CITE PUBLICATIONS
Journal of Medicine and Applied Clinical Sciences
Volume: 2, Issue: 1, 2026 (January - June), Pages: 68-81
ISSN (Online): 3139-5120 | DOI: DOI: https://doi.org/10.67914/jmacs/rsa/2.1/68-81
Research Article

Short-Term Visual, Anatomical, and Ocular Safety Outcomes Following Three Monthly Intravitreal Ranibizumab Injections in Diabetic Macular Edema: A Retrospective Observational Study

Ankit Sanjay Varshney[1*], Anushka A. Singh[2], Chetna Patel[3], Mahendrasinh D. Chauhan[4], Darshana Patel[5]

[1]Associate Professor, Department of Optometry, Shree Bharatimaiya College of Optometry & Physiotherapy, Surat, India.
[2]Master of Optometry student, Department of Optometry, Shree Bharatimaiya College of Optometry & Physiotherapy, Surat, India.
[3]Professor, Department of Optometry, Shree Bharatimaiya College of Optometry & Physiotherapy, Surat, India.
[4]Principal, Department of Optometry, Shree Bharatimaiya College of Optometry & Physiotherapy, Surat, India.
[5]Assistant Professor, Department of Optometry, Shree Bharatimaiya College of Optometry & Physiotherapy, Surat, India.

[*]**Correspondence**
Ankit S. Varshney
ankitsvarshney@yahoo.com

Received: 16 February 2026 / Accepted: 28 May 2026 / Published: 30 June 2026

Background: Diabetic macular edema (DME) is an important cause of visual impairment associated with diabetic retinopathy. Although intravitreal ranibizumab is an established treatment for DME, outcomes observed in routine clinical settings may vary from those reported in controlled trials. Assessment of treatment response should therefore consider functional vision, retinal morphology, and short-term ocular safety together. **Objective:** To examine longitudinal changes in distance and near visual acuity, central macular thickness (CMT), and intraocular pressure (IOP) during the first 12 weeks following a three-dose monthly course of intravitreal ranibizumab in patients with DME.

Methods: Medical records of patients treated for DME at a tertiary vitreoretinal referral center in India between June 2022 and November 2024 were retrospectively reviewed. The analysis included 50 eyes belonging to 45 patients who received three consecutive monthly intravitreal ranibizumab injections. Best-corrected distance visual acuity (BCDVA), best-corrected near visual acuity (BCNVA), OCT-derived CMT, and IOP were documented before treatment and at approximately 4, 8, and 12 weeks. Longitudinal changes in these parameters were evaluated statistically across the observation period.

Results: During follow-up, mean BCDVA improved from 0.562 ± 0.305 logMAR at baseline to 0.246 ± 0.163 logMAR at Week 12. Mean BCNVA similarly changed from 0.806 ± 0.295 to 0.454 ± 0.146 logMAR. Retinal thickness also decreased progressively, with mean CMT falling from 482.84 ± 85.99 µm at baseline to 292.52 ± 46.46 µm at Week 12. Significant longitudinal changes were identified for BCDVA, BCNVA, and CMT (all $p < 0.001$), with large time-associated effects for both visual acuity measures and a very large effect for CMT. Mean IOP increased from 15.90 ± 2.79 mmHg to 16.92 ± 2.36 mmHg over the same period ($p = 0.0037$); however, no sustained ocular hypertension requiring treatment or sight-threatening injection-related complication was recorded.

Conclusion: A three-monthly-injection course of ranibizumab was accompanied by meaningful short-term functional and anatomical improvement in this real-world DME cohort. The modest rise in IOP was not associated with clinically

important short-term ocular hypertension. Because the study was retrospective, single-center, and lacked an untreated comparison group, the observed changes cannot be attributed exclusively to ranibizumab. Prospective studies involving larger populations and longer observation are required to establish the persistence of treatment response and longer-term ocular safety.

Keywords: *Diabetic macular edema, Ranibizumab, Intravitreal anti-VEGF therapy, Diabetic retinopathy, Visual acuity, Central macular thickness, Optical coherence tomography, Intraocular pressure*

Introduction

Diabetes mellitus (DM) has emerged as one of the most significant and rapidly increasing health challenges worldwide, affecting not only individual health but also healthcare delivery and socioeconomic systems. In 2024, approximately 589 million adults aged 20–79 years were estimated to be living with diabetes globally, representing nearly one in every nine adults. This figure is projected to increase substantially, reaching approximately 853 million by 2050. The majority of affected individuals, nearly 81%, reside in low- and middle-income countries, where limited healthcare infrastructure, financial constraints, geographical barriers, and shortages of specialist services may impede timely diagnosis and treatment. These challenges contribute to a greater risk of undetected disease and preventable diabetes-related complications (Genitsaridi et al., 2026; Bhattacharjee & Varshney, 2025; Hossain et al., 2024). India represents a substantial proportion of the global diabetes burden. In 2024, an estimated 89.8 million adults aged 20–79 years in the country were living with diabetes, while approximately 43% were believed to remain undiagnosed, corresponding to nearly 38.6 million individuals (Genitsaridi et al., 2026). As the diabetic population continues to expand, the number of individuals at risk of microvascular complications, including diabetic retinopathy (DR), is also expected to rise. This growing burden highlights the importance of early identification of diabetic eye disease, appropriate screening, and timely access to specialist ophthalmic services. However, unequal availability of eye care services and persistent barriers to accessing healthcare may further delay the detection and management of vision-threatening complications, particularly in resource-limited communities (Bhattacharjee & Varshney, 2025; Bhattacharjee et al., 2026). Diabetic retinopathy is a common microvascular consequence of diabetes and remains an important cause of potentially preventable visual loss. The risk and progression of DR are influenced by several factors, including the duration of diabetes, sustained hyperglycemia, and systemic metabolic status. Inadequate glycemic control has been associated with a greater likelihood of diabetes-related complications and may adversely influence ocular health and the course of diabetic eye disease (Hossain et al., 2024; Thakkar et al., 2025; Tınkır Kayıtmazbatır et al., 2022; Varshney et al., 2024). Among the complications capable of producing significant visual dysfunction, diabetic macular edema (DME) is particularly important. The development of DME involves disruption of the blood-retinal barrier and increased vascular permeability, with vascular endothelial growth factor (VEGF), inflammatory mechanisms, oxidative stress, and retinal ischemia contributing to the accumulation of fluid within the retina and subsequent macular thickening. Because the macula is essential for detailed central vision, DME can impair both distance and near visual function and may adversely affect activities of daily living and vision-related quality of life (Daldal et al., 2021). Therapeutic strategies for DME have changed substantially over recent decades, and intravitreal anti-VEGF agents are now central to the treatment of many patients, particularly those with center-involving disease accompanied by visual impairment. Ranibizumab is a recombinant humanized monoclonal antibody fragment that inhibits VEGF-A activity, thereby reducing abnormal vascular permeability and the associated accumulation of retinal fluid. Its clinical efficacy was demonstrated in the pivotal RISE and RIDE randomized trials, which reported significant visual benefits among individuals with DME receiving ranibizumab treatment (Nguyen et al., 2012). Evidence from subsequent clinical studies has similarly demonstrated improvements in retinal structure and visual function, although the magnitude of response may differ according to baseline disease characteristics, retinal morphology, and individual patient factors (Dervenis et al., 2017; Kwak et al., 2016). In addition to improvements in visual acuity, ranibizumab therapy has been associated with better vision-related quality of life and favorable short-term changes in macular thickness and visual performance (Daldal et al., 2021; Minami et al., 2017; Seo et al., 2023; Swelem et al., 2015). However, structural abnormalities may persist in some treated eyes despite visual improvement, highlighting the fact that anatomical recovery and functional recovery do not necessarily occur in parallel (Bressler et al., 2016). Assessment of retinal structure using optical coherence tomography (OCT) has become an essential component of DME diagnosis and follow-up. The technique permits non-invasive visualization of retinal morphology and quantitative measurement of central macular thickness (CMT), allowing structural changes to be monitored over time. Nevertheless, a reduction in retinal thickness does not invariably result in a proportional improvement in visual function. Factors such as baseline retinal architecture and the underlying extent of retinal damage may influence the relationship between anatomical response and visual recovery (Kwak et al., 2016). For this reason, evaluating treatment response using structural parameters alone may provide an incomplete picture of clinical benefit. Best-corrected visual acuity remains a key functional outcome, but assessment of near visual acuity is also relevant because macular involvement can interfere with reading and other activities requiring detailed near vision. In addition,

monitoring intraocular pressure (IOP) is important in patients receiving repeated intravitreal injections, as changes in IOP may occur following treatment and may require clinical attention in some individuals (Sharma et al., 2024). Findings obtained from randomized clinical trials may not fully represent outcomes encountered in routine ophthalmic practice. Patients managed in real-world settings often differ considerably with respect to diabetes duration, metabolic control, severity and chronicity of DME, previous ocular treatment, and continuity of follow-up care. These differences may influence both treatment response and the ability to maintain long-term disease control. This issue has particular relevance in India, where a substantial and increasing diabetes burden exists alongside unequal access to screening facilities and specialized retinal services (Bhattacharjee & Varshney, 2025; Bhattacharjee et al., 2026). Although the efficacy of ranibizumab has been well documented, evaluating functional vision, retinal structural response, and short-term ocular safety together may provide additional insight into its performance in routine clinical practice, particularly when a standardized treatment schedule is used. Against this background, the present study investigated the short-term functional, anatomical, and ocular safety outcomes observed after three consecutive monthly intravitreal ranibizumab injections in patients with DME receiving care at a tertiary eye care center in India. The study specifically examined longitudinal changes in best-corrected distance visual acuity, best-corrected near visual acuity, OCT-derived CMT, and IOP from treatment initiation through 12 weeks of follow-up.

Materials and Methods

Study Design and Settings

A retrospective observational investigation was undertaken using electronic clinical records from the Department of Vitreoretinal Services at Shree K.P. Sanghvi Eye Institute, Surat, Gujarat, India, a tertiary-level referral facility for ophthalmic care. Records of consecutive patients diagnosed with diabetic macular edema (DME) who underwent intravitreal ranibizumab therapy between June 2022 and November 2024 were identified and reviewed. The analysis was designed to characterize short-term changes in visual function, retinal morphology, and ocular safety parameters following treatment delivered as part of routine clinical care. The study was prepared and reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) recommendations applicable to observational research.

Ethical Considerations and Protection of Patient Information

The study protocol received approval from the Institutional Ethics Committee of Shree Bharatimaiya College of Optometry and Physiotherapy, Surat. All procedures were conducted in accordance with the ethical principles outlined in the Declaration of Helsinki and its subsequent amendments. Because the investigation involved retrospective analysis of anonymized medical records and did not require direct interaction with participants or introduce any additional clinical intervention, the requirement for written informed consent was waived by the Institutional Ethics Committee. Confidentiality was maintained throughout data handling, and identifiable patient information was removed before the extraction and statistical processing of study data.

Study Population and Case Selection

Electronic medical records were systematically screened to identify consecutive patients with DME who had received intravitreal ranibizumab during the predefined study period. Cases satisfying the prespecified eligibility criteria were included consecutively to reduce the possibility of selective case inclusion. The final dataset consisted of 50 eyes from 45 patients. Both eyes were represented for five patients, while each of the remaining patients contributed a single eye. As the study was based on retrospective review of routinely available clinical records, no prospective sample size calculation was undertaken. All eyes meeting the eligibility requirements and having complete baseline and follow-up information were included in the final analysis.

Diagnostic Criteria and Classification of DME

The diagnosis of DME was established from clinical ophthalmic examination and supported by spectral-domain optical coherence tomography (SD-OCT) findings demonstrating retinal thickening and/or intraretinal fluid compatible with diabetic macular edema in the setting of diabetic retinopathy. Eyes with DME occurring in association with either non-proliferative diabetic retinopathy (NPDR) or proliferative diabetic retinopathy (PDR) were eligible. Center-involving DME was defined according to involvement of the central 1-mm ETDRS subfield identified on SD-OCT. Where documentation was available, clinically significant macular edema (CSME) was classified using established Early

Treatment Diabetic Retinopathy Study (ETDRS) clinical criteria. DME, center-involving DME, and CSME were treated as separate clinical descriptors and were not considered synonymous.

Eligibility Criteria
Inclusion Criteria

Eyes were eligible for analysis when all of the following conditions were met: the patient was aged 40 years or older; the eye had a documented diagnosis of DME associated with either NPDR or PDR; the eye was pseudophakic; three consecutive intravitreal ranibizumab injections had been administered according to the institutional treatment protocol; and complete ophthalmic documentation was available at baseline and at approximately 4, 8, and 12 weeks following initiation of treatment. Restriction of the study population to pseudophakic eyes was undertaken to reduce the potential confounding effect of cataract formation or progression on longitudinal visual acuity measurements. Accordingly, phakic and aphakic eyes were not included. A previous history of focal or grid macular laser photocoagulation did not constitute an exclusion criterion when complete treatment and follow-up documentation was available. Previous macular laser therapy and prior anti-VEGF exposure were extracted from the clinical records and documented as baseline characteristics.

Exclusion Criteria

Eyes were excluded when other ocular disorders could independently influence visual acuity or OCT-derived retinal measurements. These included age-related macular degeneration, non-diabetic retinal vascular disease, previous vitreoretinal surgery, ocular trauma, glaucoma, uveitis, significant corneal opacity, clinically important media opacity, and other clinically relevant ocular conditions affecting visual function or retinal assessment. Records were also excluded when baseline clinical measurements were unavailable, essential clinical information was incomplete, or the patient did not attend one or more of the predefined follow-up assessments. Pregnancy was also considered an exclusion criterion when documented in the medical record.

Baseline and Follow-up Clinical Assessment

Information extracted from the electronic medical records included demographic characteristics, diabetes-related clinical information, ocular history, diabetic retinopathy classification, previous ocular interventions, and clinical findings recorded during follow-up. Data were collected using a standardized format. A comprehensive ophthalmic assessment was performed at baseline and at each scheduled follow-up visit. The assessment included best-corrected distance visual acuity (BCDVA), best-corrected near visual acuity (BCNVA), slit-lamp biomicroscopy, intraocular pressure (IOP), dilated fundus examination, and SD-OCT imaging. Distance visual acuity was determined using an illuminated Snellen chart at 6 m. The recorded Snellen measurements were subsequently converted into logarithm of the minimum angle of resolution (logMAR) values using a standardized conversion procedure for statistical analysis. Near visual function was evaluated with a standardized near-vision chart at a fixed reading distance under consistent illumination. Measurements were initially documented using routine clinical notation and subsequently converted into logMAR equivalents for statistical analysis. IOP was recorded at every scheduled assessment using a Topcon non-contact tonometer (Topcon Corporation, Tokyo, Japan), following the manufacturer's recommended measurement procedure.

OCT-Based Assessment of Macular Structure

Retinal morphology was evaluated using a Cirrus HD-OCT system (Carl Zeiss Meditec, Dublin, California, USA). Imaging was obtained at baseline and at each subsequent scheduled visit according to the institution's standardized macular imaging protocol. Central macular thickness (CMT) was defined as the thickness measured within the central 1-mm ETDRS subfield and was obtained using the device's automated retinal segmentation software. Measurements were expressed in micrometers (μm). Before inclusion in the analysis, OCT scans were assessed for image quality and the accuracy of automated segmentation. The same OCT platform and standardized acquisition protocol were maintained throughout the study period to improve consistency and facilitate comparison of CMT measurements over time.

Intravitreal Ranibizumab Administration

Each eligible eye received ranibizumab at a dose of 0.5 mg in 0.05 mL. Injections were performed by experienced vitreoretinal surgeons under aseptic conditions in the operating room. After administration of topical anesthesia, the periocular skin and conjunctival sac were prepared using 5% povidone-iodine. The drug was delivered through the pars plana with a sterile 30-gauge needle, using an injection site appropriate for pseudophakic eyes and consistent with standard intravitreal injection procedures.

Immediately after injection, optic nerve head perfusion and light perception were assessed. Patients were also examined for any acute post-injection complication before discharge. The treatment schedule consisted of three injections administered at approximately baseline, Week 4, and Week 8. Clinical and OCT assessments were conducted at baseline and approximately Weeks 4, 8, and 12. The Week 12 examination served as the final scheduled evaluation after completion of the three-dose treatment regimen.

Study Outcomes

The principal efficacy outcomes were the changes in BCDVA and CMT between baseline and the 12-week assessment. Changes in BCNVA across the observation period, including measurements obtained at Weeks 4, 8, and 12, constituted the secondary functional outcome. The principal ocular safety endpoint was the change in IOP over time following repeated intravitreal ranibizumab administration. Any ocular adverse event or injection-related complication documented during treatment or subsequent follow-up was also identified from the medical records and recorded.

Schedule of Follow-up Assessments

Four predefined assessment points were considered for longitudinal evaluation: the pretreatment baseline visit and approximately Weeks 4, 8, and 12 after treatment initiation. Ranibizumab was administered at baseline, Week 4, and Week 8, whereas the Week 12 visit represented the final post-treatment assessment. At each scheduled visit, measurements of BCDVA, BCNVA, and IOP were obtained, while slit-lamp and dilated fundus examinations were performed and OCT-derived CMT was recorded. The same clinical assessment framework was applied across visits to evaluate changes in functional vision, macular structure, and ocular safety during the 12-week observation period.

Statistical Analysis

Clinical information was extracted from the electronic medical records and entered into Microsoft Excel (Microsoft Corporation, Redmond, WA, USA) before statistical analysis using IBM SPSS Statistics version 26.0 (IBM Corp., Armonk, NY, USA). Continuous data were summarized using means and standard deviations (SD), while categorical variables were expressed as frequencies and percentages. The Shapiro-Wilk test was used to examine the distribution of continuous variables. Longitudinal changes in BCDVA, BCNVA, CMT, and IOP were assessed across the baseline and subsequent follow-up evaluations. For repeated-measures analyses, sphericity was evaluated using Mauchly's test, with the Greenhouse-Geisser adjustment applied when the assumption of sphericity was not satisfied. Because five patients contributed data from both eyes, the possibility of within-patient correlation was considered in the statistical analysis. Linear mixed-effects models were specified to examine longitudinal changes in BCDVA, BCNVA, CMT, and IOP, with assessment time treated as a fixed effect and patient identification incorporated as a random effect to account for the non-independence of observations contributed by the same patient. Pairwise comparisons between baseline and each follow-up assessment were performed with correction for multiple testing. Treatment-associated effect estimates were reported together with corresponding 95% confidence intervals, and effect sizes were calculated where appropriate to describe the magnitude of observed longitudinal changes. All hypothesis tests were two-sided, and statistical significance was defined as a p-value below 0.05.

Results

Baseline Demographic and Clinical Characteristics

Table 1. Baseline demographic and clinical characteristics of the study population

Characteristic	Value
Patients, n	45
Eyes, n	50
Eyes contributed by bilateral patients, n	5
Mean age, years (mean ± SD)	63.36 ± 8.32
Age range, years	47-79
Study design	Retrospective observational
Study setting	Tertiary vitreoretinal referral center
Study period	June 2022–November 2024
Follow-up duration	12 weeks
Assessment time points	Baseline, Week 4, Week 8, Week 12
Functional outcomes	BCDVA, BCNVA

Anatomical outcome	CMT
Safety outcome	IOP
Treatment regimen	Three consecutive monthly intravitreal ranibizumab injections

Note. *BCDVA, best-corrected distance visual acuity; BCNVA, best-corrected near visual acuity; CMT, central macular thickness; IOP, intraocular pressure; SD, standard deviation.*

The final analysis comprised 50 eyes from 45 individuals diagnosed with diabetic macular edema (DME). Bilateral data were available for five participants, while each of the other participants contributed data from one eye. Complete assessments were available for all included eyes at the four predefined time points: baseline and approximately Weeks 4, 8, and 12. Participants had a mean age of 63.36 ± 8.32 years, ranging from 47 to 79 years. The longitudinal analysis focused on four prespecified clinical outcomes: best-corrected distance visual acuity (BCDVA), best-corrected near visual acuity (BCNVA), central macular thickness (CMT), and intraocular pressure (IOP), assessed during the 12-week period following three consecutive monthly intravitreal ranibizumab injections. The baseline demographic and clinical profile of the study population is presented in Table 1.

Functional outcomes

Changes in best-corrected distance visual acuity

A gradual improvement in best-corrected distance visual acuity (BCDVA) was observed across the 12-week follow-up period (Table 2; Figure 1). The mean BCDVA changed from 0.562 ± 0.305 logMAR at baseline to 0.400 ± 0.213 logMAR at Week 4, followed by further improvement to 0.332 ± 0.159 logMAR at Week 8 and 0.246 ± 0.163 logMAR at Week 12. Relative to baseline, the mean change in BCDVA was −0.162 logMAR at Week 4, -0.230 logMAR at Week 8, and -0.316 logMAR at Week 12. The progressively greater negative change in logMAR values indicates a continuous improvement in distance visual acuity during the observation period. The repeated-measures ANOVA identified a significant difference in BCDVA across the four assessment time points ($F(3,147) = 93.26$, $p < 0.001$, partial $\eta^2 = 0.66$), with the effect size indicating a large time-associated effect. However, given the retrospective observational design and the absence of an untreated comparison group, the temporal improvement observed in BCDVA cannot be interpreted as being attributable solely to ranibizumab therapy.

After adjustment for multiple comparisons, pairwise analyses showed significant differences between baseline and each of the three follow-up assessments, as well as between consecutive follow-up time points ($p < 0.05$). Overall, the findings demonstrate that the improvement in BCDVA was progressive rather than confined to a single follow-up interval during the 12-week observation period.

Table 2. Changes in best-corrected distance visual acuity (BCDVA) over 12 weeks

Follow-up	Mean ± SD (logMAR)	Mean change from baseline (logMAR)	p-value for overall time effect
Baseline	0.562 ± 0.305	—	—
Week 4	0.400 ± 0.213	-0.162	<0.001
Week 8	0.332 ± 0.159	-0.230	<0.001
Week 12	0.246 ± 0.163	-0.316	<0.001

Overall repeated-measures ANOVA: *$F(3,147) = 93.26$, $p < 0.001$, partial $\eta^2 = 0.66$.*
Note. *Lower logMAR values indicate better visual acuity. The p-value represents the overall effect of time and should not be interpreted as an individual pairwise comparison between each visit and baseline.*

Changes in best-corrected near visual acuity

Best-corrected near visual acuity (BCNVA) improved progressively throughout the 12-week observation period (Table 3; Figure 1). The mean BCNVA was 0.806 ± 0.295 logMAR before treatment and improved to 0.594 ± 0.232 logMAR at Week 4. Further improvement was observed at Week 8 (0.514 ± 0.196 logMAR) and at the final assessment at Week 12 (0.454 ± 0.146 logMAR). The mean difference relative to baseline was -0.212 logMAR at Week 4, increasing to -0.292 logMAR at Week 8 and -0.352 logMAR at Week 12. Thus, the largest improvement in near visual acuity relative to the pretreatment measurement was recorded at the end of the 12-week follow-up. Analysis using repeated-measures ANOVA revealed a statistically significant change in BCNVA across the four assessment points ($F(3,147) = 96.08$, $p < 0.001$, partial $\eta^2 = 0.66$). The magnitude of the effect associated with time was large. Pairwise comparisons with adjustment for multiple testing also identified significant differences between the assessed time points ($p < 0.05$), supporting a progressive improvement in near visual acuity over the observation period.

As with the findings for BCDVA, these changes represent an improvement observed over time following treatment but cannot establish a direct causal effect of ranibizumab. The absence of an untreated or comparator group limits the ability to distinguish treatment-related effects from other temporal influences.

Table 3. Changes in best-corrected near visual acuity (BCNVA) over 12 weeks

Follow-up	Mean ± SD (logMAR)	Mean change from baseline (logMAR)	p-value for overall time effect
Baseline	0.806 ± 0.295	—	—
Week 4	0.594 ± 0.232	-0.212	<0.001
Week 8	0.514 ± 0.196	-0.292	<0.001
Week 12	0.454 ± 0.146	-0.352	<0.001

Overall repeated-measures ANOVA: *$F(3,147) = 96.08$, $p < 0.001$, partial $\eta^2 = 0.66$.*
Note. *Lower logMAR values indicate better near visual acuity. The p-value represents the overall effect of time.*

Anatomical outcomes

Changes in central macular thickness

A consistent decline in central macular thickness (CMT) was recorded over the 12-week follow-up period (Table 4; Figure 1). At baseline, the mean CMT was 482.84 ± 85.99 µm. This decreased to 407.34 ± 72.13 µm at Week 4 and subsequently to 341.18 ± 58.50 µm at Week 8. By the final assessment at Week 12, the mean CMT had declined further to 292.52 ± 46.46 µm. Compared with the baseline measurement, the mean reduction in CMT was 75.50 µm at Week 4, 141.66 µm at Week 8, and 190.32 µm at Week 12. The progressive decline indicates that the greatest absolute reduction in macular thickness occurred at the end of the 12-week observation period. The repeated-measures ANOVA identified a statistically significant difference in CMT across the four assessment time points ($F(3,147) = 259.45$, $p < 0.001$, partial $\eta^2 = 0.84$). The corresponding effect size indicated a very large time-associated effect. Following adjustment for multiple comparisons, pairwise analyses also demonstrated statistically significant differences between the assessed time points ($p < 0.001$). Overall, the findings demonstrate a marked anatomical improvement in macular thickness during the 12 weeks following initiation of ranibizumab treatment. Nevertheless, the retrospective design and absence of an untreated or comparator group mean that the observed reduction in CMT should be interpreted as a temporal association occurring during the treatment period rather than as definitive evidence of a causal effect of ranibizumab.

Table 4. Changes in central macular thickness (CMT) over 12 weeks

Follow-up	Mean ± SD (µm)	Mean change from baseline (µm)	p-value for overall time effect
Baseline	482.84 ± 85.99	—	—
Week 4	407.34 ± 72.13	-75.50	<0.001
Week 8	341.18 ± 58.50	-141.66	<0.001
Week 12	292.52 ± 46.46	-190.32	<0.001

Overall repeated-measures ANOVA: *$F(3,147) = 259.45$, $p < 0.001$, partial $\eta^2 = 0.84$.*
Note. *Negative values indicate a reduction in CMT relative to baseline. The p-value represents the overall effect of time.*

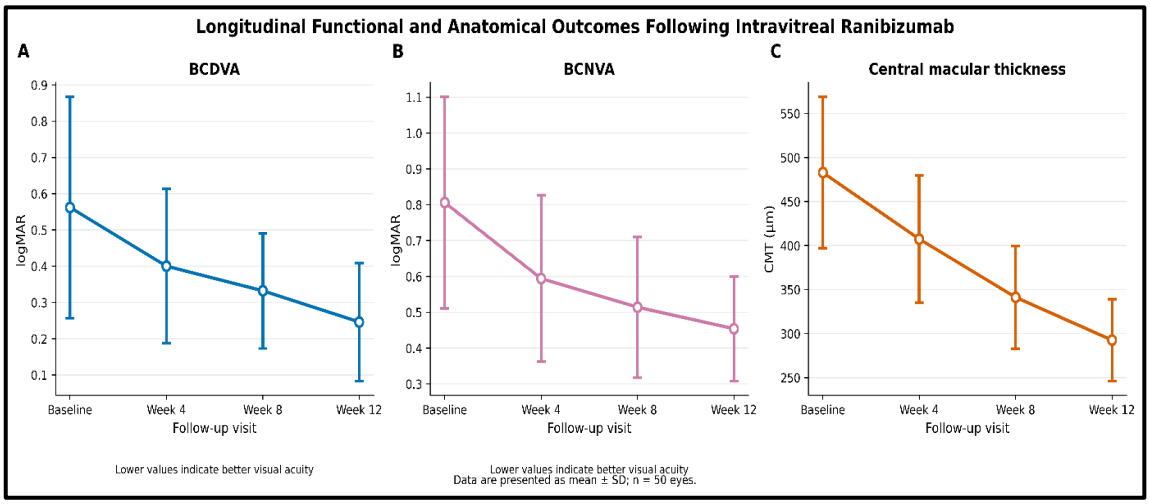

Figure 1. Longitudinal changes in best-corrected distance visual acuity (BCDVA) (A), best-corrected near visual acuity (BCNVA) (B), and central macular thickness (CMT) (C) following intravitreal ranibizumab treatment for diabetic macular edema.

Safety outcomes

Changes in intraocular pressure

Mean IOP remained within the expected physiological range throughout the 12-week follow-up period (Table 5) (Figure 2). The mean IOP increased from 15.90 ± 2.79 mmHg at baseline to 16.96 ± 2.49 mmHg at Week 4, 16.94 ± 2.25 mmHg at Week 8, and 16.92 ± 2.36 mmHg at Week 12. The mean change from baseline was +1.06 mmHg at Week 4, +1.04 mmHg at Week 8, and +1.02 mmHg at Week 12. Repeated-measures ANOVA demonstrated a statistically significant overall effect of time on IOP ($F(3,147) = 4.70$, $p = 0.0037$, partial $\eta^2 = 0.09$). The effect size was small, indicating that the magnitude of temporal variation in IOP was limited. Multiplicity-adjusted pairwise comparisons indicated statistically significant differences between baseline and follow-up measurements, whereas differences among Weeks 4, 8, and 12 were not statistically significant. This pattern suggests a modest increase in IOP during the early follow-up period that remained relatively stable thereafter. No sustained ocular hypertension requiring treatment was documented during the 12-week follow-up period, and no injection-related sight-threatening complications were recorded in the available medical records. These findings suggest that no clinically important short-term IOP elevation or major ocular safety event was observed in this cohort during the study period. However, the relatively short follow-up duration limits conclusions regarding the long-term safety of repeated intravitreal ranibizumab injections.

Table 5. Changes in intraocular pressure (IOP) over 12 weeks

Follow-up	Mean ± SD (mmHg)	Mean change from baseline (mmHg)	p-value for overall time effect
Baseline	15.90 ± 2.79	—	—
Week 4	16.96 ± 2.49	+1.06	0.0037
Week 8	16.94 ± 2.25	+1.04	0.0037
Week 12	16.92 ± 2.36	+1.02	0.0037

Overall repeated-measures ANOVA: *$F(3,147) = 4.70$, $p = 0.0037$, partial $\eta^2 = 0.09$.*
Note. *The p-value represents the overall effect of time and is not a separate p-value for each individual follow-up visit.*

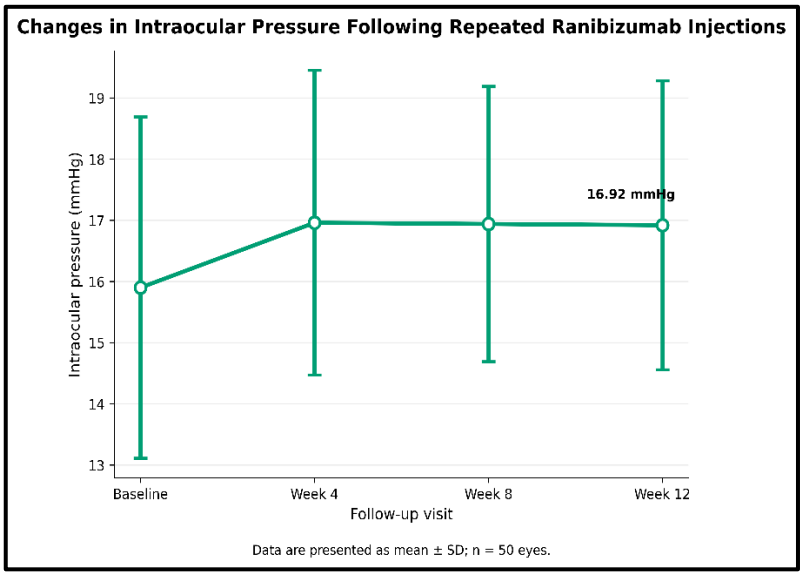

Figure 2. Longitudinal changes in intraocular pressure (IOP) following three consecutive monthly intravitreal ranibizumab injections for diabetic macular edema.

Summary of repeated-measures analyses

Repeated-measures ANOVA demonstrated statistically significant changes over time in all four prespecified outcomes: BCDVA, BCNVA, CMT, and IOP (Table 6). The magnitude of the time-associated effect was large for BCDVA and BCNVA, very large for CMT, and small for IOP.

The largest temporal effect was observed for CMT (partial $\eta^2 = 0.84$), followed by BCDVA and BCNVA (partial $\eta^2 = 0.66$ for each). In contrast, IOP demonstrated a considerably smaller effect size (partial $\eta^2 = 0.09$). Importantly, these effect sizes quantify the magnitude of the association between time and each outcome within the repeated-measures model; they do not establish that the observed changes were caused exclusively by ranibizumab.

Table 6. Summary of repeated-measures ANOVA findings

Outcome	F-statistic (df = 3,147)	p-value	Partial η^2	Magnitude of time-associated effect
BCDVA	93.26	<0.001	0.66	Large
BCNVA	96.08	<0.001	0.66	Large
CMT	259.45	<0.001	0.84	Very large
IOP	4.70	0.0037	0.09	Small

Note. *Partial η^2 represents the magnitude of the effect associated with the time factor in the repeated-measures model and should not be interpreted as the proportion of outcome change attributable solely to ranibizumab treatment.*

Pairwise comparisons across follow-up visits

Multiplicity-adjusted pairwise comparisons were performed to determine whether changes occurred between individual assessment time points (Table 7). BCDVA demonstrated statistically significant improvement between baseline and each follow-up assessment, as well as between successive follow-up visits. BCNVA similarly demonstrated statistically significant differences across the assessed time points. CMT showed statistically significant reductions between all assessment intervals, indicating progressive anatomical change throughout follow-up.

For IOP, statistically significant differences were observed between baseline and follow-up assessments, whereas comparisons among Weeks 4, 8, and 12 did not demonstrate statistically significant differences. This pattern is consistent with a modest early increase in IOP followed by relative stabilization during the remainder of the 12-week observation period.

Table 7. Summary of multiplicity-adjusted pairwise comparisons across follow-up visits

Outcome	Pairwise comparison	Statistical significance
BCDVA	Baseline vs. Week 4	Significant ($p < 0.05$)
BCDVA	Baseline vs. Week 8	Significant ($p < 0.05$)
BCDVA	Baseline vs. Week 12	Significant ($p < 0.05$)
BCDVA	Week 4 vs. Week 8	Significant ($p < 0.05$)
BCDVA	Week 8 vs. Week 12	Significant ($p < 0.05$)
BCNVA	Pairwise comparisons across assessment visits	Significant ($p < 0.05$)
CMT	Pairwise comparisons across assessment visits	Significant ($p < 0.001$)
IOP	Baseline vs. follow-up visits	Significant ($p < 0.05$)
IOP	Comparisons among Weeks 4, 8, and 12	Not significant

Note. *Pairwise comparisons were performed following repeated-measures ANOVA with adjustment for multiple comparisons. Exact adjusted p-values should be reported if available from the statistical software output.*

Overall findings

Across the 12-week follow-up period, improvement was observed concurrently in the functional and anatomical parameters assessed after initiation of intravitreal ranibizumab therapy. Mean BCDVA improved from 0.562 logMAR at baseline to 0.246 logMAR at Week 12, representing a mean change of -0.316 logMAR. Over the same period, mean BCNVA changed from 0.806 to 0.454 logMAR, corresponding to a mean improvement of -0.352 logMAR. A substantial anatomical change was also observed, with mean CMT declining from 482.84 μm at baseline to 292.52 μm at Week 12, equivalent to a mean reduction of 190.32 μm. The magnitude of these longitudinal changes was considerable. The analyses demonstrated large time-associated effects for both distance and near visual acuity, while the effect observed for CMT was very large. Taken together, these results indicate that functional visual improvement and reduction in macular thickness occurred concurrently during the 12-week observation period in this cohort. A modest increase in mean IOP was observed, rising from 15.90 mmHg at baseline to 16.92 mmHg at Week 12. Although the change across follow-up reached statistical significance, the absolute magnitude of the increase was small. No sustained elevation in IOP requiring treatment was documented during the observation period, and the available clinical records did not identify any major ocular complication related to the intravitreal injection procedure. Overall, the study findings indicate significant short-term changes in both visual acuity and macular thickness during the period following initiation of intravitreal ranibizumab therapy, without evidence of clinically important short-term IOP elevation in the study cohort. However, these observations must be interpreted within the context of the retrospective, single-center, uncontrolled design and the relatively short 12-week follow-up. The findings therefore represent temporal associations observed during the treatment period and should not be considered definitive evidence of a causal treatment effect. Prospective controlled investigations involving larger patient populations and extended follow-up are required to determine whether the observed functional and anatomical benefits are sustained over time and to better characterize the longer-term safety of repeated ranibizumab treatment.

Discussion

This study examined the early functional response, retinal structural changes, and short-term ocular safety profile observed after three monthly intravitreal ranibizumab injections in patients with diabetic macular edema (DME) treated in routine clinical practice at a tertiary eye care center in India. During the 12-week observation period, both distance and near visual function improved progressively, accompanied by a marked reduction in OCT-derived central macular thickness (CMT). In contrast, intraocular pressure (IOP) showed only a modest increase, and no clinically important ocular hypertension requiring intervention or serious injection-related complication was identified. Collectively, these findings indicate a favorable short-term clinical response following ranibizumab treatment in this cohort. Nevertheless, because the study was retrospective and lacked an untreated or active comparator group, the observed changes should not be interpreted as definitive evidence that ranibizumab alone caused the improvements.

The improvement in best-corrected distance visual acuity observed over the study period is in keeping with the established role of ranibizumab in the treatment of DME. Evidence from the landmark RISE and RIDE trials demonstrated meaningful visual benefits following intravitreal ranibizumab therapy and established its efficacy in reducing vision loss associated with DME (Nguyen et al., 2012). The direction of change observed in the present cohort is also comparable with findings reported in previous short-term clinical investigations in which ranibizumab treatment was followed by improved visual acuity (Minami et al., 2017; Seo et al., 2023; Swelem et al., 2015). Direct comparison between studies, however, should be approached cautiously because differences in baseline vision, severity and duration of DME, prior treatment exposure, injection schedules, and follow-up intervals may substantially influence the magnitude of observed response. Furthermore, longer-term evidence suggests that functional improvement may occur even when residual retinal thickening persists, demonstrating that anatomical resolution and visual recovery are related but not necessarily synchronous outcomes (Bressler et al., 2016; Bressler et al., 2018).

The assessment of near visual acuity represents an additional functional dimension of the present study. Although distance visual acuity is commonly used as the principal measure of treatment response, macular edema can also interfere with reading and other visually demanding near tasks. The improvement in near visual acuity identified in this cohort therefore provides complementary information regarding functional recovery. Previous work has shown that treatment-related visual improvement may be accompanied by better vision-related quality of life in individuals with DME (Daldal et al., 2021). Although the present study did not directly measure quality of life or patient-reported functional outcomes, the observed improvement in near vision may have practical implications for activities such as reading and other tasks requiring detailed central vision. Prospective research incorporating validated patient-reported outcome instruments would help determine whether measurable gains in near visual acuity correspond to improvements in everyday visual functioning and quality of life.

A pronounced reduction in CMT was also observed during the 12-week follow-up. This structural response is biologically plausible given the anti-VEGF mechanism of ranibizumab, which reduces VEGF-mediated vascular leakage and thereby limits retinal fluid accumulation. The finding is also consistent with previous studies documenting reductions in macular thickness following ranibizumab therapy (Dervenis et al., 2017; Minami et al., 2017; Kwak et al., 2016). OCT is particularly valuable in this context because it permits objective, quantitative monitoring of retinal morphology. However, retinal thickness alone cannot fully characterize functional recovery. Factors including the initial pattern of retinal involvement, integrity of photoreceptor layers, duration of edema, and irreversible retinal damage may determine how closely structural improvement translates into visual gain (Kwak et al., 2016). The combined improvement in CMT and visual acuity observed in this study therefore supports the use of both anatomical and functional measures when judging response to treatment.

The interpretation of these longitudinal changes requires consideration of the study design. Since no untreated or comparator group was included, it is not possible to establish that the improvements observed over 12 weeks resulted exclusively from ranibizumab administration. Other explanations, including spontaneous changes in disease activity, regression toward the mean, or other temporal effects, cannot be completely excluded. Even so, the parallel improvement in visual function and retinal morphology throughout the observation period is compatible with the therapeutic response reported in previous randomized and observational investigations of anti-VEGF treatment (Nguyen et al., 2012; Dervenis et al., 2017). The degree of response may also differ between individuals according to baseline disease characteristics and previous interventions, including earlier macular laser treatment or anti-VEGF exposure. Such factors should therefore be considered when interpreting outcomes obtained from heterogeneous real-world populations.

The safety findings were generally reassuring over the short observation period. Although the increase in IOP reached statistical significance, the absolute change was small and mean IOP remained within clinically acceptable limits. No

patient developed sustained ocular hypertension requiring treatment, and no serious injection-associated ocular complication was recorded during the 12-week follow-up. These observations are broadly comparable with previous reports evaluating ocular parameters following intravitreal treatment (Sharma et al., 2024). However, the absence of clinically important short-term IOP elevation should not be interpreted as evidence of long-term safety. A 12-week observation period is insufficient to determine whether repeated anti-VEGF exposure may contribute to persistent IOP elevation or cumulative injection-related complications. Longer surveillance is therefore required to address these concerns adequately.

The role of ranibizumab should also be considered within the broader and evolving therapeutic landscape of DME. Multiple anti-VEGF agents and individualized treatment approaches are currently available, and the choice of therapy may be influenced by factors such as baseline visual acuity, retinal morphology, disease severity, treatment frequency, accessibility, and financial considerations. Because the present investigation was not designed as a comparative study, its findings cannot be used to establish superiority of ranibizumab over alternative anti-VEGF agents or to recommend it universally as the preferred first-line therapy. Instead, the results add to the body of real-world evidence indicating that ranibizumab can provide meaningful functional and anatomical benefits in patients with DME (Dervenis et al., 2017; Mitchell et al., 2012).

The interpretation of treatment response is further complicated by the incomplete availability of systemic clinical information in the retrospective records. Variables such as diabetes duration, glycated hemoglobin (HbA1c), blood pressure, lipid status, renal function, and other indicators of metabolic health were either unavailable or insufficiently documented and could therefore not be incorporated into the analysis. These factors may be relevant to both the development and progression of diabetic complications and may potentially influence the retinal response to treatment (Hossain et al., 2024; Tınkır Kayıtmazbatır et al., 2022; Thakkar et al., 2025). Future prospective studies should therefore collect systemic metabolic data in a standardized manner alongside detailed ophthalmic measurements to allow more comprehensive investigation of predictors of treatment response.

Several features strengthen the present study. Rather than relying on a single outcome, the analysis incorporated measures representing three clinically relevant dimensions of treatment response: distance and near visual function, retinal structural change assessed by OCT-derived CMT, and short-term ocular safety reflected by IOP and documented complications. The use of a uniform three-dose monthly ranibizumab regimen and predefined assessments through 12 weeks also provided a consistent framework for evaluating early treatment response. In addition, because the study reflects treatment delivered in routine clinical practice at a tertiary eye care center, the findings provide complementary information to evidence generated through highly controlled clinical trials.

The results should nevertheless be interpreted in the context of several limitations. The retrospective design and single-center setting introduce the possibility of selection and information bias, while the relatively small study population limits the extent to which the findings can be generalized to other clinical settings. An additional statistical consideration arises from the fact that five patients contributed data from both eyes. Observations from these eyes may not be statistically independent because outcomes from two eyes belonging to the same individual can be correlated. Failure to account for this clustering may lead to underestimated standard errors and potentially overstate the precision of effect estimates. The absence of a control or comparator group is another important limitation because it prevents definitive separation of treatment effects from other time-dependent changes. Moreover, the 12-week follow-up does not provide sufficient information regarding the persistence of visual improvement, recurrence of edema, long-term IOP behavior, or the requirement for additional treatment. Finally, incomplete information concerning systemic metabolic status, including glycemic control and duration of diabetes, restricted the ability to evaluate important clinical factors that could influence treatment response.

Despite these limitations, the findings have practical implications for the assessment of DME in routine care. The concurrent improvement observed in distance vision, near vision, and macular structure suggests that treatment response may be better characterized through a multidimensional assessment rather than by relying exclusively on distance visual acuity or CMT. Continued OCT monitoring remains important for documenting retinal response, while functional assessment can provide complementary information regarding the patient's visual benefit. These considerations may be particularly relevant in settings where access to specialized retinal services is uneven. In view of the continuing increase in diabetes prevalence and persistent disparities in access to eye care, timely referral, appropriate treatment initiation, and sustained follow-up remain important components of DME management (Genitsaridi et al., 2026; Bhattacharjee & Varshney, 2025; Bhattacharjee et al., 2026).

Further prospective multicenter research involving larger and more diverse patient populations would strengthen the evidence base. Such studies should incorporate longer follow-up, standardized assessment of systemic metabolic

variables, validated patient-reported outcomes, and statistical models that appropriately account for the correlation between fellow eyes when both eyes are included.

Conclusion

In this real-world cohort of pseudophakic eyes with diabetic macular edema, three monthly intravitreal administrations of ranibizumab were followed by clinically meaningful improvements in both visual function and OCT-derived central macular thickness during 12 weeks of observation. The accompanying increase in intraocular pressure was small, and no clinically important short-term ocular hypertension or serious injection-related complication was identified. However, the retrospective design, absence of a comparator group, limited sample size, contribution of both eyes from some participants, incomplete systemic clinical information, and short follow-up period restrict the strength of causal and long-term safety inferences. Larger prospective multicenter studies using longer follow-up periods, standardized systemic and retinal assessments, and statistical approaches that account for inter-eye correlation are needed to clarify the durability of treatment response and the longer-term safety profile of ranibizumab in routine DME care.

Acknowledgement

The authors acknowledge the support of the Department of Optometry, Shree Bharatimaiya College of Optometry and Physiotherapy, Surat, India, for facilitating access to the institutional clinical facilities required for this study. The authors sincerely thank all participants for their cooperation and contribution to the research. The authors also acknowledge the assistance of the biostatistics consultant in organizing the study data and interpreting the statistical findings.

Author contributions

Concept and study design: Ms. Anushka A. Singh, Dr. Ankit Sanjay Varshney
Data collection: Ms. Anushka A. Singh, Mrs. Darshana Patel
Statistical analysis: Dr. Ankit Sanjay Varshney, Ms. Anushka A. Singh
Manuscript drafting: Dr. Ankit Sanjay Varshney, Mrs. Darshana Patel
Critical revision of manuscript: Dr. Chetna Patel, Dr. Mahendrasinh D. Chauhan
Final approval of manuscript: All authors

Funding

No funding.

Conflict of interest

The author declared no conflict of interest.

Ethics approval

The study protocol was reviewed and approved by the Institutional Ethics Committee (Approval No. IEC/BMCOP/2024/015). The research was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki.

AI tool usage declaration

No artificial intelligence (AI) tools were used in the preparation, analysis, or writing of this manuscript.

References

Bhattacharjee, D., & Varshney, A. (2025). Barriers to eye care access in low- and middle-income countries: Focus on Asia. *Acta Scientific Ophthalmology, 8*(10), 1–4. https://doi.org/10.5281/zenodo.17430730

Bhattacharjee, D., Varshney, A. S., & Dhankhar, N. (2026). Global barriers to eye care access: A systematic review and meta-analysis of gender, geographic, and economic disparities. *Pakistan Journal of Ophthalmology, 42*(2). https://doi.org/10.36351/pjo.v42i2.2132

Bressler, S. B., Ayala, A. R., Bressler, N. M., et al. (2016). Persistent macular thickening after ranibizumab treatment for diabetic macular edema with vision impairment. *JAMA Ophthalmology, 134*(3), 278–285. https://doi.org/10.1001/jamaophthalmol.2015.5346

Bressler, S. B., Odia, I., Glassman, A. R., Danis, R. P., Grover, S., Hampton, G. R., Jampol, L. M., Maguire, M. G., & Melia, M. (2018). Changes in diabetic retinopathy severity when treating diabetic macular edema with ranibizumab: DRCR.net Protocol I 5-year report. *Retina, 38*(10), 1896–1904. https://doi.org/10.1097/IAE.0000000000002302

Daldal, H., Turkyilmaz, M., Balikoglu Yilmaz, M., & Berberoglu, U. (2021). The effect of ranibizumab loading treatment on vision-related quality of life in diabetic macular edema. *Clinics and Practice, 11*(3), 659–670. https://doi.org/10.3390/clinpract11030081

Dervenis, N., Mikropoulou, A. M., Tranos, P., & Dervenis, P. (2017). Ranibizumab in the treatment of diabetic macular edema: A review of the current status, unmet needs, and emerging challenges. *Advances in Therapy, 34*(6), 1270–1282. https://doi.org/10.1007/s12325-017-0548-1

Genitsaridi, I., Salpea, P., Salim, A., Sajjadi, S. F., Tomic, D., James, S., Thirunavukkarasu, S., Issaka, A., Chen, L., Basit, A., Luk, A. O. Y., Ma, R. C. W., Mbanya, J. C., Ramachandran, A., Wild, S. H., Duncan, B. B., Boyko, E. J., & Magliano, D. J. (2026). 11th edition of the IDF Diabetes Atlas: Global, regional, and national diabetes prevalence estimates for 2024 and projections for 2050. *The Lancet Diabetes & Endocrinology, 14*(2), 149–156. https://doi.org/10.1016/S2213-8587(25)00299-2

Hossain, M. J., Al-Mamun, M., & Islam, M. R. (2024). Diabetes mellitus, the fastest growing global public health concern: Early detection should be focused. *Health Science Reports, 7*(3), e2004. https://doi.org/10.1002/hsr2.2004

Kwak, H., Kim, M., Yu, S.-Y., & Seo, K. (2016). Visual and morphologic outcomes of intravitreal ranibizumab for diabetic macular edema based on optical coherence tomography patterns. *Retina, 36*(3), 588–595. https://doi.org/10.1097/IAE.0000000000000770

Minami, Y., Nagaoka, T., Ishibazawa, A., et al. (2017). Short-term effects of intravitreal ranibizumab therapy on diabetic macular edema. *BMC Ophthalmology, 17*, Article 28. https://doi.org/10.1186/s12886-017-0420-8

Mitchell, P., Annemans, L., Gallagher, M., et al. (2012). Cost-effectiveness of ranibizumab in the treatment of diabetic macular oedema causing visual impairment: Evidence from the RESTORE trial. *British Journal of Ophthalmology, 96*(5), 688–693. https://doi.org/10.1136/bjophthalmol-2011-300726

Nguyen, Q. D., Brown, D. M., Marcus, D. M., Boyer, D. S., Patel, S., Feiner, L., Gibson, A., Sy, J., Rundle, A. C., Hopkins, J. J., Rubio, R. G., Ehrlich, J. S., & RISE and RIDE Research Group. (2012). Ranibizumab for diabetic macular edema: Results from two phase III randomized trials: RISE and RIDE. *Ophthalmology, 119*(4), 789–801. https://doi.org/10.1016/j.ophtha.2011.12.039

Seo, J. S., Kwon, L., Cho, Y. W., Yoo, W., & Chung, I. Y. (2023). The short-term treatment efficacy of intravitreal ranibizumab injection in treatment-naïve patients with diabetic macular edema. *Journal of Retina, 8*(2), 105–110. https://doi.org/10.21561/jor.2023.8.2.105

Sharma, A., Sharma, N., Kumari, A., Kaistha, P., & Kumar, S. (2024). The effect of intravitreal injection on macular thickness, visual acuity, and intraocular pressure in diabetic macular edema. *Indian Journal of Clinical and Experimental Ophthalmology, 10*(4), 634–638. https://doi.org/10.18231/j.ijceo.2024.111

Swelem, H., Sharaf, A., Nabawi, K., & Shalaby, T. (2015). Short-term results of intravitreal ranibizumab injection in eyes with diabetic macular edema. *Delta Journal of Ophthalmology, 16*(2), 77–83. https://doi.org/10.4103/1110-9173.168536

Thakkar, H., Gupta, S., & Varshney, A. (2025). Glycemic status and its relationship with corneal tomographic and endothelial parameters in diabetes mellitus. *Journal of Medicine and Applied Clinical Sciences, 1*(1), 25–35. https://doi.org/10.5281/zenodo.19113473

Tınkır Kayıtmazbatır, E., Bitirgen, G., Şatırtav, G., Kılınç, İ., Kulaksızoğlu, M., Savut, B., & Kerimoğlu, H. (2022). Short-term impact of glycaemic control and intravitreal ranibizumab treatment on serum cytokine levels and diabetic

macular edema in patients with unregulated blood glucose. *Genel Tıp Dergisi, 32*(6), 774–780. https://doi.org/10.54005/geneltip.1191169

Varshney, A. S., Saraiya, A. B., Mahida, H. B., Patel, C. S., & Chauhan, M. D. (2024). Impact of diabetes mellitus on tear secretion, intraocular pressure, and contrast sensitivity: A comparative study of controlled and uncontrolled diabetics. *IP International Journal of Ocular Oncology and Oculoplasty, 10*(4), 213–219. https://doi.org/10.18231/j.ijooo.2024.038