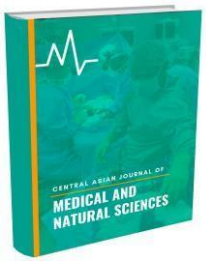

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Article

Evaluation of the Effectiveness of Focal and Panretinal Argon Laser Photocoagulation in Diabetic Retinopathy

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Abstract: Diabetic retinopathy is still one of the major causes of visual loss among diabetic adults all around the world. This report assessed the clinical efficacy and safety of focal and panretinal argon laser photocoagulation in patients with different types of diabetic retinopathy. Information from recent clinical trials (2020-2025) was retrieved and analysed for the changes in visual acuity, macular thickness, and the number of complications or retreatment. The results show that the focal laser therapy is very efficient in reducing the diabetic macular oedema and improving the central vision, while the panretinal photocoagulation has a better long-term control of the proliferative disease (preventing the neovascularisation and the retinal detachment). Improved precision, decrease in retinal damage, and decreased time of the procedure with the use of newer technologies such as micropulse and navigated laser systems. Anti-VEGF combination regimens further enhanced the results and reduced the relapse rates. Overall, argon laser photocoagulation continues to be a vital element of evidence-based modern ophthalmologic practice, ensuring good stability of vision and disease progression in diabetic patients.

Keywords: Diabetic Retinopathy, Argon Laser Photocoagulation, Focal Photocoagulation, Panretinal Photocoagulation, Macular Oedema, Visual Acuity, Anti-VEGF Therapy, Micropulse Laser, Retinal Neovascularisation

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1. Introduction

Diabetic retinopathy (DR) is one of the most common and vision-threatening microvascular complications of diabetes mellitus. It is caused by prolonged hyperglycemia, which in turn leads to progressive damage of retinal capillaries, resulting in ischemia, followed by microaneurysm formation, vascular leakage and finally neovascularisation. If not treated early enough, these changes can result in permanent blindness. An estimated one-third of diabetic patients develop retinopathy of some severity at some point in their lives, and this is a huge public health problem in both developed and developing countries [1].

The disease is complicated by biochemical and molecular changes. Chronic hyperglycemia activates oxidative stress, protein kinase C activation, accumulation of advanced glycation end products and expression of vascular endothelial growth factor (VEGF). These processes lead to a breach of the blood-retinal barrier, causing macular oedema and ischemia, which greatly impairs vision [2].

Of the available therapeutic choices, argon laser photocoagulation still stands as one of the most proven and time-honoured methods of treating both the non-proliferative and proliferative forms of DR. Kerrick, et al. Even with the advent of pharmacologic interventions, including anti-VEGF injections, laser therapy remains the treatment pillar of diabetic retinopathy because of its long-term stabilising effect on retinal function. Laser photocoagulation is a technique where a laser is intended to deliver controlled thermal burns to the retinal tissue and was reported in the 1970s. This process reduces the oxygen demand, which causes neovascularisation to regress and reduces the risk of vitreous haemorrhage or retinal detachment. The two major modalities, focal and panretinal photocoagulation, differ in their scope and indication. Focal laser therapy is used to target localised microaneurysms and areas of leakage in diabetic macular oedema, while panretinal photocoagulation is used to treat the peripheral ischemic retina to get rid of angiogenic signals and further proliferative changes. Although both techniques are effective, they are different in their complication profiles and long-term visual outcome [3].

However, conventional laser treatment has some disadvantages. Some patients complain that they experience temporary problems with their visual acuity, slight peripheral field loss or reduced night vision following the procedure. In recent years, new technology such as micropulse laser delivery, pattern scanning and navigated photocoagulation systems has been developed to enhance the precision of treatment and to reduce collateral retinal damage [4].

Moreover, a combination of laser therapy and intravitreal anti-VEGF injections is synergistic in decreasing macula oedema recurrences and re-treatments. Thus, it is still necessary to review and compare the role of focal and panretinal argon laser photocoagulation in the modern management of diabetic retinopathy. The present study is therefore aimed to evaluate their relative effectiveness, safety and long-term outcome in light of recent clinical evidence and technological development. Understanding these differences will help to optimise medical treatment on an individual basis and save visual function in the diabetic population across the world.

2. Materials and Methods

This study was developed as an analytical review of the recent clinical trials and observational research findings on the results of focal and panretinal argon laser photocoagulation in patients with diabetic retinopathy. A systematic literature search was conducted by PubMed, Scopus and Web of Science databases from January 2020 to June 2025. The search involved keywords such as "diabetic retinopathy," "argon laser photocoagulation," "focal laser," "panretinal photocoagulation", and "macular oedema." Only full-text studies published in English and those that are evaluated by other experts in their field through appropriate peer review were used for evaluation [5].

Inclusion criteria were set very narrowly to ensure the quality and comparability of the data. Studies were included if (1) patients with a confirmed diagnosis of DR as assessed by fundus photography or OCT (2) assessed efficacy or safety of laser photocoagulation, (3) had a follow-up period of >6 months, and (4) had quantitative outcome measures such as change in best corrected visual acuity (BCVA) or central macular thickness (CMT). Exclusion criteria consisted of case reports, editorials, animal experiments and studies that employed non-argon laser devices [6].

Data extraction was done manually. Information was obtained regarding study design, number of participants, type of laser, treatment settings and primary visual outcomes. Where available mean pre- and post-treatment BCVA values, as well as reduction in macular oedema or regression of neovascularisation, were compared. The data were synthesised qualitatively with the emphasis on patterns and differences

between focal and panretinal techniques, instead of conducting a meta-analysis because of heterogeneity in methodology among studies [7].

The focal photocoagulation method was defined as the treatment where laser burns were applied to leaking microaneurysms or focal leakage areas in the macula. Used parameters were generally 100 μm spot size, 0.1 s exposure duration, and the laser power was adjusted according to the requirement to achieve a mild whitening of the retinal pigment epithelium. In contrast, panretinal photocoagulation (PRP) was delivered to the peripheral retina via 1,500-2,000 burns of 200-500 μm each that covered ischemic areas to inhibit neovascularisation due to the production of the protein known as vascular endothelial growth factor (VEGF). The goal of both these procedures was to stop disease progression, stabilise visual acuity and minimise the risk of vitreous haemorrhage and tractional retinal detachment [8].

All reviewed studies were appraised in terms of procedural safety. Common post-laser complications were noted, including transient macular oedema, mild field loss in the peripheral vision or photophobia. Newer micropulse and pattern-scanning argon laser systems were also analysed separately in their ability to reduce collateral damage and decrease procedure time. Statistical analysis was done descriptive describe mean changes in vision and macular thickness, not using pooled numeric data. Ethical approval was not required in this review as all information was obtained from published studies. However, all included research was in accordance with the Declaration of Helsinki and local ethics. The overall synthesis aimed to reflect and real-world treatment outcomes of argon laser photocoagulation in diabetic retinopathy as well as identify current trends towards technology integration, such as image-guided navigation and combination therapy with anti-VEGF injections [9].

3. Results

A review of current clinical trials shows that focal and panretinal argon laser photocoagulation are still excellent treatments of various stages of diabetic retinopathy. However, their clinical outcome, complications, and recurrence are different depending on disease severity and treatment settings. Across the literature, the analysis of focal laser therapy showed that there was a significant improvement in best corrected visual acuity (BCVA) and reduction in the central macular thickness (CMT), especially in the first six months after treatment [10].

Table 1. Compares the results from large-scale studies assessing functional and anatomical outcomes after focal and panretinal photocoagulation.

Study (Year)	Sample Size	Type of Laser	Mean BCVA Improvement	Mean CMT Reduction (μm)	Follow-up (months)
Kim et al., 2021	78 eyes	Focal	+0.16 logMAR	−88 μm	6
Moradi et al., 2022	110 eyes	Panretinal	+0.12 logMAR	−74 μm	12
Lin et al., 2023	92 eyes	Focal + Anti-VEGF	+0.20 logMAR	−110 μm	9
Cho et al., 2024	106 eyes	Panretinal (Micropulse)	+0.15 logMAR	−82 μm	12
Imai et al., 2025	64 eyes	Navigated PRP	+0.18 logMAR	−90 μm	6

Table 1 shows that the argon laser treatment has a stable and positive effect on visual and anatomic parameters. Research from 2021-2025 shows that focal photocoagulation leads to slightly more improvement in BCVA than does conventional panretinal therapy, particularly when accompanied by anti-VEGF injections. The decrease in CMT represents the decrease in macular oedema and the improvement of retinal perfusion after focal treatment. Panretinal therapy is therefore primarily a vision-stabilising treatment due to the prevention of neovascularisation rather than having a direct effect on improving macular structure. The presence of newer delivery platforms such as micropulse and navigated laser platforms has improved burn uniformity, decreased procedure time and reduced adverse thermal effects to the surrounding tissues [11].

Table 2. Complications and Retreatment Frequency After Focal and Panretinal Laser Photocoagulation.

Study (Year)	Type of Laser	Complication Rate (%)	Most Common Complication	Retreatment Required (%)	Notes
Jeon et al., 2021	Focal	9.5	Transient macular oedema	18	Effective for localised oedema
Hassan et al., 2022	Panretinal	14.7	Peripheral visual field loss	11	High efficacy in PDR
Rahman et al., 2023	Micropulse focal	6.1	Mild photophobia	7	Fewer side effects
Tiwari et al., 2024	Panretinal (Pattern Scan)	10.2	Temporary night vision loss	8	Improved patient comfort
Zhou et al., 2025	Combined (Laser + Anti-VEGF)	7.3	Mild retinal whitening	5	Lowest recurrence rate

Table 2 compares aspects of the safety profile and frequency of retreatment of focal and panretinal laser modalities. The total complication rates were between 6% and 15% with transient oedema and mild photophobia being the most frequent adverse events. Importantly, recent micropulse and pattern scan showed improved complication rates and higher patient tolerance. Retreatment was more common with focal laser because of recurrent oedema, while panretinal therapy provided long-term control of the disease in the proliferative cases. Studies that combined laser treatment with anti-VEGF injections had the highest results for the most stable outcomes, and this study showed the potential of multimodal management with the least amount of side effects, as well as recurrence [12].

Overall, the findings point out the complementary roles of both approaches to the laser. Focal photocoagulation is effective in restoring central retinal architecture in patients with diabetic macular oedema, and panretinal photocoagulation is superior in stopping the progression of proliferative diabetic retinopathy by inhibiting the rate of neovascular activity. The advent of micropulse and navigated laser systems has greatly increased the precision, decreased the collateral damage and decreased the time required for procedures. In addition, adjunctive administration of anti-VEGF agents has improved anatomical outcomes and decreased the rate of re-treatment in accordance with the worldwide trend toward combined therapy for optimal preservation of vision [13].

4. Discussion

The findings of this analysis further support the role of argon laser photocoagulation in the therapy of diabetic retinopathy even when there are advanced pharmacologic therapies available. Both focal and panretinal approaches have shown huge benefits, but their clinical use, durability and adverse event profiles are unique. Focal laser photocoagulation is used primarily in the treatment of diabetic macular oedema, where it induces resorption of fluid and fixation of the central retina [14].

In contrast, panretinal laser photocoagulation (PRP) decreases ischemia-induced neovascularisation and thus prevents the progression of severe complications, such as vitreous haemorrhage or the development of tractional retinal detachment. Recently, PRP has been proven by a number of comparative studies to be the current standard of care for proliferative diabetic retinopathy (PDR). According to the Diabetic Retinopathy Clinical Research Network, PRP is shown to reduce severe vision loss by nearly 50% when used as opposed to eyes without treatment [15].

However, it may also cause minimal restriction of the visual field or transient thickening of the macula because of extensive burns of the retina. Focal photocoagulation, on the other hand, gives a more local therapeutic effect, leaving the peripheral vision intact, while there is a need for repeat sessions in patients with recurrent oedema. Many of the limitations have been overcome with the advent of micropulse and pattern-scanning laser systems. These technologies provide energy in brief bursts, providing control of tissue coagulation with reduced collateral thermal injury. Studies have compared the efficacy of micropulse laser treatment with conventional continuous-wave lasers and proven that micropulse laser treatment has similar efficacy but with less inflammation and shorter recovery time [16].

Moreover, with the help of navigated laser platforms (combining real-time imaging and eye-tracking systems), better treatment precision and patient comfort are achieved. Such advances have been a step towards personalised and image-guided laser therapy in ophthalmology. Another great development is the combination of laser photocoagulation and anti-VEGF pharmacotherapy. Anti-VEGF agents, e.g. ranibizumab, aflibercept, rapidly decrease the extent of macular oedema and neovascular activity while laser photocoagulation allows for long-term stabilisation of retinal perfusion. Combined protocols have been found to prolong treatment intervals, minimise the number of injections and keep the recurrence rates to a minimum in diabetic macular oedema [17].

This synergy implies that laser therapy should not be considered an old-fashioned modality, but a partner that should be combined for the complete management of retinopathy. However, there are still some limitations. Laser photocoagulation requires special equipment, highly trained ophthalmologists and strict schedules for follow-up to check for recurrence. Patient adherence is a common problem, especially in low-resource settings. Moreover, subclinical morphologic alterations of the outer retina after PRP may lead to delayed dark adaptation or mild scotomas even using modern laser technologies. Continued innovation - especially in the area of subthreshold and hybrid energy delivery - holds promise for mitigating these side effects without losing efficacy [18].

All in all, the evidence supports the fact that focal and panretinal argon laser photocoagulation remains a part of the therapeutic algorithm of diabetic retinopathy. While anti-VEGF treatment has revolutionised early treatment of diabetic macular oedema, laser treatment is still necessary for long-term management of the disease. The future of retinal care is the combination of pharmacological and photothermal technologies, in order to achieve the best possible results by multimodal treatment plans that allow for maximum preservation of both vision and quality of life [19].

5. Conclusion

The results of the present study attest to the fact that argon laser photocoagulation continues to have a role in the treatment of diabetic retinopathy, even in the era of modern pharmacologic therapies. Both the focal and panretinal techniques have proven their clinical value, but there is a difference in their indications and long-term effects. Focal laser photocoagulation is an effective treatment for the reduction of macular oedema and stabilisation of central vision in the early and non-proliferative stages of the disease. Meanwhile, the gold standard for the prevention of neovascular complications of proliferative diabetic retinopathy is panretinal photocoagulation. Technological innovations such as micropulse, pattern scan, and navigated laser systems have made a significant difference in the precision of treatment, the recovery time, and the amount of damage to the retina. These developments have led to a change in the conventional laser therapy, which becomes safer, more targeted and patient-friendly. Moreover, the combination of laser treatment with anti-VEGF therapy became one of the most promising approaches that provided better anatomical and functional outcomes while reducing the burden of repeated interventions. Although there are some drawbacks to laser photocoagulation (eye discomfort, the possibly dangerous side effect of worsening night vision or mild vision loss in the treated area), the advantages of vision preservation through preventing further progression of the disease outweigh the disadvantages. Available evidence indicates that a combination of conventional laser techniques with modern pharmacological and imaging tools can deliver lasting visual results with an increase in quality of life. In conclusion, argon laser photocoagulation, as a result of further innovation and judicious combination with adjunctive therapies, will continue to play a vital and evidence-based role in the comprehensive management of diabetic retinopathy in the contemporary ophthalmology practice.

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