%) required a mean of 1.9 additional interventions per eye; the median time to the first additional intervention was 3.0 months. Overall, eight (3.9%) eyes developed complications after MPTLT.

Conclusions: MPTLT is a safe and effective treatment modality for various glaucoma subtypes, reducing IOP and the need for topical and oral anti-glaucoma medication. The optimal treatment parameters remain to be determined.

Key words: *Glaucoma; Intraocular pressure; Laser therapy*

Introduction

Glaucoma is a neurodegenerative eye disease characterized by progressive retinal ganglion cell loss and distinctive visual field changes. Approximately 80 million people were affected worldwide in 2020; the number is anticipated to increase to 112 million by 2040.[1] Glaucoma remains a leading cause of irreversible blindness. Although various risk factors contribute to its development, lowering intraocular pressure (IOP) is the most effective way to delay the disease's progression.

Traditionally, the treatment algorithm for glaucoma follows a stepwise approach that comprises topical medication, laser therapy, and surgery, each with differing levels of efficacy and risks. Since the 1930s, cyclodestructive procedures have been used to coagulate or destroy the ciliary body, aiming to reduce aqueous humor production.[2] Various methods can be used for cyclodestruction, including diathermy, surgical excision, cryotherapy, ultrasound, and laser therapy (cyclophotocoagulation). To date, both transscleral and endoscopic approaches have been used for cyclophotocoagulation.[3] Transscleral diode laser cyclophotocoagulation (G-probe) used to be the primary modality for laser cyclophotocoagulation. However, it is associated with complications such as prolonged intraocular inflammation, hyphema, conjunctival burns, and cystoid macular edema, as well as higher rates of severe complications including hypotony, phthisis bulbi, malignant glaucoma, scleral perforation, and sympathetic ophthalmia.[4] Consequently, G-probe is typically a last resort for refractory glaucoma and eyes with poor visual potential.

Micropulse transscleral laser therapy (MPTLT) is a safer technique than G-probe for cyclophotocoagulation. Instead of a continuous laser transmission, MPTLT utilizes repetitive micropulses of diode laser ('on' cycles) interspersed with rest intervals ('off' cycles).[5] It is postulated that the 'off' periods promote thermal dissipation, reducing heat build-up and subsequent collateral tissue damage and adverse effects.[6] MPTLT operates through three mechanisms of action: (1) subthreshold cell damage at the pigmented ciliary epithelium level and, to a lesser extent, the non-pigmented epithelium level; (2) increased uveoscleral outflow,[7,8] and (3) a pilocarpine-like effect (ie, the contraction of ciliary muscle longitudinal fibers, increasing aqueous humor outflow via the conventional pathway).[9,10] MPTLT has demonstrated a lower incidence of complications than G-probe.[6,11] Histological examinations of autopsied eyes treated with MPTLT reveal minimal changes in the normal tissue architecture surrounding the ciliary body.[12] MPTLT's improved safety profile enables its earlier use to treat glaucoma. Its other advantages include repeatability, feasibility as an office procedure, reduced postoperative inflammation, and less need for intensive follow-up.

Methods

Medical records of patients who underwent MPTLT at Hong Kong Eye Hospital between 1 August 2020 and 31 July 2021 were retrospectively reviewed. The start date was the implementation of the revised Iridex P3 delivery device (Iridex, Mountain View [CA], USA). Data collected included patient age, sex, ethnicity, glaucoma type and severity, history of glaucoma surgery, number of MPTLT received, MPTLT parameters, visual acuity, IOP, number of topical anti-glaucoma medications taken prior to treatment/retreatment (calculated by adding the number of different medication classes), need for oral acetazolamide, incidence of complications, and need for retreatment or additional interventions. Where retreatment or additional interventions were required, the interval (in months) from the MPTLT to the first intervention and the form of intervention were noted.

All MPTLT procedures were performed at Hong Kong Eye Hospital by or under the supervision of a glaucoma specialist. Preoperatively, patients received a retrobulbar block with 2% lidocaine and 0.75% bupivacaine in a 1:1 ratio. The 810 nm laser (G6) was used with the Generation 2 MicroPulse P3 handpiece. A speculum was used to ensure adequate exposure, and topical xylocaine gel was applied to facilitate probe movement. The handpiece was moved in a continuous sliding arc motion for 15 to 20 seconds each cycle, with consistent firm pressure perpendicular to the globe. The superior and inferior hemispheres of the eye were treated while avoiding the 3 and 9 o'clock positions, any areas of scleral thinning, pigmented or hemorrhagic conjunctiva, and sites of previous glaucoma surgery. Following MPTLT, patients were prescribed topical dexamethasone plus chloramphenicol eye drops 6 times per day for 2 weeks with initial continuation of all pre-laser hypotensive therapy.

Successful treatment was defined as a postoperative IOP between 6 and 21 mmHg or a 20% reduction in IOP from baseline, without an increase in glaucoma medications (topical or oral) or additional glaucoma interventions. Patients' data were recorded until the point of treatment failure or when additional oral glaucoma medications or interventions were needed. The decision to continue or taper the use of anti-glaucoma medications subsequently was based on the postoperative IOP measured at follow-ups and the physician's discretion.

Statistical analysis was performed using SPSS (version 29.0.2.0, IBM, New York, USA). A p value of <0.05 was considered statistically significant.

Results

In total, 205 eyes underwent MPTLT either for the first time (n=100) or retreatment (n=105) [**Table 1**]. The mean patient age was 67.4 years, and the male-to-female ratio was approximately 2:1. The most common diagnosis was primary open-angle glaucoma (35.1%), followed by neovascular glaucoma (18.5%), uveitic glaucoma (10.2%), and angle-closure glaucoma (9.3%).

The mean preoperative visual acuity was 1.6 LogMAR, and 42 (20.5%) eyes had a baseline visual acuity of light perception or worse. The mean preoperative visual field index using the Humphrey visual field analyzer was 45.7%, with a baseline mean deviation of -20.0 dB and pattern standard deviation of 6.7 dB. 62 (30.2%) eyes had undergone at least one previous incisional glaucoma surgery. The mean preoperative IOP was 27.7 mmHg. All the patients were on the maximum tolerated medical therapy prior to undergoing MPTLT; the mean number of preoperative topical anti-glaucoma medications was 4.1 (range, 2-5). 148 (72.2%) eyes required an oral carbonic anhydrase inhibitor.

Table 1. Clinical characteristics of patients undergoing micropulse transscleral laser therapy (MPTLT)

	All eyes (n=205)*	Eyes undergoing first-time MPTLT (n=100)*	Eyes undergoing MPTLT retreatment (n=105)*	p Value
Age, y	67.4±15.0	67.4±15.6	67.4±14.4	0.755
Sex				<0.001
Male	136 (66.3)	55 (55)	81 (77.1)	
Female	69 (33.7)	45 (45)	24 (22.9)	
Ethnicity				0.972
Chinese	203	99	104	
Others	2	1	1	
Glaucoma				
Primary open-angle	72 (35.1)	40 (40.0)	32 (30.5)	0.153
Neovascular	38 (18.5)	16 (16.0)	22 (21.0)	0.362
Uveitis	21 (10.2)	5 (5.0)	16 (15.2)	0.016
Angle-closure	19 (9.3)	12 (12.0)	7 (6.7)	0.188
Silicone oil-related	10 (4.9)	5 (5.0)	5 (4.8)	0.937
Aphakia	8 (3.9)	4 (4.0)	4 (3.8)	0.944
Iridocorneal endothelial syndrome	7 (3.4)	3 (3.0)	4 (3.8)	0.750
Post-keratoplasty	6 (3.9)	3 (3.0)	3 (2.9)	0.952
Uveitis-glaucoma-hyphema syndrome	5 (2.4)	3 (3.0)	2 (1.9)	0.611
Red cell	4 (2.0)	2 (2.0)	2 (1.9)	0.961
Others (juvenile open-angle glaucoma, normal tension glaucoma, epithelial downgrowth, trauma, aniridia, congenital glaucoma, painful blind eye)	15 (7.3)	7 (7.0)	8 (7.6)	0.865
No. of topical intraocular pressure–lowering medications used	4.1±0.7	4.2±0.7	4.0±0.7	0.217
Use of oral carbonic anhydrase inhibitor	148 (72.2)	74 (74.0)	74 (70.5)	0.574
Preoperative intraocular pressure, mmHg	27.7±8.7	28.5±9.5	27.0±7.9	0.349
Visual acuity, LogMAR	1.6±1.0 (0.18-3.0)	1.5±1.0 (0.1-3.0)	1.7±0.9 (0.18-3.0)	0.263
Visual field index, %	45.7±34.3	53.7±30.3	38.5±36.4	0.026
Mean deviation, dB	-20.0±9.5	-17.7±8.8	-22.4±9.7	0.010
Pattern standard deviation, dB	6.7±3.7	7.7±3.7	5.9±3.5	0.011
Prior glaucoma surgery	62 (30.2)	31 (31.0)	31 (29.5)	0.818

* *Data are presented as mean±standard deviation, No. (%) of patients, No. of patients, or mean ± standard deviation (range)*

Compared with patients undergoing MPTLT for the first time, a higher proportion of patients undergoing MPTLT retreatment were male (p<0.001) and had uveitic glaucoma (p=0.016) and worse visual field index (p=0.026), mean deviation (p=0.010), and pattern standard deviation (p=0.011) at baseline. The two groups were comparable in terms of other clinical characteristics.

Regarding MPTLT parameters, the mean power was 2151.6 mW for a mean duration of 173.5 s for a 31.3% duty cycle (**Table 2**). The total energy in joules (J) was calculated as power in watts (W) × total treatment duration in seconds (s) × duty cycle.[8] The mean energy administered was 116.4 J. Similar laser parameters were used for both the first-time treatment and retreatment groups. Patients were stratified by energy levels: low (<100 J, n=15), intermediate (100-<200 J, n=190), and high (≥200 J, n=0).

The overall success rates were 64.9% at 1 month, 51.7% at 3 months, 42.4% at 6 months, 31.2% at 1 year, and 29.3% at

18 months (**Table 3**). Success rates were comparable across all time points for both groups.

At 18 months or the last visit before additional intervention, the mean IOP reduced 11.3% to 23.3 mmHg (p<0.001, **Table 4**), and approximately 23% of patients had an IOP reduction of at least 20% (**Table 5**).

Overall, the mean number of topical anti-glaucoma medications required decreased 5.3% from 4.1 to 3.9 (p=0.003, **Table 6**). The decrease was significant in eyes undergoing first-time MPTLT (p=0.004) but not in eyes undergoing MPTLT retreatment (p=0.278). The percentage of eyes requiring an oral carbonic anhydrase inhibitor also decreased from 72.2% to 44.9% (p<0.001). The two groups were comparable in terms of tapering the use of oral acetazolamide.

Patients who received intermediate-energy MPTLT experienced a greater reduction in the number of topical glaucoma medications and in eyes requiring oral carbonic anhydrase inhibitor (acetazolamide) than patients who received low-energy MPTLT (**Table 7**). Nevertheless, the overall success rates were comparable between groups.

Of 205 eyes, 124 (60.5%) required a mean of 1.9 additional interventions per eye; the median time to the first additional intervention was 3.0 months (**Table 8**). The

Table 2. Micropulse transscleral laser therapy (MPTLT) parameters

	All eyes (n=205)*	Eyes undergoing first-time MPTLT (n=100)*	Eyes undergoing MPTLT retreatment (n=105)*	p Value
Power, mW	2151.6±202.5 (1500-2500)	2150.5±192.8 (1900-2500)	2154.0±212.6 (1500-2500)	0.921
Duration, s	173.5±20.0 (100-240)	172.2±15.3 (120-200)	174.7±23.6 (100-240)	0.575
Duty cycle, %	31.3	31.3	31.3	
Energy, J	116.4±14.4 (70.4-156.5)	115.7±13.1 (75.1-148.7)	117.2±15.5 (70.4-156.5)	0.223
Energy level, J				
Low (<100)	15 (7.3)	8 (8.0)	7 (6.7)	
Intermediate (100-<200)	190 (92.7)	92 (92.0)	98 (93.3)	
High (≥200)	0	0	0	

* *Data are presented as mean, mean ± standard deviation (range), or No. (%) of patients*

Table 3. Success rates at different time points after micropulse transscleral laser therapy (MPTLT)

Postoperative time point	All eyes (n=205)*	Eyes undergoing first-time MPTLT (n=100)*	Eyes undergoing MPTLT retreatment (n=105)*	p Value
1 month	133 (64.9)	64 (64.0)	69 (65.7)	0.884
3 months	106 (51.7)	51 (51.0)	55 (52.4)	0.889
6 months	87 (42.4)	42 (42.0)	45 (42.9)	0.999
12 months	64 (31.2)	33 (33.0)	31 (29.5)	0.652
18s months	60 (29.3)	28 (28.0)	32 (30.5)	0.760

* *Data are presented as No. (%) of patients.*

Table 4. Intraocular pressure before and after micropulse transscleral laser therapy (MPTLT)

Intraocular pressure, mmHg	All eyes (n=205)*	Eyes undergoing first-time MPTLT (n=100)*	Eyes undergoing MPTLT retreatment (n=105)*	p Value
Preoperative	27.7±8.7 (7-64)	28.5±9.5 (11-64)	27.0±7.9 (7-52)	0.349
Postoperative 18 months	23.3±9.2 (5-58)	23.0±9.3 (9-56)	23.6±9.1 (5-58)	0.559
p Value	<0.001	<0.001	<0.001	

* *Data are presented as mean ± standard deviation (range) unless otherwise indicated*

most common additional intervention was repeat MPTLT (33.1%), followed by G-probe (16.1%), MPTLT plus G-probe (16.1%), MPTLT/G-probe plus surgery (12.1%), trabeculectomy (11.3%), MPTLT plus G-probe plus selective laser trabeculoplasty (4.0%), selective laser trabeculoplasty (3.2%), insertion of a glaucoma drainage device (1.6%), and others (2.4%). Both groups were comparable in terms of the number of eyes requiring additional interventions and the number of additional interventions.

Overall, eight (3.9%) eyes developed complications after MPTLT. No eyes developed macular edema, hypotony, or phthisis bulbi. Among eyes with 20/400 vision or better, none experienced permanent vision loss of >2 Snellen lines. However, six eyes with light perception to count finger vision progressed to no light perception vision. Additionally, one eye developed corneal decompensation at 1 month, necessitating endothelial keratoplasty. Another eye had a flare-up of underlying anterior uveitis and decreased visual acuity secondary to a persistent corneal epithelial defect and corneal scar formation.

Table 5. Percentage of eyes with ≥20% reduction in intraocular pressure after micropulse transscleral laser therapy (MPTLT)

Postoperative time point	% of eyes with ≥20% reduction in intraocular pressure		p Value
	Eyes undergoing first-time MPTLT (n=100)	Eyes undergoing MPTLT retreatment (n=105)	
1 month	50.0	44.8	0.486
3 months	36.0	31.4	0.555
6 months	29.0	31.4	0.762
12 months	19.0	23.8	0.496
18 months	23.0	23.8	0.999

Discussion

MPTLT is a safe and effective treatment for various types of glaucoma, significantly reducing IOP and the use of topical and systemic anti-glaucoma medications for up to 18 months. Although eyes undergoing MPTLT retreatment had worse visual field parameters at baseline, they were comparable with eyes undergoing first-time MPTLT in terms of success rate, IOP control, need for oral acetazolamide, and need for additional interventions. Intermediate-energy MPTLT was more effective than low-energy MPTLT in reducing the need for topical and systemic anti-glaucoma medications, with a comparable safety profile.

In our patients, the mean preoperative IOP was 27.7 (range, 7-64) mmHg. It is uncommon to perform MPTLT on an eye with an IOP of 7 mmHg. Before MPTLT, the patient's IOP was uncontrollable despite receiving the maximum tolerated medical therapy until he was given the highest dose of oral acetazolamide, which he was unable to wean off. The postoperative period was uneventful with no complications, and the patient was able to wean off oral acetazolamide with no need for retreatment at 18 months.

Table 6. Change in topical and systemic medication need before and after micropulse transscleral laser therapy (MPTLT)

Medication	All eyes (n=205)*	Eyes undergoing first-time MPTLT (n=100)*	Eyes undergoing MPTLT retreatment (n=105)*	p Value
No. of topical medications				
Preoperative	4.1±0.7	4.2±0.7	4.0±0.7	0.217
Postoperative 18 months	3.9±1.1	3.8±1.3	3.9±0.1	0.832
p Value	0.0030	0.0040	0.278	
% of eyes on oral acetazolamide				
Preoperative	72.2	74.0	70.5	0.574
Postoperative 18 months	44.9	46.0	43.8	0.752
p Value	<0.001	<0.001	<0.001	
Acetazolamide need				
Reduced	91 (44.4)	43 (43.0)	48 (45.7)	
Increased	28 (13.7)	15 (15.0)	13 (12.4)	
Unchanged	41 (20.0)	21 (21.0)	20 (19.0)	
Not required throughout	45 (22.0)	21 (21.0)	24 (22.9)	

* *Data are presented as mean ± standard deviation or No. (%) of patients unless otherwise indicated*

Table 7. Postoperative outcomes by energy level

	Low energy (<100 J) [n=15]*	Intermediate energy (100-<200 J) [n=190]*	p Value
Success rate			
1 month	11 (73.3)	122 (64.2)	0.476
3 months	11 (73.3)	95 (50.0)	0.082
6 months	8 (53.3)	79 (41.6)	0.375
12 months	6 (40.0)	58 (30.5)	0.446
18 months	5 (33.3)	55 (28.9)	0.719
% of intraocular pressure reduction	13.3	11.2	
No. of topical medications used			
Preoperative	4.3±0.5	4.1±0.7	0.370
Postoperative 18 months	3.5±1.7	3.9±1.1	0.803
p Value	0.078	0.014	
% of eyes on oral acetazolamide			
Preoperative	73.3	72.1	0.919
Postoperative 18 months	60.0	42.6	0.192
p Value	0.699	<0.001	

** Data are presented as mean, mean ± standard deviation, or No. (%) of patients unless otherwise indicated*

Table 8. Need for additional interventions after micropulse transscleral laser therapy (MPTLT)

Additional intervention	All eyes (n=205)*	Eyes undergoing first-time MPTLT (n=100)*	Eyes undergoing MPTLT retreatment (n=105)*	p Value
Eyes requiring additional interventions	124 (60.5)	59 (59.0)	65 (61.9)	0.775
No. of additional interventions	1.9±1.2 (1-8)	2.0±1.4 (1-8)	1.9±1.1 (1-5)	0.709
Median time to first additional intervention, mo	3.0±4.2 (0.25-18)	3.0±4.2 (1-18)	3.0±4.1 (0.25-18)	0.714
Type of additional intervention				
Surgical	34 (27.4)	20 (33.9)	14 (21.5)	
Non-surgical	90 (72.6)	39 (66.1)	51 (74.5)	

** Data are presented as mean ± standard deviation (range) or No. (%) of patients*

The MPTLT success rates vary from 26% to 100%, as do retreatment rates from 0% to 46%.[13] These differences can be explained by the diverse combinations of treatment parameters and heterogenous patient populations, which make direct comparisons difficult. In our patients, the overall retreatment rate was 60.5%, and the median time to retreatment was 3.0 months. This higher retreatment rate was in part due to the lower laser power used (range, 1500-2500 mW), compared with the 2000-2500 mW recommended by the manufacturer. Our cohort comprised eyes with various glaucoma subtypes such as neovascular glaucoma (18.5%) and uveitic glaucoma (10.2%), which are associated with worse prognoses[14] and higher retreatment rates than primary open-angle glaucoma.[5,13,15] Furthermore, 20.5% of eyes had a baseline visual acuity of light perception or worse and were unable to perform a Humphrey visual field analysis. The preoperative visual field mean deviation of -20.0 dB would therefore have been underestimated. There was no standardized set of indications for retreatment or additional interventions, and the decision was based on the physician's discretion at each follow-up visit, which may have contributed to the higher retreatment rate.

MPTLT is a safe procedure for both keratoplasty-naïve and post-keratoplasty eyes.[16-18] In 61 eyes with mild to advanced glaucoma treated with MPTLT, three (4.9%) eyes had corneal decompensation, and all three had previous corneal pathologies (herpetic keratitis, Fuchs' endothelial dystrophy, and bullous keratopathy).[19] In 14 eyes with refractory glaucoma treated with MPTLT, one (5%) eye developed corneal decompensation at 3 years; the eye had a history of multiple intraocular surgeries.[20] Among our patients, one eye developed corneal decompensation 1 month after MPTLT, necessitating endothelial keratoplasty. The patient had uveitic glaucoma with a history of trabeculectomy for more than two decades. Preoperatively, there was no clinical evidence of corneal pathologies or early signs of decompensation. The MPTLT parameters were within intermediate ranges (2000 mW power, 160 seconds duration, total energy 100.2 J). Therefore, specular microscopy examination prior to treatment is advocated for patients at risk of postoperative corneal decompensation including inherited or acquired endothelial deficiencies, post-keratoplasty eyes, uveitic glaucoma, history of herpetic eye disease, and eyes with multiple previous intraocular procedures.

A laser energy level of <112 J is associated with a lower complication rate, but the treatment efficacy tends to be short-lived. In contrast, medium-energy levels (100 to <200 J) result in higher success rates and longer-lasting effects while maintaining a favorable safety profile.[21] In our patients, 93.2% of eyes received treatment within the intermediate energy range; the mean energy used was 116.4 J and the maximum energy used was 156.5 J. How higher energy levels affect treatment outcomes could be explored.

Fluence is proposed to be a more representative metric than total energy in predicting clinical outcome.[22] Fluence at the scleral surface (J/cm^2) is calculated as power in watts (W) × duty cycle (31.3%) × dwell time/area of the laser spot (for the Generation 2 (Rev 2) probe with a spot diameter of 600 µm, equivalent to an area of 0.0028 cm^2). The dwell time is the stationary pulse duration during which equal energy is deposited per unit area per unit time, which depends on the laser probe's sweep velocity. Fluence can be increased either by increasing the treatment power or decreasing the sweep velocity. When stratifying patients based on the median fluence level of 52.4 J/cm^2, total energy used is not associated with reduced IOP, but fluence is positively associated with reduced IOP.[22] Patients with fluence >52.4 J/cm^2 consistently achieve higher IOP reduction of ≥50% from baseline, despite similar total energy used. Among cohorts with the same fluence level, IOP reduction ranges from 28.5% to 49.0%, which indicates that other variables affect treatment efficacy. Nonetheless, the review study is limited by the small number of studies considered and the variation in patient inclusion criteria.

Limitations of the present study include its retrospective nature and lack of a standardized set of indications for anti-glaucoma medications, retreatment, or additional interventions. However, the sample size was large, various glaucoma subtypes were included, and the follow-up duration was up to 18 months.

Conclusion

MPTLT is a safe and effective treatment modality for various glaucoma subtypes, reducing IOP and the need for topical and oral anti-glaucoma medication. The optimal treatment parameters remain to be determined. The use of standardized laser parameters and techniques including sweep velocity and number of sweeps per hemisphere is advocated to enable systematic evaluation of dose-response relationships and comparison of results across studies.

Contributors

All authors designed the study, acquired the data, analyzed the data, drafted the manuscript, and critically revised the manuscript for important intellectual content. All authors had full access to the data, contributed to the study, approved the final version for publication, and take responsibility for its accuracy and integrity.

Conflicts of interest

All authors have disclosed no conflicts of interest.

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Data availability

All data analyzed in this study are available from the corresponding author upon reasonable request.

Ethics approval

The study was approved by Hospital Authority Central Institutional Review Board (Reference: CIRB-2024-226-3). The patients were treated in accordance with the tenets of the Declaration of Helsinki. The patients provided written informed consent for all treatments and procedures and for publication.

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