The Egyptian Journal of Hospital Medicine (October 2025) Vol. 101, Page 4581-4587

Long-term Outcomes of Pan-retinal Laser Photocoagulation in Retinal Vascular Disorders: A Systematic Review

Abdelfattah H.
Department of Ophthalmology, Teaching Hospital, Sohag, Egypt
Corresponding Author: Hossam Abdelfattah, **Mobile:** (+20)1026808348, **E-mail:** dr.hossamhmmad@yahoo.com

ABSTRACT

Background: Panretinal photocoagulation (PRP) is a laser-based therapy in which the peripheral retina is burned, and the heat energy causes tissue coagulation. It is mostly utilized to treat diseases, including proliferative diabetic retinopathy (PDR) and retinal vein occlusions that are marked by widespread peripheral ischemia.

Objectives: To systematically review the long-term macular and visual outcomes associated with PRP in patients with retinal vascular disorders, with a focus on evaluating the durability of treatment effects, overall efficacy, and potential complications of the procedure.

Methods: This systematic review was conducted in accordance with PRISMA guidelines. A comprehensive literature search was performed using PubMed, Web of Science, Scopus, and Embase to identify studies reporting outcomes of panretinal photocoagulation (PRP). The Inclusion criteria were studies involving adult patients with retinal vascular disorders who underwent PRP, with a minimum follow-up duration of six months**.**

Results: Seven studies involving a total of 392 patients were included. Macular thickness remained stable in most patients, with transient increases postoperatively in some cases. Visual acuity was generally maintained, with a portion of patients retaining 20/40 vision or better for up to five years. Visual field changes were more frequent than acuity loss, particularly in peripheral regions. Some retinal nerve fiber thinning was noted long-term, though functional impact varied.

Conclusion: PRP offers reliable long-term anatomical and functional outcomes in retinal vascular diseases, maintaining its role as an essential treatment, especially in situations with weak anti-vascular endothelial growth factor (VEGF) compliance or long-term follow-up. To reduce functional visual field loss and assess the best integration with adjunctive therapy, more study is required.

Keywords: pan-retinal photocoagulation; proliferative diabetic retinopathy; retinal vascular disorders; macular thickness; visual acuity; visual field loss.

INTRODUCTION

PRP is a laser-based therapy in which the peripheral retina is burned, and the heat energy causes tissue coagulation. It is mostly utilized to treat diseases including proliferative diabetic retinopathy (PDR) and retinal vein occlusions that are marked by widespread peripheral ischemia. The therapeutic effect of PRP is thought to stem from enhanced retinal oxygenation and a reduction in the retina's stimulus to produce VEGF. Oxygenation improves through two main mechanisms: firstly, the choriocapillaris approaches the inner retinal layers as a result of the laser-induced retinal thinning; second, the elimination of photoreceptors, which are among the most metabolically active retinal cells, lowers total oxygen consumption [1–3].

In individuals with high-risk PDR, PRP decreased the probability of severe vision loss by more than 50% over a four-year period, according to the 1976 Diabetic Retinopathy Study (DRS). Despite its vision-preserving benefits in proliferative disease, PRP has been linked to various side effects and complications [2].

The majority of patients with proliferative diabetic retinopathy (PDR) have traditionally received PRP as their primary therapy. Laser photocoagulation is a type of destructive treatment that lowers the oxygen demand of tissues by targeting and killing photoreceptors and other metabolically active cells of the retinal pigment epithelium (RPE) [4]. This decrease in metabolic activity leads to the downregulation of VEGF, a key molecule involved in promoting neovascularization in response to hypoxia, ultimately resulting in the regression of PDR [5].

PDR and retinal vein occlusion are two of the most common retinal vascular diseases that cause visual impairment worldwide. PRP has long been established as a primary treatment modality for managing these conditions by reducing ischemia-driven neovascularization. Despite its widespread use and proven efficacy, PRP is a destructive procedure with potential side effects, including diminished night vision and loss of the peripheral visual field. Furthermore, concerns regarding the long-term comparative effectiveness and safety of PRP have been raised by the introduction of alternative or supplementary therapy options brought about by the development of anti-VEGF medicines [1, 3].

Given the evolving therapeutic landscape, a comprehensive evaluation of PRP's long-term outcomes across various retinal vascular diseases is crucial for guiding clinical decision-making [3].

This review aimed to comprehensively examine and assess the long-term visual, anatomical, and safety outcomes of pan-retinal photocoagulation in the management of retinal vascular diseases, including

Received: 02/07/2025
Accepted: 01/09/2025

retinal vein occlusion and proliferative diabetic retinopathy.

METHODS

To maintain scientific integrity and openness, this systematic review was carried out in compliance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) criteria [6]. Assessing PRP's long-term effects on individuals with retinal vascular conditions, such as proliferative diabetic retinopathy and retinal vein occlusion, was the goal.

Search Strategy

From the beginning until the most current update, a thorough literature search was conducted throughout the four main electronic databases: PubMed, Web of Science, Scopus, and Embase. Only English-language research involving human participants was included in the search, which also contained Medical Subject Headings (MeSH) and keywords associated with:

- PRP (such as "laser treatment," "panretinal photocoagulation," and "retinal laser ")
- Retinal vascular disorders (e.g., "proliferative diabetic retinopathy," "retinal vein occlusion," "ischemic retinopathy")
- Clinical outcomes (e.g., "visual acuity," "macular thickness," "complications," "long-term outcomes").

The search results were refined using boolean operators (AND, OR). To find any more pertinent papers, the reference lists of the included studies were also manually filtered.

Study Selection and Eligibility Criteria

After screening all titles and abstracts, two impartial reviewers evaluated the complete texts of the papers that met the eligibility requirements. A third reviewer was consulted or discussed in order to address any discrepancies. The following were the requirements for inclusion:

- Studies involving adult patients (≥18 years) with retinal vascular disorders treated with PRP
- Reporting of long-term outcomes (≥6 months) such as visual acuity, anatomical changes (e.g., macular thickness, neovascularization), or post-treatment complications
- Research designs: English-language cross-sectional analysis, case-control studies, cohort studies, and randomized controlled trials

Exclusion criteria included:

- Case studies, commentaries, and reviews with <10 patients, conference abstracts
- Animal or in vitro studies
- Studies lacking relevant outcome measures or isolatable PRP data

Data Extraction

The selection and screening process was managed using Rayyan (QCRI) [7] to reduce reviewer bias and enhance transparency. Key information from each trial was collected using a standardized data extraction form, which included:

- Study details (author, year, country, design)
- Patient characteristics (sample size, disease type, duration, follow-up period)
- Treatment protocol (laser type, pattern, timing)
- Reported outcomes (changes in best-corrected visual acuity, macular or RNFL thickness, complications)
- Statistical metrics (effect size, p-values, confidence intervals)

Risk of Bias Assessment

All eligible non-randomized studies were evaluated for methodological quality and possible sources of bias using the Risk of Bias in Non-randomized Studies of Interventions (ROBINS-I) tool [8]. Where appropriate, the Cochrane Risk of Bias Tool was used to randomized controlled trials.

Ethical Consideration

This systematic review study was ethically approved by Sohag Teaching Hospital Research Ethics Committee (No.; HSO00009).

RESULTS

The search process initially identified 914 publications **(Figure 1).** After removing 422 duplicates, Titles and abstracts were used to screen 492 trials. Of these, 101 full-text articles were left for a thorough assessment after 391 did not fit the qualifying requirements. Seven papers were ultimately chosen for evidence synthesis and analysis after meeting the inclusion criteria.

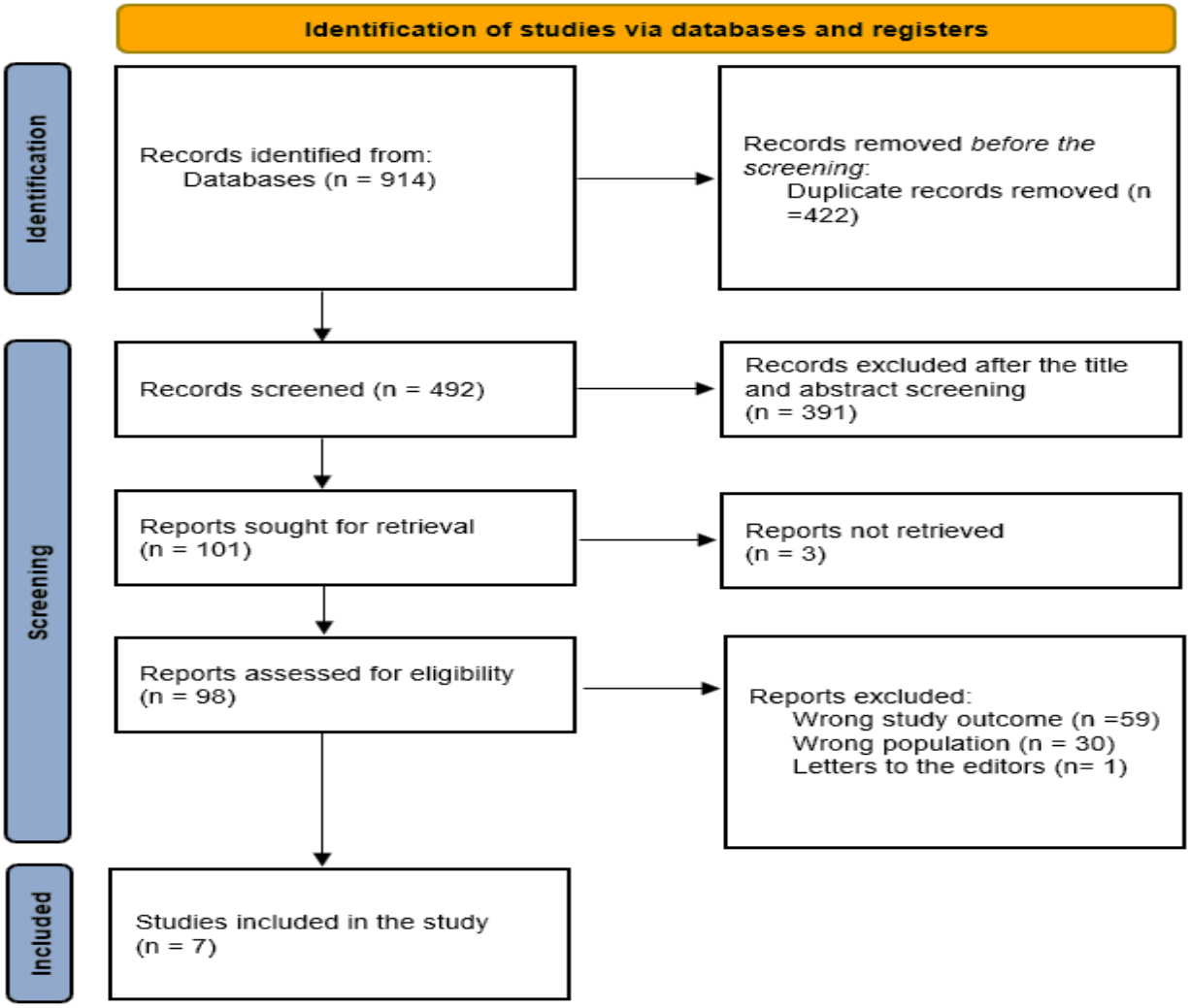

Figure (1): Search summary illustrated in PRISMA flow diagram.

Sociodemographic and clinical outcomes

Out of the 348 patients in the seven included trials, 199 (57.1%) were men. The study designs consisted of three retrospective cohorts [9, 10, 15], two retrospective case-series [12, 13]. A cross-sectional study was one of them [11], and a prospective observational research was one of them [14]. The first investigation was carried out in 1999 [10] and the latest in 2023 [15]. **Table (1)**

Macular Outcomes

The macular outcomes following PRP were variable across the studies. In several cases, Foveal and macular thickness did not significantly alter over time, suggesting a somewhat stable anatomical response to therapy [9, 11, 12]. Some studies reported a temporary increase in macular thickness at early postoperative intervals (e.g., 1 and 3–6 months), which subsequently resolved or stabilized by later follow-ups [9, 14]. Furthermore, although the temporal quadrant was unaffected, variations in the thickness of the ganglion cell complex (GCC) and retinal nerve fiber layer (RNFL) were seen, especially in the superior and inferior quadrants [12, 14]. In a few studies, macular treatment details were found to have no statistically significant influence on final anatomical outcomes [11], while other studies did not report macular findings (NM) [10, 13, 15].

Visual Outcomes

Visual outcomes generally showed a trend toward stability or mild deterioration. In long-term follow-ups, many patients maintained stable BCVA, with a notable proportion preserving 20/40 or better vision over several years [10, 13]. Some studies reported a decline in visual field performance, particularly evident at 12–24 months, though BCVA remained largely unaffected or declined non-significantly [9, 12]. Visual acuity was often influenced by comorbid conditions like cataract and age, rather than by the laser treatment itself [11]. In responder groups, more than half of the treated eyes achieved 20/20 vision or better, although complications like delayed vitreous hemorrhage occurred but were self-limiting [13]. Other studies found no significant changes in BCVA, visual field sensitivity, or structural measures such as subfoveal choroidal thickness (SFCT) post-treatment [14, 15].

Table (1): Summary of demographic from the included studies.

Study ID	Country	Study design	Sociodemographic	Condition	Macular outcomes	Visual outcomes
Filek *et al.* 2017 [9]	Canada	Retrospective cohort	Cases: 16 Mean age: 70.6 Males: 12 (75%)	Diabetic retinopathy	While the perfused ratio rose considerably at 12 and 24 months (P = 0.02), macular and nerve fiber layer thickening at 6 months post-laser was not significant and disappeared by 24 months.	At 12 and 24 months after the laser, the visual field dramatically decreased (P≤0.02), whereas the BCVA exhibited a non-significant trend of deteriorating.
Dogru *et al.* 1999 [10]	Japan	Retrospective cohort	Cases: 59 Mean age: 56 Males: 39 (66.1%)	Diabetic retinopathy	NM	With 28.2% of patients keeping 20/40 or greater vision at 5 years and the majority maintaining constant visual acuity over 10 years, long-term vision results were excellent in stage B-II DR.
Baptista *et al.* 2021 [11]	Portugal	Cross-sectional	Cases: 71 Mean age: 62.2 Males: 44 (61.9%)	Diabetic retinopathy	Macular treatment details had no significant impact on the outcome (p>0.05).	BCVA was generally good but reduced in eyes with cataract and in older patients, with no significant differences between treatment groups. Visual field performance was overall satisfactory.
Kim *et al.* 2012 [12]	Korea	Retrospective case-series	Cases: 45 Mean age: 59.3 Males: 24 (53.3%)	Severe diabetic retinopathy	foveal thickness remained stable with no significant changes post-PRP, although its temporal changes followed a similar trend to the temporal RNFL thickness.	Visual acuity remained stable, with no significant change in foveal thickness. Visual field changes were reflected by a significant long-term reduction in RNFL thickness, especially in the superior and inferior quadrants, while the temporal quadrant remained unaffected.
Vander *et al.* 1991 [13]	USA	Retrospective case-series	Cases: 59 Mean age: 46 Males: 32 (54.2%)	Proliferative diabetic retinopathy	NM	Over half of the responder eyes achieved 20/20 or better visual acuity long-term, while very few non-responder eyes reached this level. Delayed vitreous hemorrhage occurred in over a third of responder eyes but was generally self-limited.
Huang *et al.* 2021 [14]	China	Prospective observational study	Cases: 41 Mean age: 57.5 Males: 22 (53.7%)	Diabetic retinopathy	RNFL and GCC thicknesses revealed a substantial rise at 1 month post-op (p < 0.01), whereas macular thickness increased considerably at 1 and 3–6 months after PRP (p < 0.05).	When comparing the BCVA, SFCT, and macular and peripapillary vascular density following PRP to the baseline, no discernible changes occurred.
Koca *et al.* 2023 [15]	Turkey	Retrospective cohort	Cases: 57 Mean age: 60.8 Males: 26 (45.6%)	Diabetic retinopathy	NM	BCVA showed no significant change from baseline to 12 months.

Table (2): Risk of bias assessment using ROBINS-I

Study ID	Bias brought induced by confusion	Bias in the selection of participants into	Prejudice in how interventions are categorized	Bias brought caused by departures from the planned interval	Bias brought on by incomplete data	Inaccuracy in result measurement	Bias in the selection of reported result	Overall bias
Filek *et al.* 2017 [9]	Low	Low	Low	Low	Low	Low	Mod	Low
Dogru *et al.* 1999 [10]	Mod	Low	Low	Low	Low	Mod	Low	Low
Baptista *et al.* 2021 [11]	Low	Low	Mod	Low	Low	Low	Mod	Low
Kim *et al.* 2012 [12]	Low	Low	Mod	Low	Mod	Mod	Low	Moderate
Vander *et al.* 1991 [13]	Mod	Mod	Mod	Low	Low	Low	Mod	Moderate
Huang *et al.* 2021 [14]	Mod	Mod	Low	Low	Low	Mod	Mod	Moderate
Koca *et al.* 2023 [15]	Mod	Mod	Crit	Low	Low	Mod	Low	Critical

DISCUSSION

This systematic review analyzed long-term outcomes of PRP in patients with retinal vascular disorders, primarily diabetic retinopathy. The findings demonstrated that PRP remains an effective intervention for stabilizing vision and preventing severe complications of proliferative retinal disease. Across the included studies, macular anatomy was largely preserved or returned to baseline following transient early changes in thickness, and significant improvements in disease progression were observed. Although some studies reported temporary macular thickening or thinning of specific retinal layers such as the RNFL and GCC, these changes did not consistently correlate with significant visual deterioration [9-15].

Visual acuity outcomes varied, yet the overall trend favored stability over time, with some patients even maintaining 20/20 or 20/40 vision years after treatment. Notably, visual field defects were more commonly reported than reductions in central acuity, suggesting that peripheral laser-induced damage may affect field sensitivity without necessarily impacting clarity of vision. Additionally, patient-specific factors including age and the existence of cataracts affected eyesight results. indicating the importance of individualized patient monitoring after treatment. **Shimura *et al.*** [16] reported that there is still a potential risk that PRP may lead to reduced VA and trigger macular edema, which can cause either temporary or long-lasting declines in VA. As a result, clinicians may be cautious when considering PRP for diabetic patients with advanced retinopathy, particularly in eyes that already have good VA. This raises important questions about which retinal features can help predict visual outcomes following PRP and the likelihood of PRP-associated visual impairment [17, 18].

Although the exact mechanism underlying PRP-induced macular edema remains unclear,, parafoveal thickening has been proposed as a potential predictor of subsequent foveal involvement, which can contribute to visual impairment [14]. Consequently, eyes that maintain good visual acuity and lack clinically evident edema but show thickening on OCT might benefit from pre-PRP interventions aimed at reducing macular thickness. These interventions could include conventional focal laser, micropulse laser therapy [19], or pharmacologic options such as corticosteroids [20] or anti-VEGF agents [21].

Despite the rise of anti-VEGF therapies as a first-line or adjunctive approach, this review found that PRP still demonstrates a valuable role in long-term disease control. It offers a durable treatment effect with minimal retreatment burden in appropriate candidates, especially in settings where access to frequent intravitreal injections is limited. **Gunasekaran *et al.*** [22] also demonstrated that anti-VEGF agents have demonstrated significant effectiveness in addressing some of the limitations associated with PRP in the management of PDR. Nonetheless, laser photocoagulation retains certain advantages that account for its long-standing use in clinical practice. Ultimately, both treatment approaches have their respective benefits and drawbacks, and selecting the most appropriate therapy should be tailored to the individual patient, taking into account specific ocular and systemic factors. Moreover, the combination of laser PRP—particularly subthreshold PRP—with anti-VEGF therapy represents a promising strategy that warrants further investigation [22].

Everett et al.[23] reported that PRP remains the most definitive treatment for proliferative PDR, effectively preventing vision-threatening complications such as tractional retinal detachment and neovascular glaucoma. Completing PRP has the major benefit of removing the need for continuous intravitreal anti-VEGF injections to treat PDR, which lowers the risk of uncommon but serious side effects such post-injection endophthalmitis. Additionally, it lessens the risk of disease development when patients are unable to attend routine follow-up sessions, such during the peak of the COVID-19 epidemic or when insurance coverage is canceled [23, 24].

Furthermore, advancements in laser technology have improved clinical outcomes while reducing the risk of long-term visual complications like choroidal neovascularization, scotoma formation, retinal scarring, and patient discomfort. Pattern scanning laser technology, for example, has greatly reduced treatment duration and patient pain during PRP for PDR. Retinal pigment epithelium (RPE) cells can be specifically treated with selective retinal therapy (SRT), which minimizes harm to the surrounding neurosensory retina. Subthreshold micropulse lasers provide therapeutic advantages without harming retinal tissues in a noticeable way. Furthermore, advancements like Endpoint Management and Navigated Laser have improved retinal photocoagulation's overall efficacy, safety, and accuracy [23, 25, 26].

STRENGTHS AND LIMITATIONS

A thorough search of several databases and the incorporation of both prospective and retrospective research enabled a wide collection of empirical data. The inclusion of long-term follow-up data—spanning up to 10 years in some cases—enabled a thorough evaluation of PRP's durability.

Several limitations must be acknowledged. First, heterogeneity in outcome reporting, particularly regarding macular and visual field parameters, limited the ability to perform a meta-analysis or directly compare results across studies. Potential selection and follow-up biases were also introduced by the retrospective character of the majority of the included research.

CONCLUSION

PRP continues to be a cornerstone therapy for retinal vascular disorders, offering durable anatomical and visual stability in the majority of treated patients. While modern therapies offer additional benefits, PRP remains particularly valuable for long-term disease suppression, especially in patients who are unsuitable for or unresponsive to anti-VEGF injections. Future studies should concentrate on improving combination treatment strategies and better describing long-term functional effects including peripheral field alterations.

No funding.

No conflict of interest.

REFERENCES

1. **Alasil T, Waheed N (2014):** Pan retinal photocoagulation for proliferative diabetic retinopathy. Curr Opin Ophthalmol., 25(3):164–170.
2. **Diabetic T, Study R (1976):** Preliminary report on effects of photocoagulation therapy. Am J Ophthalmol., 81(4):383–396.
3. **Zhu Y, Zhang T, Wang K *et al.* (2015):** Changes in choroidal thickness after panretinal photocoagulation in patients with type 2 diabetes. Retina, 35(4):695–703.
4. **Landers M, Stefansson E, Wolbarsht M (1982):** Panretinal photocoagulation and retinal oxygenation. Retina, 2:167–175.
5. **Manaviat M, Rashidi M, Afkhami-Ardekani M *et al.* (2011):** Effect of pan retinal photocoagulation on the serum levels of vascular endothelial growth factor in diabetic patients. Int Ophthalmol., 31:271–275.
6. **Page M, McKenzie J, Bossuyt P *et al.* (2021):** The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. International Journal of Surgery, 88:105906. https://doi.org/10.1016/j.ijsu.2021.105906
7. **Ouzzani M, Hammady H, Fedorowicz Z *et al.* (2016):** Rayyan—a web and mobile app for systematic reviews. Systematic Reviews, 5(1):210. doi:10.1186/s13643-016-0384-4
8. **Sterne J, Hernán M, Reeves B *et al.* (2016):** ROBINS-I: a tool for assessing risk of bias in non-randomised studies of interventions. BMJ., 355:i4919. doi:10.1136/bmj.i4919
9. **Filek R, Hooper P, Sheidow T *et al.* (2017):** Structural and functional changes to the retina and optic nerve following panretinal photocoagulation over a 2-year time period. Eye, 31(8):1237-44.
10. **Dogru M, Nakamura M, Inoue M *et al.* (1999):** Long-term visual outcome in proliferative diabetic retinopathy patients after panretinal photocoagulation. Japanese Journal of Ophthalmology, 43(3):217-24.
11. **Baptista P, Marta A, Heitor J *et al.* (2021):** Long-term visual function effects of pan-retinal photocoagulation in diabetic retinopathy and its impact in real life. Diabetes, Metabolic Syndrome and Obesity, 14:1281-93.
12. **Kim J, Woo S, Ahn J *et al.* (2012):** Long-term temporal changes of peripapillary retinal nerve fiber layer thickness before and after panretinal photocoagulation in severe diabetic retinopathy. Retina, 32(10):2052-60.
13. **Vander J, Duker J, Benson W *et al.* (1991):** Long-term stability and visual outcome after favorable initial response of proliferative diabetic retinopathy to panretinal photocoagulation. Ophthalmology, 98(10):1575-79.
14. **Huang T, Li X, Xie J *et al.* (2021):** Long-term retinal neurovascular and choroidal changes after panretinal photocoagulation in diabetic retinopathy. Frontiers in Medicine, 8:752538. https://doi.org/10.3389/fmed.2021.752538
15. **Koca S, Kılıç D (2023):** Long-term longitudinal retinal changes after conventional and pattern scan laser panretinal photocoagulation in diabetic retinopathy. Photodiagnosis and Photodynamic Therapy, 44:103845. https://doi.org/10.1016/j.pdpdt.2023.103845
16. **Shimura M, Yasuda K, Nakazawa T *et al.* (2005):** Visual dysfunction after panretinal photocoagulation in patients with severe diabetic retinopathy and good vision. American Journal of Ophthalmology, 140(1):8. https://doi.org/10.1016/j.ajo.2005.02.029
17. **McDonald H, Schatz H (1985):** Macular edema following panretinal photocoagulation. Retina, 5(1):5-10.
18. **Ferris III F, Kleiner R, Elman M *et al.* (1988):** Transient severe visual loss after panretinal photocoagulation. American Journal of Ophthalmology, 106(3):298-306.
19. **Dorin G (2003):** Subthreshold and micropulse diode laser photocoagulation. Semin Ophthalmol., 18:147–153.
20. **Massin P, Andren F, Haouchine B *et al.* (2004):** Intravitreal triamcinolone acetonide for diabetic macular edema—preliminary results of a prospective controlled trial. Ophthalmology, 111:218–225.
21. **Bandello F, Rognuz R, Polito A *et al.* (2003):** Diabetic macular edema: classification, medical and laser therapy. Semin Ophthalmol., 18:251–258.
22. **Gunasekaran Jr T, Gunasekaran Y, Hui P *et al.* (2022):** Review of studies comparing panretinal photocoagulation and anti-vascular endothelial growth factor therapy in the treatment of proliferative diabetic retinopathy. Cureus, 14(2): e22471. https://doi.org/10.7759/cureus.22471
23. **Everett L, Paulus Y (2021):** Laser therapy in the treatment of diabetic retinopathy and diabetic macular edema. Current Diabetes Reports, 21:35. doi:10.1007/s11892-021-01403-6
24. **Lindeke-Myers A, Zhao P, Meyer B *et al.* (2021):** Patient Perceptions of SARS-CoV-2 Exposure Risk and Association with Continuity of Ophthalmic Care. JAMA Ophthalmol., 139(5):508-515.
25. **Li J, Paulus Y (2018):** Advances in retinal laser therapy. Int J Ophthalmic Res., 4(1):259–264.
26. **Birngruber R, Hillenkamp F, Gabel V (1985):** Theoretical investigations of laser thermal retinal injury. Health Phys., 48(6):781–796.