VOLUME - 15, ISSUE - 09, SEPTEMBER - 2026 • PRINT ISSN No. 2277 - 8160 • DOI : 10.36106/gjra

Original Research Paper

Ophthalomology

COMPARATIVE EVALUATION OF ANTI-VEGF INTRAVITREAL INJECTION AND LASER PHOTOCOAGULATION IN RETINAL VEIN OCCLUSION USING OPTICAL COHERENCE TOMOGRAPHY

Dr Sakina Kanchwala	M.S. Ophthalmology
Dr Anubhuti Gulla	M.S. Ophthalmology
Dr Harsha Singh	M.S. Ophthalmology

ABSTRACT **Background:** Retinal vein occlusion (RVO) commonly causes macular edema and visual impairment. Anti-VEGF therapy and laser photocoagulation are established treatments, while OCT objectively evaluates macular edema and treatment response. **Aim:** To compared the functional and anatomical outcomes of anti-VEGF intravitreal injection and laser photocoagulation in patients with RVO. **Methods:** A prospective randomized comparative study was conducted among 44 patients with RVO-associated macular edema. Participants were randomly allocated into two equal groups of 22 patients each. Group A received intravitreal anti-VEGF therapy, while Group B underwent laser photocoagulation. Best-corrected visual acuity (BCVA), intraocular pressure, central macular thickness (CMT), macular volume, and resolution of macular edema were assessed at baseline and during 12 months of follow-up using clinical examination and OCT. **Results:** Baseline demographic and ocular characteristics were comparable between the groups. At 12 months, mean BCVA improved from 0.42 ± 0.18 to 0.16 ± 0.11 logMAR in the anti-VEGF group and from 0.45 ± 0.20 to 0.27 ± 0.15 logMAR in the laser group ($p=0.002$). Mean CMT decreased from 421.5 ± 68.3 to 215.7 ± 36.2 μm with anti-VEGF and from 428.7 ± 71.2 to 268.4 ± 45.8 μm with laser ($p=0.001$). Complete macular edema resolution occurred in 100% and 81.8% of eyes, respectively ($p=0.048$). Resolution was achieved significantly earlier with anti-VEGF therapy (78.2 ± 31.4 vs. 125.6 ± 42.3 days; $p=0.001$). **Conclusion:** Anti-VEGF therapy produced significantly greater and faster functional and anatomical improvement than laser photocoagulation in RVO-associated macular edema.

KEYWORDS : Anti-VEGF; Laser Photocoagulation; Macular Edema; Optical Coherence Tomography; Retinal Vein Occlusion.

1. INTRODUCTION

Retinal vein occlusion (RVO) is one of the most common retinal vascular disorders and an important cause of visual impairment, particularly among older adults. It results from obstruction of retinal venous circulation, leading to venous congestion, retinal hemorrhages, increased vascular permeability, macular edema, retinal ischemia, and, in severe cases, neovascular complications [1,2]. RVO is broadly classified into branch retinal vein occlusion (BRVO) and central retinal vein occlusion (CRVO), depending on the site of venous obstruction [3]. Macular edema is the principal cause of visual deterioration in patients with RVO and is therefore a major therapeutic target [4]. Optical coherence tomography (OCT) provides a non-invasive, high-resolution assessment of retinal morphology and enables quantitative evaluation of central macular thickness, intraretinal fluid, subretinal fluid, and structural changes associated with edema [5,6]. Intravitreal anti-vascular endothelial growth factor (anti-VEGF) therapy has emerged as an important treatment for RVO-associated macular edema by reducing vascular permeability and improving retinal thickness and visual function [7,8]. However, repeated injections may be required, creating challenges related to treatment burden, follow-up compliance, cost, and potential injection-related complications [9]. Laser photocoagulation has historically been used in the management of RVO, particularly in selected cases of macular edema and retinal ischemia, and remains relevant in appropriately selected patients [10,11]. Although laser treatment can reduce retinal leakage and may stabilize vision, its anatomical and functional effects may differ from those achieved with anti-VEGF therapy [12]. OCT-based assessment provides an objective method for comparing these treatment modalities and monitoring anatomical response over time [13]. Evaluating changes in central macular thickness alongside visual outcomes can therefore provide useful evidence regarding treatment effectiveness [14,15]. The present study was undertaken to comparatively evaluate the effects of these two treatment approaches on retinal morphology and macular edema using OCT.

2. METHODOLOGY

The study was conducted as a prospective, comparative, randomized clinical trial in the Upgraded Department of Ophthalmology, N.S.C.B. Medical College & Hospital, Jabalpur, Madhya Pradesh, India, over 18 months from July 2024 to December 2025. Patients aged ≥18 years with confirmed branch or central retinal vein occlusion (BRVO/CRVO), associated macular edema, central macular thickness (CMT) ≥250 μm on spectral-domain optical coherence tomography (SD-OCT), and best-corrected visual acuity (BCVA) between 20/30 and 20/200 (logMAR 0.2–1.0) were eligible. Patients were required to have adequate media clarity, provide written informed consent, and comply with scheduled follow-up. Patients with other retinal vascular diseases, recent vitreoretinal surgery, epiretinal membrane or vitreomacular traction, recent intravitreal injection or laser treatment, significant media opacity, glaucoma or IOP >21 mmHg, pregnancy or lactation, active ocular infection or inflammation, uncontrolled hypertension, or recent myocardial infarction or stroke were excluded.

Eligible patients presenting to the outpatient, inpatient, and emergency ophthalmology services were recruited. A total of 44 patients were included and randomly allocated in a 1:1 ratio using a computer-generated random sequence and sealed-envelope allocation concealment. Group A (n=22) received intravitreal anti-VEGF therapy, consisting of bevacizumab 1.25 mg, ranibizumab 0.5 mg, or aflibercept 2 mg according to clinical discretion, while Group B (n=22) underwent laser photocoagulation using focal, grid, or sectoral techniques based on retinal findings. PRN anti-VEGF retreatment was performed when CMT remained >250 μm or BCVA declined by ≥5 ETDRS letters, with a minimum 4-week interval and maximum six injections. Laser retreatment was performed at 4–6 weeks when persistent edema or clinically significant retinal abnormalities were present.

Baseline assessment included BCVA, refraction, slit-lamp examination, IOP measurement, fundus examination, and SD-OCT using the Cirrus HD-OCT system. Follow-up assessments were performed on Days 7, 28, 56, 84, 180, 270, and 365. Primary outcomes were changes in BCVA and CMT from baseline to 12 months. Secondary outcomes included

macular edema resolution, macular volume changes, number of treatments, time to resolution, adverse events, ≥10-letter visual improvement, and visual stability.

Data were entered into Microsoft Excel and analyzed using IBM SPSS Statistics Version 23.0. Continuous variables were expressed as mean ± SD, while categorical variables were presented as frequencies and percentages. Appropriate parametric or non-parametric tests were applied following the Shapiro-Wilk test. Statistical significance was considered at $p<0.05$, with 95% confidence intervals. Ethical approval was obtained from the Institutional Ethics Committee, and written informed consent was obtained from all participants.

3. RESULTS

Table 1. Baseline Demographic Characteristics

Characteristic	Group A: Anti-VEGF (n=22)	Group B: Laser (n=22)	p-value
Age (years)			
Mean ± SD	58.4 ± 8.3	59.8 ± 7.9	0.463
Gender			
Male, n (%)	14 (63.6%)	13 (59.1%)	0.742
Female, n (%)	8 (36.4%)	9 (40.9%)	
Eye involved			
Right eye, n (%)	12 (54.5%)	11 (50.0%)	0.743
Left eye, n (%)	10 (45.5%)	11 (50.0%)	
Type of RVO			
BRVO, n (%)	16 (72.7%)	17 (77.3%)	0.642
CRVO, n (%)	6 (27.3%)	5 (22.7%)	

Both groups were comparable at baseline regarding age, sex, eye involvement, and RVO subtype, with no significant differences (all $p>0.05$). Mean age was 58.4 ± 8.3 years vs. 59.8 ± 7.9 years, with BRVO predominating in both groups (72.7% vs. 77.3%).

Table 2. Systemic Risk Factors at Baseline

Risk factor	Group A: Anti-VEGF (n=22)	Group B: Laser (n=22)	p-value
Hypertension, n (%)	16 (72.7%)	15 (68.2%)	0.707
Diabetes mellitus, n (%)	10 (45.5%)	11 (50.0%)	0.743
Type 2 diabetes, n (%)	9 (90.0%)	10 (90.9%)	1.000
Dyslipidemia/hypercoagulable states, n (%)	12 (54.5%)	13 (59.1%)	0.718
Current smoker, n (%)	6 (27.3%)	5 (22.7%)	0.819
Former smoker, n (%)	8 (36.4%)	9 (40.9%)	
Never smoker, n (%)	8 (36.4%)	8 (36.4%)	
Coronary artery disease, n (%)	5 (22.7%)	4 (18.2%)	0.695
Previous stroke, n (%)	3 (13.6%)	2 (9.1%)	0.647
Hyperhomocysteinemia, n (%)	4 (18.2%)	3 (13.6%)	0.682

Hypertension was the most common risk factor, followed by diabetes and dyslipidemia/hypercoagulable states.

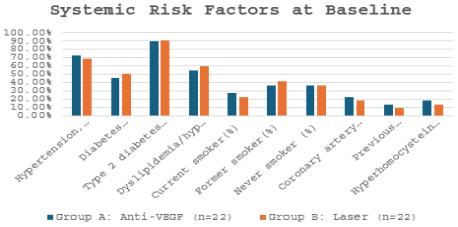

Figure 1. Systemic Risk Factors at Baseline

Table 3. Baseline Ocular Characteristics

Parameter	Group A: Anti-VEGF (n=22)	Group B: Laser (n=22)	p-value
BCVA (logMAR), Mean ± SD	0.42 ± 0.18	0.45 ± 0.20	0.598
IOP (mmHg), Mean ± SD	16.3 ± 2.8	16.7 ± 2.5	0.555
CMT (μm), Mean ± SD	421.5 ± 68.3	428.7 ± 71.2	0.693
Macular volume (mm³), Mean ± SD	11.8 ± 2.1	12.2 ± 2.3	0.546

Baseline BCVA, IOP, CMT, and macular volume were comparable between groups, with no significant differences (all $p>0.05$).

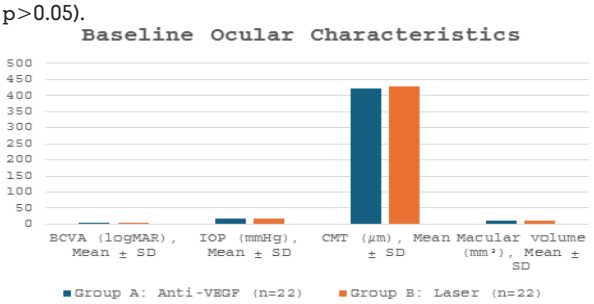

Figure 2. Baseline Ocular Characteristics

Table 4. Best-Corrected Visual Acuity (BCVA) Over 12 Months

Time point	Anti-VEGF Mean ± SD (logMAR)	Laser Mean ± SD (logMAR)	p-value
Baseline	0.42 ± 0.18	0.45 ± 0.20	0.598
Week 1	0.40 ± 0.18	0.44 ± 0.21	0.421
Week 4	0.36 ± 0.16	0.40 ± 0.19	0.351
Week 8	0.32 ± 0.15	0.37 ± 0.17	0.234
Month 3	0.28 ± 0.14	0.35 ± 0.18	0.089
Month 6	0.22 ± 0.13	0.32 ± 0.17	0.028
Month 9	0.18 ± 0.12	0.29 ± 0.16	0.004
Month 12	0.16 ± 0.11	0.27 ± 0.15	0.002
Change from baseline	−0.26 ± 0.12	−0.18 ± 0.13	0.022

BCVA improved progressively in both groups, with greater improvement after anti-VEGF therapy. At Month 12, logMAR improved from 0.42 to 0.16 with anti-VEGF versus 0.45 to 0.27 with laser. The difference was significant at Months 6, 9, and 12 ($p=0.028$, 0.004, and 0.002), with greater overall improvement in the anti-VEGF group ($p=0.022$).

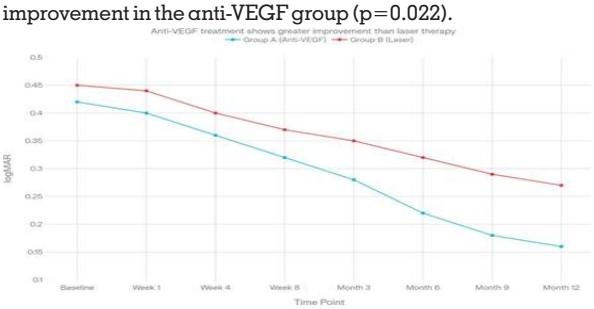

Figure 3. Longitudinal Changes in BCVA (logMAR)

Table 5. Categories of Visual Acuity Response at 12 Months

Response category	Anti-VEGF n (%)	Laser n (%)	p-value
Improvement ≥10 ETDRS letters	20 (90.9%)	16 (72.7%)	0.112
Improvement ≥5 ETDRS letters	21 (95.5%)	18 (81.8%)	0.148
Stable vision	1 (4.5%)	4 (18.2%)	0.153
Deterioration >4 ETDRS letters	0 (0%)	0 (0%)	—

Clinically meaningful visual improvement favored anti-VEGF therapy, with ≥10 ETDRS-letter improvement in 90.9% vs. 72.7% and ≥5 letters in 95.5% vs. 81.8% of patients.

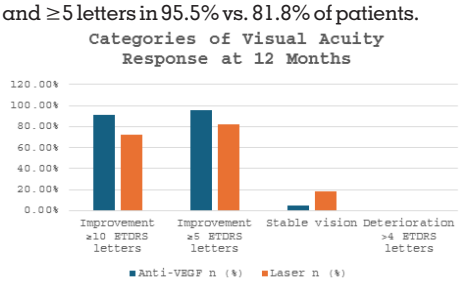

Figure 4. Categories of Visual Acuity Response at 12 Months

Table 6. Central Macular Thickness Over 12 Months

Time point	Anti-VEGF Mean ± SD (μm)	Laser Mean ± SD (μm)	p-value
Baseline	421.5 ± 68.3	428.7 ± 71.2	0.693
Week 1	365.2 ± 60.4	420.3 ± 69.8	0.041
Week 4	310.4 ± 55.2	385.6 ± 64.2	0.018
Week 8	285.4 ± 52.3	355.2 ± 61.8	0.009
Month 3	255.3 ± 48.1	315.7 ± 57.4	0.005
Month 6	230.1 ± 42.5	285.3 ± 51.2	0.003
Month 9	220.4 ± 38.9	275.1 ± 48.6	0.002
Month 12	215.7 ± 36.2	268.4 ± 45.8	0.001
Change from baseline	−205.8 ± 46.1	−160.3 ± 48.2	0.007
Percentage reduction	48.8% ± 8.5%	37.4% ± 9.1%	0.001

OCT showed a significantly greater CMT reduction with anti-VEGF therapy from Week 1 onward (p=0.041). At Month 12, CMT was 215.7 ± 36.2 μm with anti-VEGF versus 268.4 ± 45.8 μm with laser (p=0.001), with greater percentage reduction (48.8% vs. 37.4%; p=0.001).

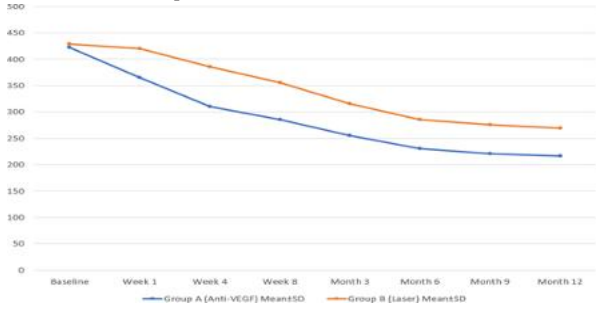

Figure 5. Longitudinal Changes in CMT (μm)

Table 7. Percentage of Eyes with Macular Edema Resolution

Time point	Anti-VEGF n (%)	Laser n (%)	p-value
Baseline	0 (0%)	0 (0%)	—
Week 4	2 (9.1%)	1 (4.5%)	0.591
Week 8	8 (36.4%)	3 (13.6%)	0.075
Month 3	14 (63.6%)	8 (36.4%)	0.081
Month 6	18 (81.8%)	12 (54.5%)	0.058
Month 9	21 (95.5%)	15 (68.2%)	0.013
Month 12	22 (100%)	18 (81.8%)	0.048

Macular edema resolved earlier and more frequently with anti-VEGF therapy. By Month 12, resolution was achieved in 100% of anti-VEGF eyes versus 81.8% of laser-treated eyes (p=0.048). The difference was also significant at Month 9 (95.5% vs. 68.2%; p=0.013).

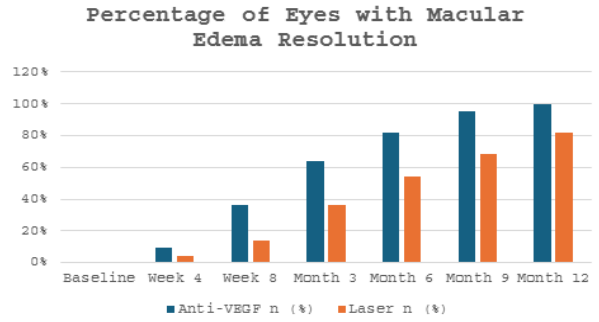

Figure 6. Percentage of Eyes with Macular Edema Resolution

Table 8. Time to First Achievement of CMT <250 μm

Parameter	Anti-VEGF	Laser	p-value
Mean ± SD (days)	78.2 ± 31.4	125.6 ± 42.3	0.001
Difference in mean time	47.4 days faster		
Cohen's d	1.38		

The time to achieve OCT-defined macular edema resolution was significantly shorter with anti-VEGF treatment than with laser (78.2 ± 31.4 vs. 125.6 ± 42.3 days; p=0.001). Anti-VEGF achieved resolution approximately 47 days earlier, with a large treatment effect (Cohen's d=1.38).

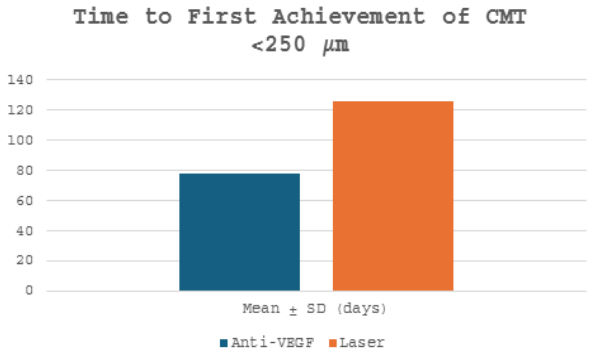

Figure 7. Time to First Achievement of CMT <250 μm

4. DISCUSSION

The present prospective randomized comparative study evaluated anti-VEGF intravitreal injection and laser photocoagulation for retinal vein occlusion (RVO)-associated macular edema using visual and OCT outcomes. Forty-four patients were followed for 12 months, with 22 receiving anti-VEGF and 22 laser treatment. Baseline characteristics were comparable. Hypertension was present in 72.7% and 68.2%, while diabetes occurred in 45.5% and 50.0% of the anti-VEGF and laser groups, respectively. Baseline BCVA was 0.42 ± 0.18 versus 0.45 ± 0.20 logMAR, and CMT was 421.5 ± 68.3 versus 428.7 ± 71.2 μm, respectively.

Anti-VEGF produced significantly greater functional improvement. Mean BCVA improved by 0.26 logMAR compared with 0.18 logMAR with laser (p=0.022). At Month 12, BCVA was 0.16 versus 0.27 logMAR (p=0.002), while ≥10 ETDRS-letter gain occurred in 90.9% versus 72.7%. These findings were consis-tent with Lip et al. (2018) [16], who evaluated 66 treatment-naïve RVO patients and reported significant visual improvement at 12 months, with 77% showing significant VA improvement and 52% achieving at least three-line improvement.

OCT findings further favored anti-VEGF. At Month 12, CMT decreased to 215.7 ± 36.2 μm versus 268.4 ± 45.8 μm (p=0.001). The reported CMT reduction was 205.8 ± 46.1 μm with anti-VEGF and 160.3 ± 48.2 μm with laser (p=0.007), corresponding to 48.8% and 37.4% reductions (p=0.001). Lip et al. [16] similarly reported reduction in median CRT from 531 μm to 245 μm (p<0.001), with 76% achieving a dry fovea at one year.

Conversely, Pikkel et al. (2016) [17], in 65 patients with ischemic CRVO, found no significant differences in macular thickness (p=0.110) or visual acuity changes (p=0.111) among treatment groups. The difference from the present study may reflect their inclusion of ischemic CRVO only, whereas the present study included both BRVO and CRVO. In the present study, CMT <250 μm was achieved in 78.2 ± 31.4 days with anti-VEGF versus 125.6 ± 42.3 days with laser (p=0.001), while complete edema resolution at 12 months occurred in 100% versus 81.8% (p=0.048).

Azad et al. (2014) [18] evaluated 30 BRVO eyes and found no significant difference in BCVA or CFT at six months (p>0.05), although ≥3-line gain occurred in 60%, 40%, and 20% of ranibizumab-plus-laser, bevacizumab-plus-laser, and laser-alone groups. Zou et al. (2022) [19], reviewing 20 studies involving 1,387 patients, found no significant BCVA or CMT advantage for combination therapy over anti-VEGF alone, although injection numbers were reduced in BRVO (WMD=−0.69, p=0.005). Karasu et al. (2022) [20], studying 139 BRVO eyes, reported CFT reduction to 266.43 ± 51.89 μm with aflibercept and 312.59 ± 78.15 μm with ranibizumab. Overall, the present findings supported anti-VEGF therapy as the more effective modality, while laser remained beneficial in selected patients.

CONCLUSION

The present study concluded that both anti-VEGF intravitreal injection and laser photocoagulation improved visual function and macular anatomy in retinal vein occlusion-associated macular edema. However, anti-VEGF therapy demonstrated a more favorable response, with earlier and greater improvement in visual acuity, OCT parameters, and edema resolution.

REFERENCES

1. Klein R, Moss SE, Meuer SM, Klein BE. The 15-year cumulative incidence of retinal vein occlusion: the Beaver Dam Eye Study. Ophthalmology. 2008;126 :513-518.
2. The Central Retinal Vein Occlusion Study Group. A randomized clinical trial of early panretinal photocoagulation for ischemic central vein occlusion. Ophthalmology. 1995;102(10):1434-1444.
3. Montoro-García S, Lip PL, Chan CC, Lip GY. Soluble vascular endothelial growth factor receptor (VEGFR)-2 in macular oedema—a mechanism for regulating angiogenesis? Eye (Lond). 2011;95(6):757-758.
4. HUANG J, ZOU W, JI X, HUA W, XU S, DU Y, ZHOU C, XU G, ZHANG J. Comparison of the efficacy of anti-vascular endothelial growth factor drugs with or without retinal laser photocoagulation for macular edema secondary to retinal vein occlusion: a systematic review. Chinese Journal of Ocular Fundus Diseases. 2021:715-22.
5. Glacet-Bernard A, Mahadavi KN, Coscas G, Zourdani A, Fardeau C. Macular grid photocoagulation in persistent macular edema due to central retinal vein occlusion. Ophthalmologica. 1994;4(3):166-174.
6. Ai E, Yang SS. Venous occlusive disease: the latest in current management. Int Ophthalmol Clin. 2006;26(6 Suppl):S63-S64.
7. Höh AE, Schaal KB, Dithmar S. Central and branch retinal vein occlusion: current strategies for treatment in Germany, Austria and Switzerland. Ophthalmologe. 2007;104(4):290-294.
8. Park CH, Scott AW, Fekrat S. Effect of oral pentoxifylline on cystoid macular edema associated with central retinal vein occlusion. Ophthalmic Surg Lasers Imaging. 2007;27(8):1020-1025.
9. Wright JK, Franklin B, Zant E. Clinical case report: treatment of a central retinal vein occlusion with hyperbaric oxygen. Undersea Hyperb Med. 2007;34(5):315-319.
10. Arevalo JF, Garcia RA, Wu L, et al. Radial optic neurotomy for central retinal vein occlusion: results of the Pan-American Collaborative Retina Study Group (PACORES). Retina. 2008;28(8):1044-1052.
11. Park DH, Kim IT. Long-term effects of vitrectomy and internal limiting membrane peeling for macular edema secondary to central retinal vein occlusion and hemiretinal vein occlusion. Retina. 2010;30(1):117-124.
12. Weiss JN, Bynoe LA. Injection of tissue plasminogen activator into a branch retinal vein in eyes with central retinal vein occlusion. Ophthalmology. 2001;108(12):2249-2257.
13. Pielen A, Feltgen N, Isserstedt C, Callizo J, Junker B, Schmucker C. Efficacy and safety of intravitreal therapy in macular edema due to branch and central retinal vein occlusion: a systematic review. PLoS One. 2013;8(10):e78538.
14. Coscas G, Loewenstein A, Augustin A, Bandello F, Battaglia Parodi M, Lanzetta P, et al. Management of retinal vein occlusion—consensus document. Ophthalmologica. 2011;226(1):4-28.
15. Ogino K, Tsujikawa A, Murakami T, Muraoka Y, Kurashige Y, Yoshimura N. Grid photocoagulation combined with intravitreal bevacizumab for recurrent macular edema associated with retinal vein occlusion. Clin Ophthalmol. 2011;5:1031-1036.
16. Lip PL, Cikatricis P, Sarmad A, Damato EM, Chavan R, Mitra A, Elsherbiny S, Yang Y, Mushtaq B. Efficacy and timing of adjunctive therapy in the anti-VEGF treatment regimen for macular oedema in retinal vein occlusion: 12-month real-world result. Eye. 2018 Mar;32(3):537-45.
17. Pikkel YY, Sharabi-Nov A, Beiran I, Pikkel J. Comparison of anti-vascular endothelial growth factors, laser treatments and a combination of the both for treatment of central retinal vein occlusion. International Journal of Ophthalmology. 2016 Mar 18;9(3):431.
18. Azad SV, Salman A, Mahajan D, Sain S, Azad R. Comparative evaluation between ranibizumab combined with laser and bevacizumab combined with laser versus laser alone for macular oedema secondary to branch retinal vein occlusion. Middle East African Journal of Ophthalmology. 2014 Oct;21(4):296.
19. Zou W, Du Y, Ji X, Zhang J, Ding H, Chen J, Wang T, Ji F, Huang J. Comparison of the efficiency of anti-VEGF drugs intravitreal injections treatment with or without retinal laser photocoagulation for macular edema secondary to retinal vein occlusion: a systematic review and meta-analysis. Frontiers in Pharmacology. 2022 Jul 22;13:948852.
20. Karasu B, Aykut A. Comparison of Therapeutic Efficacy on Grid Laser Photocoagulation Combined with Aflibercept and Ranibizumab as Pro re Nata Regimen for Macular Edema Secondary to Branch Retinal Vein Occlusion. Journal of Retina-Vitreous/Retina Vitreus. 2022 Jan 1;31(1):15.