GÜSBD 2025; 14(3): 1227 - 1232 | **Gümüşhane Üniversitesi Sağlık Bilimleri Dergisi** | **Araştırma Makalesi**
GUJHS 2025; 14(3): 1227 - 1232 | Gümüşhane University Journal of Health Sciences | Original Article

Evaluation of Vitreous Humor Changes in Patients with Diabetic Retinopathy usingComputed Tomography

Diyabetik Retinopati Hastalarında Bilgisayarlı Tomografi ile Vitreus Humor Değişikliklerinin Değerlendirilmesi

Emre AYDIN[1], İsmet Miraç ÇAKIR[2], Şaban KILIÇ[3], Enes GÜRÜN[4], Mesut ÖZTÜRK[5]

ABSTRACT

Diabetic retinopathy (DR), a leading cause of blindness, is associated with retinal microvascular damage and structural changes in the vitreous humor. High-resolution computed tomography (CT) imaging allows sensitive and noninvasive assessment of changes in vitreous humor density. The objective of this study was to use CT to evaluate changes in the vitreous humor of patients with DR. DR patients aged 18 years and older who underwent brain CT between January 1, 2022, and June 1, 2024, and whose images were available in the radiological information system were retrospectively reviewed. Fifty DR patients and 50 age- and gender-matched non-diabetic controls were included. The vitreous humor CT density values of DR patients were statistically compared with those of the control group. There was no statistically significant difference between the genders in terms of vitreous humor density in both eyes in the DR and control groups ($p>0.05$). The DR group exhibited significantly higher vitreous humor density in both the right and left eyes compared to the control group ($p=0.011$, $p=0.007$, respectively). A negative correlation was found between age and vitreous humor density in both eyes in the DR and control groups; however, no statistically significant difference was found ($p>0.05$). CT measurements revealed that vitreous humor density was significantly higher in DR patients than in the control group, suggesting that increased vitreous density may serve as a potential marker for diabetic retinopathy severity or progression.

Keywords: Diabetic Retinopathy, Computed Tomography, Vitreous Humor

ÖZ

Görme kaybının önde gelen nedenlerinden biri olan diyabetik retinopati (DR), retina mikrovasküler hasarı ve vitreus humorundaki yapısal değişikliklerle ilişkilidir. Yüksek çözünürlüklü bilgisayarlı tomografi (BT) görüntüleme, vitreus humor yoğunluğundaki değişikliklerin hassas ve noninvaziv bir şekilde değerlendirilmesini sağlar. Bu çalışmanın amacı, DR hastalarının vitreus humorundaki değişiklikleri BT kullanarak değerlendirmektir.1 Ocak 2022 ile 1 Haziran 2024 tarihleri arasında beyin BT'si yapılan ve görüntüleri radyoloji bilgi sisteminde bulunan 18 yaş ve üzeri DR hastaları retrospektif olarak incelenmiştir. 50 DR hastası ve yaş ve cinsiyet açısından eşleştirilmiş 50 diyabetik olmayan kontrol hastası çalışmaya dahil edildi. DR hastalarının vitreus sıvısı BT dansite değerleri, kontrol grubunun değerleriyle istatistiksel olarak karşılaştırıldı. DR ve kontrol gruplarında her iki gözde vitreus sıvı dansitesi açısından cinsiyetler arasında istatistiksel olarak anlamlı bir fark yoktu ($p>0,05$). DR grubu, kontrol grubuna kıyasla hem sağ hem de sol gözde anlamlı olarak daha yüksek vitreus dansite sergilemiştir (sırasıyla $p=0,011$, $p=0,007$). DR ve kontrol gruplarında her iki gözde yaş ve vitreus dansite arasında negatif bir korelasyon bulunmuştur; ancak istatistiksel olarak anlamlı bir fark bulunmamıştır ($p>0,05$). BT ölçümleri, vitreus dansitenin DR hastalarında kontrol grubuna göre anlamlı olarak daha yüksek olduğunu ortaya koydu, bu da artan vitreus dansitenin diyabetik retinopati şiddetinin veya ilerlemesinin potansiyel bir belirteci olabileceğini düşündürmektedir.

Anahtar kelimeler: Diyabetik Retinopati, Bilgisayarlı Tomografi, Vitreus Humor

Highlights

*Vitreous density is increased in diabetic retinopathy patients.*CT can detect subtle changes in the vitreous humor structure.*These findings may aid early diagnosis of diabetic eye disease.*This is among the first studies using CT for vitreous assessment.

The study was approved by the local ethics committee of Samsun University (IRB protocol number: GOKAEK 2024/10/15).

[1]Assistant Professor, Emre AYDIN, Samsun University, Faculty of Medicine, Department of Ophthalmology, emreaydin0052@gmail.com, ORCID: 0000-0002-1895-8538
[2]Associate Professor, İsmet Miraç ÇAKIR, Samsun University, Faculty of Medicine, Department of Radiology, ismetcakir_55@hotmail.com, ORCID: 0000-0002-4229-7493
[3]Medical Doctor, Şaban KILIÇ, Samsun Education and Research Hospital, Department of Ophthalmology, saban841kilic@gmail.com, ORCID: 0000-0002-1077-0581
[4]Associate Professor, Enes GÜRÜN, Samsun University, Faculty of Medicine, Department of Radiology, e.grn06@gmail.com, ORCID: 0000-0002-5321-8439
[5]Associate Professor, Mesut ÖZTÜRK, Samsun University, Faculty of Medicine, Department of Radiology, dr.mesutozturk@gmail.com, ORCID: 0000-0003-4059-2656

İletişim / Corresponding Author: İsmet Miraç ÇAKIR
e-posta/e-mail: ismetcakir_55@hotmail.com

Geliş Tarihi / Received: 30.06.2025
Kabul Tarihi/Accepted: 28.08.2025

INTRODUCTION

Diabetic retinopathy (DR) is a significant microvascular complication of diabetes mellitus and a leading cause of vision impairmentworldwide.[1,2]
Pathophysiologically, DR is characterized by progressive retinal microvascular damage that can also affect the vitreous humor, a gel-like substance in direct contact with the retina.[3,4] This anatomical relationship suggests that pathological changes in the vitreous may reflect the severity or progression of retinal damage in DR.[5]

Traditionally, diagnostic modalities such as optical coherence tomography (OCT) and fluorescein angiography are preferred for evaluating DR. However, these methods primarily focus on the retina, and the role of vitreous changes remains underexplored. Recent studies have shown that inflammatory markers, increased protein concentration, and cellular debris accumulate in the vitreous of DR patients, potentially altering its physical properties.[6]

Computed tomography (CT), although not a first-line modality for ophthalmic imaging, provides high-resolution visualization and allows quantitative analysis through Hounsfield unit (HU) measurements.[7] CT may detect subtle alterations in vitreous humor density, potentially serving as ancillary findings in systemic diseases such as diabetes.[8] In the evaluation of vitreous changes in diabetic retinopathy, other imaging modalities such as optical coherence tomography (OCT) and diffusion-weighted magnetic resonance imaging (DW-MRI) have also been utilized. OCT is particularly effective in visualizing the vitreoretinal interface, while DW-MRI assesses microstructural alterations in the vitreous based on water diffusion properties. Compared to these techniques, CT offers advantages such as rapid acquisition, wide availability, and quantitative density assessment; however, its limitations include exposure to ionizing radiation and reduced sensitivity to microstructural changes.

The purpose of this study was to investigate whether patients with DR exhibit measurable changes in vitreous humor density on CT compared to age- and gender-matched non-diabetic controls, and to explore the potential diagnostic and research implications of this approach.

MATERIAL AND METHODS

Study design

This observational, cross-sectional study was based on retrospectively collected data from patients who underwent cranial CT between January 1, 2022, and June 1, 2024; fifty patients (30 females, 20 males) aged 18 years and older, diagnosed with diabetic retinopathy through comprehensive ophthalmologic examinations performed by experienced ophthalmologists, and with clearly visualized bilateral orbital vitreous humor on CT, were included. Fifty age- and gender-matched non-diabetic individuals who underwent cranial CT in the same period were selected as controls. Patients with a history of ocular surgery or trauma, systemic inflammatory diseases, poor-quality images, or CT indications related to acute neurological conditions or intracranial mass effect were excluded.

Image Acquisition

All CT examinations were performed using a 128-slice spiral CT scanner (Revolution Evo; GE Healthcare). The technical parameters were as follows: pitch ranging from 0.61 to 1.5, gantry rotation time between 50 and 270 ms, collimation set at 4×1.5 to 6.4×0.625 mm, a voltage of 120 kV, a tube current of 132–200 mAs, and a matrix size of 512×512.

Image Analysis

Two radiologists, blinded to patient clinical information, independently evaluated the CT images. Vitreous humor density was measured in both the right and left orbits by

manually placing a circular region of interest (ROI) with a fixed area of approximately 20 mm² at the central portion of the vitreous body. Care was taken to avoid the optic nerve head, lens artifacts, and any partial volume effects from adjacent orbital structures. This standardized approach was employed to ensure consistency and minimize subjectivity in the measurements. (Figure 1).

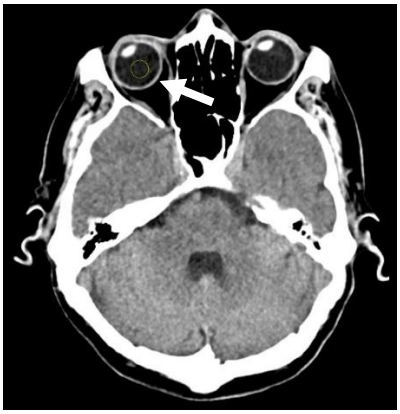

Figure 1. Mean CT HU values were measured by placing the region of interest (ROI) within the central orbital vitreous humor to ensure consistency.

The ethical aspect of the research

The retrospective study protocol was approved by the Samsun University, Non-Interventional Clinical Research Ethics Committee (IRB protocol number: GOKAEK 2024/10/15) and the requirement for informed consent was waived.

Statistical Analysis

Statistical analyses were performed using IBM SPSS v23.0. The normality of quantitative variables was evaluated with the Kolmogorov-Smirnov and Shapiro-Wilk tests. For normally distributed data, comparisons were made using the Student's t-test, while the Mann-Whitney U test was applied to non-normally distributed data. Categorical variables were analyzed using the Pearson Chi-Square test. Results were reported as mean ± standard deviation, median (minimum–maximum), and frequency (%).

RESULTS AND DISCUSSION

The control group was matched with the DR group in terms of age and gender. Consequently, no statistically significant differences were found between the groups in terms of age (mean age: 63.6 years) or gender distribution (female: 60%) (p=1.0).

No statistically significant difference was observed between genders in terms of right and left vitreous humor density in both the DR and control groups (p>0.05) (Table 1).

Table 1. Mean CT HU Values Between Genders in Patients with Diabetic Retinopathy and the Control Group

Group		Gender	N	Mean HU±SD	IQR	p-value
DR group	**RVD**	Female	30	9.5±7.2	3.38	0.271
		Male	20	7.3±5.8	4.05	
	LVD	Female	30	9.7±7.5	7.18	0.400
		Male	20	8.0 ±5.7	4.65	
Control group	**RVD**	Female	29	5.1±3.2	4.35	0.138
		Male	21	6.5±3.5	5.35	
	LVD	Female	29	5.9±3.3	4.75	0.964
		Male	21	6.0 ±3.0	3.78	

RVD: Right vitreous density; LVD: Left vitreous density; DR: Diabetic retinopathy; N:number; SD:standard deviation; IQR: Interquartile range

In the DR group, a significant increase in right and left eye vitreous humor density was observed when compared to the control group (p=0.007 and p=0.006, respectively). Table 2 summarizes the vitreous humor HU values for the right and left eyes measured on CT.

Table 2. Mean CT HU Values of Patients with Diabetic Retinopathy and the Control Group

	Group	N	Mean HU±SD	IQR	p value
RVD	**DR group**	50	8.6±6.7	3.48	**0.007**
	Control group	50	5.7±3.4	4.57	
LVD	**DR group**	50	9.0 ±6.9	5.75	**0.006**
	Control group	50	5.9±3.1	4.24	

RVD: Right vitreous density; LVD: Left vitreous density; DR: Diabetic retinopathy; N:number; SD:standard deviation; IQR: Interquartile range

A negative correlation was found between age and vitreous humor density in both the DR and control groups for the right and left eyes; however, these correlations were not statistically significant (p>0.05) (Table 3).

Table 3. Correlation Between Age and Eye Density in Patients with Diabetic Retinopathy and Controls

Group		Age and RVD	Age and LVD
DR group	Correlation coefficient	-0.115	-0.037
	p-value	0.425	0.797
Control group	Correlation coefficient	-0.218	-0.149
	p-value	0.128	0.303

RVD: Right vitreous density; LVD: Left vitreous density; DR: Diabetic retinopathy

Our study demonstrated a statistically significant increase in vitreous humor density in both eyes of diabetic retinopathy (DR) patients compared to controls, suggesting that vitreous alterations may accompany retinal pathology in DR. While CT is not routinely used in ophthalmologic practice due to concerns about ionizing radiation, it may serve as a useful adjunct in specific scenarios—particularly during incidental cranial imaging or when other modalities such as OCT are inconclusive. Moreover, as most conventional ophthalmic imaging methods do not provide quantitative data on the vitreous, CT-based density evaluation may offer novel insights into diabetic vitreopathy.

Several pathophysiological mechanisms support our findings. DR is increasingly recognized not only as a retinal vascular disease but also as a disorder affecting the vitreoretinal interface. Chronic hyperglycemia leads to disruption of the blood-retinal barrier, promoting the extravasation of proteins, inflammatory cells, and cytokines into the vitreous cavity.[9] Elevated levels of pro-inflammatory cytokines such as IL-6, TNF-α, and VEGF in the vitreous of DR patients have been well documented and are associated with disease severity.[10,11] These inflammatory mediators contribute to vitreous liquefaction, collagen remodeling, and protein accumulation, which may increase CT attenuation. Furthermore, the accumulation of advanced glycation end products (AGEs) in ocular tissues results in oxidative stress and cross-linking of collagen fibers, further altering the vitreous structure and composition.[12]

Although CT is not a primary modality in ophthalmology, it is valuable in selected indications. CT can effectively detect and localize intraocular foreign bodies, identify calcifications in intraocular tumors such as retinoblastoma, and assess lesion extension.[13,14] In infectious or inflammatory conditions like endophthalmitis, increased vitreous density on CT has also been reported.[15]

Few imaging-based studies have evaluated vitreous changes in DR. Ünlü and Ilgar demonstrated increased apparent diffusion coefficient (ADC) values in DR patients using MRI, suggesting microstructural alterations in the vitreous.[16] Most previous investigations have relied on OCT, which, although highly useful for retinal evaluation, does not provide quantitative data on the vitreous.[17,18] The high

resolution, wide coverage, and accessibility of CT may support its role as an adjunct tool in evaluating the ocular manifestations of systemic diseases such as diabetes.

In addition to the observed increase in vitreous humor density in patients with diabetic retinopathy, the potential influence of retinal hemorrhages warrants consideration. Retinal hemorrhages—frequently seen in more advanced stages of diabetic retinopathy—may lead to the diffusion of blood components into the vitreous cavity, even in the absence of clinically apparent vitreous hemorrhage. Although small or localized hemorrhages may not be directly visible on CT, the presence of hemoglobin breakdown products, hemosiderin, or elevated protein content may increase vitreous attenuation on imaging.[19] Thus, subclinical retinal hemorrhages or microvascular leakage may have contributed to the slightly higher HU values observed in the diabetic retinopathy group in our study. Future research incorporating multimodal ophthalmic imaging—such as fundus photography or OCT—along with CT, could provide a more comprehensive assessment of this association.

It is also plausible that vitreous hyperdensity correlates with DR severity, glycemic control, or disease duration. Unfortunately, due to the retrospective design and the absence of clinical data such as HbA1c levels or DR staging, these associations could not be assessed in our study. Future prospective studies including clinical parameters are warranted to better understand the diagnostic and prognostic value of CT-based vitreous assessment.

The potential utility of CT may be particularly relevant in emergency settings or underserved regions where ophthalmic imaging modalities such as OCT or fundus photography are unavailable. Incidental detection of vitreous changes on cranial CT performed for unrelated indications may offer additional clinical value, especially for the early recognition of diabetic ocular involvement.

In conclusion, our findings highlight a novel application of CT in detecting diabetes-related changes in the vitreous humor and encourage further research into its potential role in the screening, monitoring, and pathophysiologic understanding of diabetic retinopathy.

This study has several limitations. First, the observational and cross-sectional design of the study limits the ability to infer causality. Second, the use of ionizing radiation associated with CT limits its applicability in routine or repeated ophthalmologic evaluations, especially in diabetic populations. Third, the lack of clinical parameters such as HbA1c, diabetes duration, and DR staging precluded further correlation analyses. Additionally, the lack of correlation with functional ophthalmologic data—such as visual acuity, contrast sensitivity, or electrophysiological assessments—represents a limitation, as it restricts the clinical interpretation of the observed vitreous density changes.Moreover, although the differences in vitreous HU values between groups were statistically significant, the absolute differences were relatively small, which may limit their practical clinical significance. Finally, the absence of direct comparison with other imaging modalities (e.g., OCT or MRI) restricts the broader applicability of our findings. Future prospective studies with larger and more diverse populations and multimodal imaging approaches are essential to validate and extend these preliminary observations.

CONCLUSION AND RECOMMENDATIONS

This study revealed a significant increase in vitreous humor density in both eyes of patients with diabetic retinopathy (DR) compared to non-diabetic controls, as measured by cranial CT. These findings suggest that diabetic retinopathy may be associated not only with retinal changes but also with measurable alterations in the

vitreous body, potentially due to inflammatory and biochemical processes triggered by chronic hyperglycemia. Although CT is not traditionally used for ophthalmologic evaluation, its ability to detect subtle changes in vitreous density may offer additional diagnostic value, particularly when other imaging modalities such as OCT are not available or applicable.

Given the retrospective design and limited clinical data in this study, further prospective studies are recommended to validate these findings and to investigate the relationship between vitreous density and clinical parameters such as HbA1c levels, diabetes duration, and DR severity. Moreover, comparative studies with other imaging techniques would help clarify the specific role of CT in detecting diabetic ocular involvement. The incidental evaluation of vitreous density in head CTs performed for unrelated reasons may offer a valuable opportunity for early detection of diabetic eye changes, especially in settings where access to ophthalmic imaging is limited. Standardization of CT protocols for vitreous assessment and integration with clinical practice could support its use as a supplementary imaging tool in diabetic retinopathy.

REFERENCES

1. Scanlon PH, Aldington SJ, Stratton IM. Epidemiological issues in diabetic retinopathy. Middle East Afr J Ophthalmol. 2013;20(4):293-300.

2. Yau JW, Rogers SL, Kawasaki R, Lamoureux EL, Kowalski JW, Bek T, et al; Meta-Analysis for Eye Disease (META-EYE) Study Group. Global prevalence and major risk factors of diabetic retinopathy. Diabetes Care. 2012;35(3):556-64.

3. Simó R, Hernández C. Advances in the medical treatment of diabetic retinopathy. *Diabetes Care*. 2009;32(8):1556-62.

4. Sultan H, Rajagopal R, Rao PK, Piggott KD, Paley MA, Hassman LM, et al. Vitreous microparticles contain apoptotic signals suggesting a diabetic vitreopathy. Int J Ophthalmol. 2022;15(1):89-97.

5. Spitzer MS, Januschowski K. Gesunder Glaskörper und seine Alterung [Aging and age-related changes of the vitreous body]. Ophthalmologe. 2015;112(7):552, 554-8.

6. Uji A, Murakami T, Nishijima K, Akagi T, Horii T, Arakawa N, et al. Association between hyperreflective foci in the outer retina, status of photoreceptor layer, and visual acuity in diabetic macular edema. Am J Ophthalmol. 2012;153(4):710-717.

7. Naik MN, Tourani KL, Sekhar GC, Honavar SG. Interpretation of computed tomography imaging of the eye and orbit. A systematic approach. Indian J Ophthalmol. 2002;50(4):339-53.

8. Alvarez OP, Galor A, AlBayyat G, Karp CL. Update on imaging modalities for ocular surface pathologies. Curr Ophthalmol Rep. 2021;9(2):39-47.

9. Zhang J, Zhang J, Zhang C, Zhang J, Gu L, Luo D, et al. Diabetic Macular Edema: Current Understanding, Molecular Mechanisms and Therapeutic Implications. Cells. 2022;11(21):3362.

10. Koleva-Georgieva DN, Sivkova NP, Terzieva D. Serum inflammatory cytokines IL-1beta, IL-6, TNF-alpha and VEGF have influence on the development of diabetic retinopathy. Folia Med (Plovdiv). 2011;53(2):44-50.

11. Doganay S, Evereklioglu C, Er H, Türköz Y, Sevinç A, Mehmet N, Savli H. Comparison of serum NO, TNF-alpha, IL-1beta, sIL-2R, IL-6 and IL-8 levels with grades of retinopathy in patients with diabetes mellitus. Eye (Lond). 2002;16(2):163-70.

12. Iyer SSR, Lagrew MK, Tillit SM, Roohipourmoallai R, Korntner S. The Vitreous Ecosystem in Diabetic Retinopathy: Insight into the Patho-Mechanisms of Disease. Int J Mol Sci. 2021;22(13):7142.

13. Luccas R, Riguetto CM, Alves M, Zantut-Wittmann DE, Reis F. Computed tomography and magnetic resonance imaging approaches to Graves' ophthalmopathy: a narrative review. Front Endocrinol (Lausanne). 2024;14:1277961.

14. Pinto A, Brunese L, Daniele S, Faggian A, Guarnieri G, Muto M, Romano L.Role of computed tomography in the assessment of intraorbital foreign bodies. Semin Ultrasound CT MR. 2012;33(5):392-5.

15. Meltzer DE. Orbital imaging: a pattern-based approach. Radiol Clin North Am. 2015;53(1):37-80.

16. Ünlü S, Ilgar M. Diffusion MRI Evaluation of Vitreous Humor Changes in Diabetic Retinopathy Patients. Med Records. 2022;4(2):187-90.

17. Nesper PL, Soetikno BT, Zhang HF, Fawzi AA. OCT angiography and visible-light OCT in diabetic retinopathy. Vision Res. 2017;139:191-203.

18. Crincoli E, Sacconi R, Querques L, Querques G. OCT angiography 2023 update: focus on diabetic retinopathy. Acta Diabetol. 2024;61(5):533-541.

19. Nentwich MM, Ulbig MW. Diabetic retinopathy - ocular complications of diabetes mellitus. World J Diabetes. 2015 Apr 15;6(3):489-99.