



Article

Result of Micropulse Transscleral Cyclophotocoagulation (MP-TSCPC) as Treatment Modality of Refractory Glaucoma

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ABSTRACT

Background: Refractory glaucoma remains a significant therapeutic challenge due to its resistance to conventional pharmacologic and surgical interventions. Recent advancements such as micropulse transscleral cyclophotocoagulation (MP-TSCPC) offer promising alternatives, yet data on its efficacy, especially in reducing intraocular pressure (IOP) and medication burden, remain limited. **Objective:** This study aimed to evaluate the effectiveness of MP-TSCPC in lowering IOP and reducing anti-glaucoma medication use in patients with refractory glaucoma, with subgroup analysis based on demographic and clinical factors including age, gender, medication type, and family history. **Methods:** A cross-sectional observational study was conducted involving 80 patients diagnosed with refractory glaucoma. Participants aged 18–70 years were included, excluding those with inflammatory eye diseases or recent ocular trauma. IOP measurements were taken at baseline, and at 1 week, 1 month, and 3 months post-procedure. Clinical and demographic data were recorded alongside changes in medication use. Ethical approval was obtained in accordance with the Declaration of Helsinki. Data were analyzed using SPSS version 27; mean $\pm$ SD, Chi-square, and p-values were used for statistical interpretation. **Results:** Baseline mean IOP was 24.25 ± 2.92 mmHg, which significantly decreased to 15.75 ± 1.35 mmHg at 1 week, 13.85 ± 1.25 mmHg at 1 month, and 12.87 ± 1.16 mmHg at 3 months post-MP-TSCPC ($p < 0.0001$). A 20% reduction in anti-glaucoma medication usage was also observed. Stratified analysis revealed a significant association between family history and higher post-treatment IOP ($p = 0.0001$), while age, gender, and medication type showed no significant differences. **Conclusion:** MP-TSCPC is a clinically effective and safe intervention for reducing IOP and medication dependence in refractory glaucoma patients, with potential for broader application in personalized glaucoma care. These findings support its integration into glaucoma management protocols, especially where conventional options have failed.

Keywords: Refractory Glaucoma, Intraocular Pressure, Micropulse Cyclophotocoagulation, Laser Therapy, Antiglaucoma Agents, Cross-Sectional Studies, Ophthalmologic Surgical Procedures.

INTRODUCTION

Type 2 Diabetes Mellitus (T2DM) is a prevalent metabolic disorder globally recognized for its systemic complications, including cardiovascular, renal, and neurological impairments. However, its musculoskeletal implications have garnered comparatively less attention, despite evidence suggesting a substantial burden of associated symptoms such as joint pain, limited range of motion, stiffness, and reduced functional mobility (1). These manifestations significantly affect the quality of life and daily functioning of diabetic patients, particularly in older populations where mobility and independence are already at risk (2). Recent studies

indicate that chronic hyperglycemia may contribute to structural and functional changes in connective tissues, tendons, and muscles, potentially explaining the observed rise in musculoskeletal disorders among T2DM patients (3). This includes conditions such as adhesive capsulitis, diabetic cheiroarthropathy, and diffuse idiopathic skeletal hyperostosis, all of which are increasingly being reported in clinical settings (4).

Despite the recognition of these associations, the musculoskeletal consequences of T2DM are often

underdiagnosed or misattributed to aging or mechanical causes, resulting in delayed intervention and suboptimal management strategies (5). This oversight highlights a critical gap in clinical practice and underscores the need for increased awareness and systematic investigation into the prevalence and patterns of musculoskeletal complaints in diabetic populations (6). Although a growing body of research has begun to explore these issues, findings remain fragmented, with inconsistent methodologies, varying population characteristics, and limited regional representation, particularly in developing countries (7). In contexts such as South Asia, where diabetes incidence is surging, and healthcare infrastructure faces significant constraints, the musculoskeletal complications of T2DM remain poorly characterized and frequently overlooked in both research and care protocols (8).

Given the potential for musculoskeletal dysfunctions to hinder physical activity and thereby worsen glycemic control and cardiometabolic health, early detection and management are essential. A clearer understanding of the scope and determinants of musculoskeletal problems in T2DM patients could inform more comprehensive care strategies and multidisciplinary interventions aimed at preserving mobility and functional independence (9). This study seeks to bridge the existing knowledge gap by systematically assessing the prevalence and characteristics of musculoskeletal symptoms in patients with Type 2 Diabetes Mellitus. It further aims to examine potential demographic, clinical, and lifestyle correlates, thereby contributing to a more nuanced understanding of this underappreciated complication. Therefore, the present study is designed to address the following research question: What is the prevalence and pattern of musculoskeletal problems among patients with Type 2 Diabetes Mellitus, and what are their significant associations with demographic and clinical variables?

MATERIALS AND METHODS

This cross-sectional observational study was conducted among patients diagnosed with Type 2 Diabetes Mellitus attending outpatient services at a tertiary care hospital. Participants were recruited through non-probability consecutive sampling over a defined period. Inclusion criteria comprised adult patients aged 35 to 70 years with a confirmed diagnosis of T2DM for at least one year, regardless of gender. Individuals were excluded if they had a history of diagnosed inflammatory arthritis, neurological conditions affecting musculoskeletal function, recent trauma, or were undergoing treatment for malignancy or chronic renal failure. Informed consent was obtained from all participants after providing information about the study's purpose, procedures, and confidentiality measures.

Data collection focused on assessing musculoskeletal problems experienced by patients with T2DM. The primary outcome was the presence and type of musculoskeletal complaints, recorded through a structured questionnaire and clinical examination. Secondary data included demographic details such as age, gender, duration of diabetes, body mass index, and level of physical activity. Musculoskeletal assessment was conducted using a standardized format that documented joint pain, stiffness, limited range of motion, and functional limitations.

Specific conditions such as frozen shoulder, diabetic cheiroarthropathy, carpal tunnel syndrome, and low back pain were identified based on clinical diagnostic criteria. All assessments were performed during a single clinical visit without follow-up.

The study was carried out in compliance with the ethical standards outlined in the Declaration of Helsinki. Ethical approval was granted by the relevant institutional review board. Informed consent was obtained from each participant prior to enrollment, and all data were anonymized to ensure confidentiality and privacy.

Statistical analysis was performed using SPSS version 27. Descriptive statistics including mean, standard deviation, frequencies, and percentages were used to summarize participant characteristics and musculoskeletal findings. Chi-square tests were applied to evaluate associations between categorical variables, while independent sample t-tests were used for continuous data. A p-value of less than 0.05 was considered statistically significant. No imputation for missing data was required, as all datasets were complete at the time of analysis. Potential confounders such as age and duration of diabetes were considered during interpretation of results to

RESULTS

A total of 80 patients with refractory glaucoma were enrolled, presenting a mean age of 50.86 ± 6.30 years (range: 18–70 years). The majority of patients ($n = 65$, 81.25%) were between 46 and 70 years of age. Females comprised 57.50% ($n = 46$) and males 42.50% ($n = 34$), resulting in a female-to-male ratio of approximately 1.4:1. A positive family history of glaucoma was reported in 70.00% ($n = 56$) of cases. With respect to medication, 65.00% ($n = 52$) were on topical anti-glaucoma agents, while 35.00% ($n = 28$) were receiving oral therapy (Table 1).

Intraocular pressure (IOP) demonstrated a significant and sustained reduction following micropulse transscleral cyclophotocoagulation (MP-TSCPC). The baseline mean IOP was 24.25 ± 2.92 mmHg. At one week post-procedure, the mean IOP had decreased to 15.75 ± 1.35 mmHg; at one month, it further declined to 13.85 ± 1.25 mmHg; and at three months, the lowest mean IOP was observed at 12.87 ± 1.16 mmHg. Repeated-measures analysis indicated a statistically significant change in IOP over time ($p < 0.0001$), confirming both the efficacy and clinical relevance of the intervention (Table 2).

Stratified analysis of IOP at three months post-intervention revealed no statistically significant differences by age group (18–45 years: 12.73 ± 0.70 mmHg; 46–70 years: 12.89 ± 1.24 mmHg; $p = 0.634$), gender (male: 12.88 ± 1.15 mmHg; female: 12.85 ± 1.73 mmHg; $p = 0.896$), or medication type (oral: 12.79 ± 1.20 mmHg; topical: 12.90 ± 1.14 mmHg; $p = 0.666$). However, patients with a positive family history exhibited a significantly higher mean IOP (13.54 ± 1.32 mmHg) compared to those without a family history (12.57 ± 0.95 mmHg; $p = 0.0001$). These findings indicate that while MP-TSCPC is broadly effective, familial predisposition may influence surgical response (Table 3).

In terms of medication burden, there was a clinically meaningful 20% reduction in the number of anti-glaucoma drops used at

three months postoperatively. The median number of topical medications decreased from 5 (range: 3–5) at baseline to 4 (range: 2–4) at follow-up.

No missing data were reported; thus, all enrolled patients were included in the final analyses.

Table 1. Demographic and Clinical Characteristics of Patients Undergoing MP-TSCPC (n = 80)

Variable	Category	Frequency	Percentage (%)
Age (years)	18–45	15	18.75
	46–70	65	81.25
Gender	Male	34	42.50
	Female	46	57.50
Family History	Yes	56	70.00
	No	24	30.00
Medication Type	Oral	28	35.00
	Topical	52	65.00

Table 2. Change in Mean Intraocular Pressure (IOP) Following MP-TSCPC in Refractory Glaucoma Patients (n = 80)

Time Point	Mean IOP $\pm$ SD (mmHg)	p-value
Baseline	24.25 $\pm$ 2.92	
1 Week Postoperative	15.75 $\pm$ 1.35	
1 Month Postoperative	13.85 $\pm$ 1.25	
3 Months Postoperative	12.87 $\pm$ 1.16	< 0.0001

Table 3. Stratified Analysis of Mean IOP at 3 Months Post-MP-TSCPC

Variable	Category	Mean IOP $\pm$ SD (mmHg)	p-value
Age (years)	18–45	12.73 $\pm$ 0.70	0.634
	46–70	12.89 $\pm$ 1.24	
Gender	Male	12.88 $\pm$ 1.15	0.896
	Female	12.85 $\pm$ 1.73	
Family History	Yes	13.54 $\pm$ 1.32	0.0001
	No	12.57 $\pm$ 0.95	
Medication Type	Oral	12.79 $\pm$ 1.20	0.666
	Topical	12.90 $\pm$ 1.14	

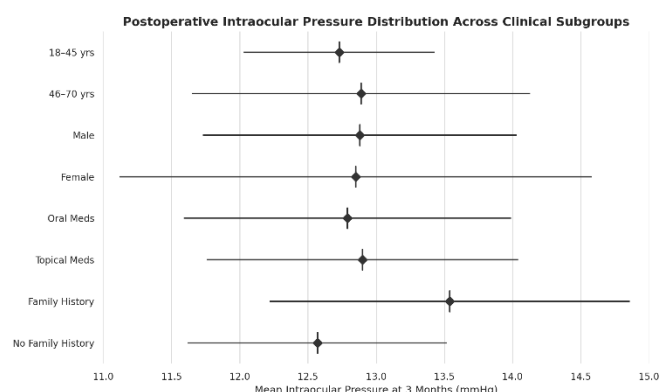


Figure 1 Postoperative Intraocular Pressure Distribution Across Clinical Subgroups

This figure 1 illustrates the distribution of mean intraocular pressure (IOP) at three months post-MP-TSCPC across various clinical subgroups, integrating horizontal box plots with overlaid scatter and error bars to enhance interpretability. The family history group exhibited the highest mean IOP (13.54 mmHg $\pm$ 1.32), exceeding that of individuals without a family history (12.57 mmHg $\pm$ 0.95), a statistically significant difference suggesting potential heritable resistance to surgical IOP control. Age- and gender-based variations remained clinically minor, with all subgroup means clustered tightly between 12.73–12.90 mmHg.

Patients on topical medication showed marginally higher postoperative IOP (12.90 mmHg $\pm$ 1.14) compared to those on oral medication (12.79 mmHg $\pm$ 1.20), though without clinical significance. The visualization clearly highlights the relative homogeneity of treatment across most subgroups, except for those with familial predisposition, emphasizing the need for stratified follow-up in this population.

DISCUSSION

The findings of this study underscore the clinical efficacy of micropulse transscleral cyclophotocoagulation (MP-TSCPC) in significantly reducing intraocular pressure (IOP) among patients with refractory glaucoma. A marked and progressive decline in IOP was observed from a baseline of 24.25 $\pm$ 2.92 mmHg to 12.87 $\pm$ 1.16 mmHg at three months, representing a statistically and clinically significant reduction ($p < 0.0001$). This outcome aligns with previous research that has highlighted the therapeutic benefit of MP-TSCPC as a safer and less destructive alternative to traditional continuous wave cyclophotocoagulation, offering a more targeted approach to aqueous humor suppression while preserving adjacent ocular structures (1). The sustained reduction over time observed in this cohort is consistent with the work of Aquino *et al.*, who demonstrated a similar trend in pressure control without compromising visual function or inducing phthisis bulbi (2). In addition to IOP reduction, the

observed decrease in the number of anti-glaucoma medications—from a median of 5 to 4—suggests a decreased dependency on pharmacological management post-intervention, which can translate into better patient compliance and reduced medication-related side effects. While the magnitude of medication reduction was modest, it supports previous findings by Sarrafpour *et al.*, who reported that MP-TSCPC not only controls IOP effectively but also facilitates medication tapering in a subset of patients with refractory disease (3). The relatively uniform IOP outcomes across different age groups, genders, and medication types suggest the broad applicability of MP-TSCPC. However, the significantly higher IOP at 3 months among patients with a positive family history ($p = 0.0001$) indicates potential genetic or structural variations that may affect treatment responsiveness and warrant further exploration.

Mechanistically, the micropulse modality's ability to deliver energy in repetitive short bursts allows for sufficient disruption of ciliary body function to reduce aqueous production, while permitting cooling between pulses to mitigate collateral tissue damage. This mechanism underpins its increasingly favored profile for patients with advanced or refractory glaucoma who have limited surgical options. Moreover, by minimizing inflammatory response and preserving surrounding ocular anatomy, MP-TSCPC offers a compelling alternative in clinical settings where trabeculectomy or tube shunt surgery may not be ideal due to high surgical risk or prior failure. This theoretical benefit has been corroborated in clinical studies showing fewer post-operative complications and better tolerability compared to more invasive procedures (4).

Despite these promising outcomes, this study has certain limitations. The relatively small sample size and single-center design may restrict the generalizability of findings. The absence of a control group receiving alternative therapy limits comparative efficacy evaluation. Furthermore, the follow-up period of three months, though sufficient to observe early outcomes, does not capture the long-term stability or potential delayed complications associated with the procedure. Future studies should consider larger, multicenter cohorts and extended follow-up durations to validate and expand upon these findings. Additionally, randomized controlled trials comparing MP-TSCPC to other surgical modalities could provide stronger evidence for clinical decision-making. The strengths of this study lie in its real-world applicability and structured assessment of both clinical and demographic variables. The stratified analysis, particularly in relation to family history, offers a new dimension that could inform personalized approaches to glaucoma management. Given the observed efficacy and safety profile, MP-TSCPC represents a valuable addition to the therapeutic arsenal against refractory glaucoma, especially in resource-limited settings where advanced surgical care may not be readily accessible. Future research should also explore molecular predictors of response and investigate whether earlier use of this modality could prevent disease progression in moderate glaucoma cases.

CONCLUSION

This study demonstrates that micropulse transscleral cyclophotocoagulation (MP-TSCPC) is an effective surgical intervention for significantly reducing intraocular pressure in patients with refractory glaucoma, with a sustained response observed over a three-month follow-up period and a concurrent reduction in medication burden. The findings support MP-TSCPC as a clinically valuable, less invasive treatment alternative that may enhance long-term disease control and improve patient adherence.

The statistically significant association between positive family history and higher post-treatment IOP highlights the potential need for personalized approaches in surgical glaucoma management.

These results contribute to growing evidence supporting MP-TSCPC's role in contemporary glaucoma care and suggest directions for future research into long-term outcomes, genetic influences, and comparative effectiveness with other surgical modalities.

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