Clinical Interventions in Aging

Dovepress

open access to scientific and medical research

Open Access Full Text Article

ORIGINAL RESEARCH

An Analysis of Optic Disc Parameters in Patients with Peripheral Retinal Tears Following Acute Posterior Vitreous Detachment: A Cross-Sectional Study

Darko Batistic[1], Ante Kreso[1], Josip Vrdoljak[2], Jaksa Batistic[3], Ivan Paladin[4], Ivan Mizdrak[4], Sandro Glumac[5]

[1]Department of Ophthalmology, University Hospital of Split, Split, Croatia; [2]Department of Pathophysiology, School of Medicine, University of Split, Split, Croatia; [3]Department of Urology, University Hospital of Split, Split, Croatia; [4]Department of Otorhinolaryngology, Head and Neck Surgery, University Hospital of Split, Split, Croatia; [5]Department of Anesthesiology and Intensive Care, University Hospital of Split, Split, Croatia

Correspondence: Sandro Glumac, Department of Anesthesiology and Intensive Care, University Hospital of Split, Spinciceva 1, Split, 21000, Croatia, Tel +385 21556176, Fax +385 21556580, Email sandro.glumac@gmail.com

Background: To investigate association between optic disc parameters analyzed by optical coherence tomography (OCT) and occurrence of peripheral retinal tears in patients with symptomatic posterior vitreous detachment (PVD).

Methods: This cross-sectional study enrolled 75 patients with symptoms of acute PVD, who were allocated into two groups based on whether a peripheral retinal tear occurred or not.

Results: When comparing the average retinal nerve fiber layer (RNFL) thickness (μm) between retinal tear and control groups, it was shown that patients with a retinal tear have a significantly higher (87.18 [95% confidence interval (CI), 84.47 to 89.9] vs 81.14 [95% CI, 77.81 to 84.46], $P = 0.005$) average RNFL thickness. Furthermore, we observed a significant difference (0.13, 0.06 to 0.22 vs 0.07, 0.04 to 0.1, $P = 0.036$, Mann–Whitney U-test) in the size of cup volume (mm^3) between the tear and control groups, respectively. Linear regression showed a significant decrease ($P = 0.029$) in average RNFL thickness with increasing age, but without a significant difference between the two groups. There was no statistically significant difference between the tear and control groups in terms of rim area, disc area, and average cup-to-disc ratio.

Conclusion: Patients with a higher average RNFL thickness and larger cup volume measured by OCT were more prone to develop a peripheral retinal tear. Increased peripapillary average RNFL thickness due to trauma and subsequent inflammation, possibly related to the more adherent posterior hyaloid membrane to the retina, may also indicate strengthened adhesions in the areas of the peripheral retina where retinal tears occur. OCT analysis of the optic nerve head may be used in everyday clinical practice as a predictor of the development of peripheral retinal tears in patients with symptomatic PVD.

Keywords: retina, retinal perforations, vitreous detachment, optic disk, optic nerve, axial length, EYE, posterior eye segment, tomography, optical coherence, aging

Introduction

The vitreous body is the gel-like structure in the human eye. It is composed of transparent connective tissue that fills the vitreous cavity, occupying more than 75% of the total ocular volume.[1] The adhesion of the vitreous body to the retina is strongest around the base of the vitreous body, at the optic disc, in the macular area, and at the large retinal blood vessels.[2]

Posterior vitreous detachment (PVD) is a separation of the vitreous body from the inner retinal layers as a result of vitreous degeneration and collapse. This aging-related state has a prevalence of 24% in the population aged between 50 and 59 years, and up to 87% in those aged between 80 and 89 years.[3]

Received: 29 February 2024
Accepted: 25 June 2024
Published: 27 June 2024

Patients with symptomatic PVD frequently present with symptoms of visual disturbances, such as floaters and/or flashes of light in their visual field.[4,5] In some patients, PVD leads to retinal damage through traction on abnormal vitreoretinal adhesion with retinal tears, which may eventually induce retinal detachment if collapse occurs.[6,7] Furthermore, a recent study showed that patients with symptomatic PVD, confirmed by fundoscopic examination, have a 14% incidence rate of retinal tears as a complication.[8]

Optical coherence tomography (OCT) is a non-invasive imaging technique commonly used to analyze the optic nerve head and peripapillary retinal nerve fiber layer (RNFL) thickness.[9,10]

While aging is a degenerative process typically associated with retinal thinning, as confirmed by several studies,[11,12] because of the more adherent hyaloid in the case of PVD with a developed peripheral retinal tear compared to PVD without a peripheral retinal tear, mechanical trauma that occurs during the separation of the posterior hyaloid membrane triggers a more severe inflammatory response that may lead to at least temporary peripapillary retinal thickening.

The aim of the current study was to determine if there is a relationship between the optic disc configuration and peripapillary RNFL thickness and the occurrence of peripheral retinal tears in patients with symptomatic PVD. We hypothesized that patients with a peripheral retinal tear have a more pronounced inflammatory response, which results in different OCT optic disc parameters compared to patients without a retinal tear.

Patients and Methods

Study Design and Participants

The current cross-sectional study was performed at the University Hospital of Split, Croatia, between August 2022 and March 2023. This paper adheres to the applicable STROBE guidelines and was conducted in accordance with the principles of the Declaration of Helsinki. Ethical approval for this study (Ethical Committee No. 2181–147/01/06/LJ.Z.-23-02) was provided by the Ethical Committee of the University Hospital of Split (Chairperson Prof Lj. Znaor) on 21 July 2022. All patients provided written informed consent.

The study enrolled 75 phakic patients aged between 48 and 87 years who were admitted to the ophthalmic emergency department with symptoms of acute PVD. The diagnosis of acute PVD and peripheral retinal tear was fundoscopically confirmed by non-contact indirect fundoscopy lens after pupil dilatation with tropicamide eye drops, by DB and AK (Figure 1). The axial length was measured by an optical biometer (Al-Scan, NIDEK Co., Ltd., Gamagori, Aichi, Japan) and the optic nerve configuration was analyzed by OCT (Zeiss Cirrus HD-OCT 400, Carl Zeiss Meditec Inc., Jena, Germany) (Figure 2), by AK and evaluated by DB and AK.

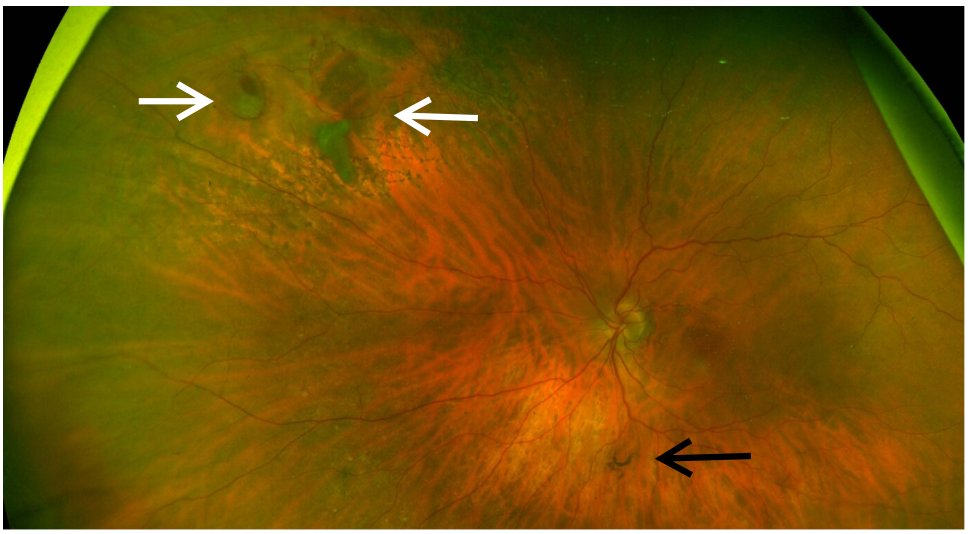

Figure 1 Wide-field fundus photography. Peripheral retinal tear (white arrows), Weiss ring - sign of PVD (black arrow).

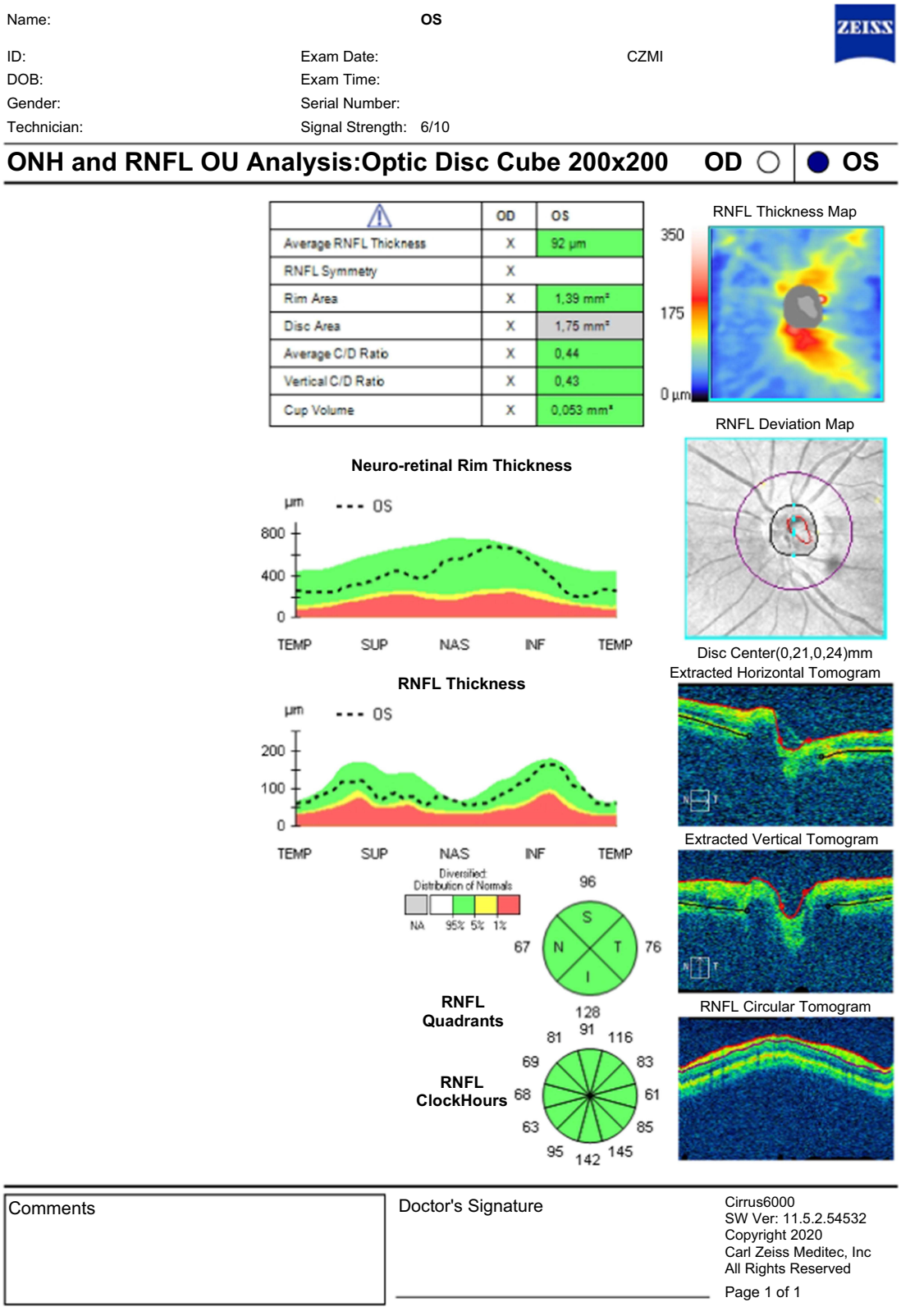

Figure 2 OCT sample.

The patients were separated into two groups, depending on whether a peripheral retinal tear was visualized by fundoscopic examination or not. Acute PVD was accompanied by a peripheral retinal tear in 38 patients, whereas in 37 patients, complete PVD developed without a peripheral retinal tear (control group of this study).

Patients who had prior cataract surgery, glaucoma, diabetes mellitus, optic neuropathies, and malignant peripheral retinal degenerations were excluded from the study. Malignant peripheral retinal degenerations were defined as peripheral retinal areas with a stronger adherence between the hyaloid membrane and the retina (ie, lattice degeneration), given that such areas are more prone to the development of retinal tears during PVD.

After completing the necessary measurements for the study, patients with peripheral retinal tears were treated with argon laser photocoagulation, while patients in the control group were scheduled for a follow-up examination in two weeks unless new visual symptoms occurred.

Statistical Analysis

Data analysis was performed using MedCalc, version 20.211 (MedCalc Software Ltd, Ostend, Belgium). The Kolmogorov–Smirnov test was applied to test if variables are normally distributed. Continuous variables are expressed as the means ± SD or medians and interquartile range (IQR), and independent-samples *t*-test or Mann–Whitney *U*-test were used to evaluate statistical significance. Linear regression was used to test the association between variables. Statistical significance was set at two-sided $P < 0.05$.

The required sample size for comparison of means: if type I error (α) was set to 0.05, type II error (β) to 0.2 (comparison of means), and power to 80%, was 64 patients (32 + 32). When considering an estimated attrition rate of less than 10%, the final sample size was increased to a total of 75 patients. MedCalc, version 20.211 was used to calculate the required sample size.

Results

Study Population

Between August 2022 and March 2023, 91 patients consulted the emergency department of the ophthalmological clinic due to PVD-related symptoms. Sixteen patients were excluded from the study due to insufficient data or poor signal strength on examination scans. Ultimately, we analyzed the data on 75 patients. The baseline demographic and clinical characteristics of the patients are presented in Table 1.

OCT Analysis

The analysis of optic nerve head and peripapillary RNFL thickness in the patients was performed using OCT.

When comparing the axial length (mm) between the tear and control groups, a significant difference was observed between the groups (IQR, 23.83 to 24.47 vs 23.27 to 23.98, $P = 0.029$, Mann–Whitney *U*-test) (Figure 3).

The linear regression showed that younger patients had a significantly ($P < 0.001$) longer axial length in comparison with older patients (Figure 4).

Table 1 Demographic and Clinical Characteristics

	Tear Group, n = 38	Control Group, n = 37	*P* value
Age (year)	65.39 (62.94 to 67.85)	68.97 (66.6 to 71.35)	0.037
Male sex	20 (52.7)	11 (29.8)	0.044
Axial length (mm)	24.15 [23.83 to 24.47]	23.62 [23.27 to 23.98]	0.029
Avg. RNFL thickness (µm)	87.18 (84.47 to 89.9)	81.14 (77.81 to 84.46)	0.005
Rim area (mm^2)	1.33 [1.28 to 1.49]	1.34 [1.27 to 1.62]	0.442
Disc area (mm^2)	1.88 [1.79 to 2.04]	1.92 [1.78 to 1.99]	0.970
Cup volume (mm^3)	0.13 [0.06 to 0.22]	0.07 [0.04 to 0.1]	0.036
Avg. CDR	0.5 (0.46 to 0.55)	0.46 (0.4 to 0.52)	0.218

Notes: Data are presented as number (%), mean ± SD, and median (IQR) as appropriate.
Abbreviations: RNFL, retinal nerve fiber layer; Avg. CDR, average cup-to-disc ratio.

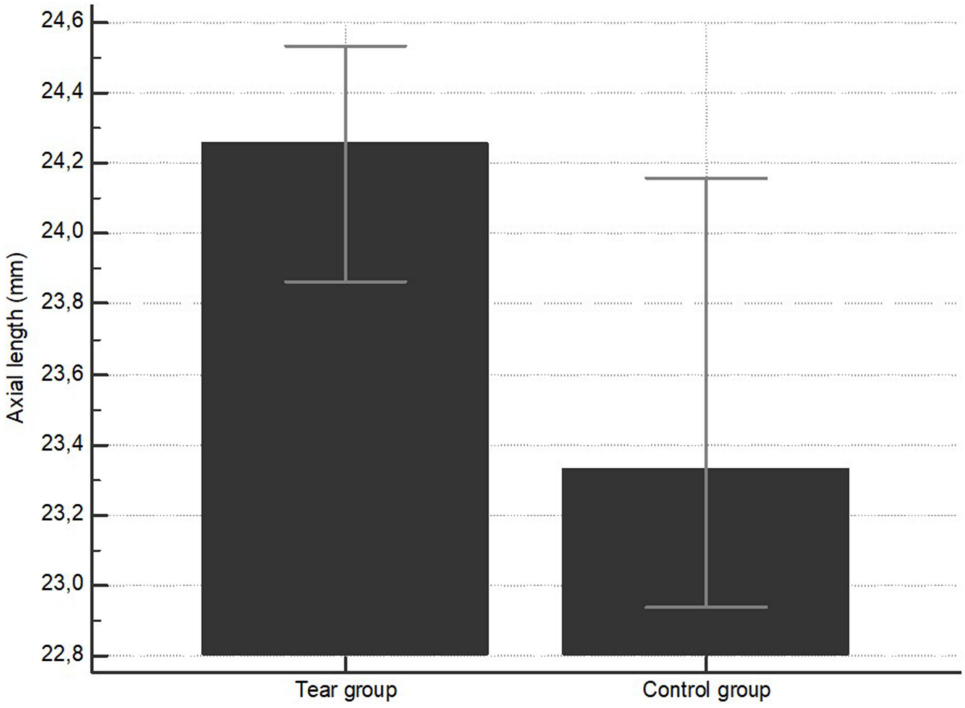

Figure 3 Comparison of axial length and between groups.

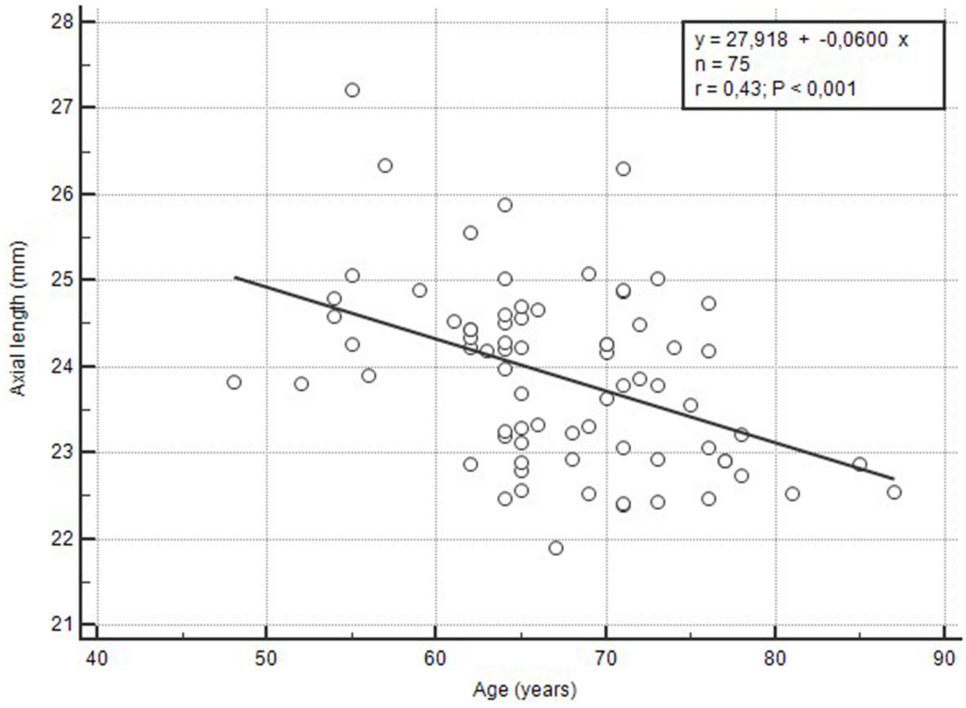

Figure 4 Relationship between axial length and age; a linear regression.

Furthermore, when comparing the average RNFL thickness (μm) between the tear and control groups, patients with retinal tears had a significantly greater average RNFL thickness (87.18 [95% confidence interval (CI), 84.47 to 89.9] vs 81.14 [95% CI, 77.81 to 84.46], $P = 0.005$) (Figure 5).

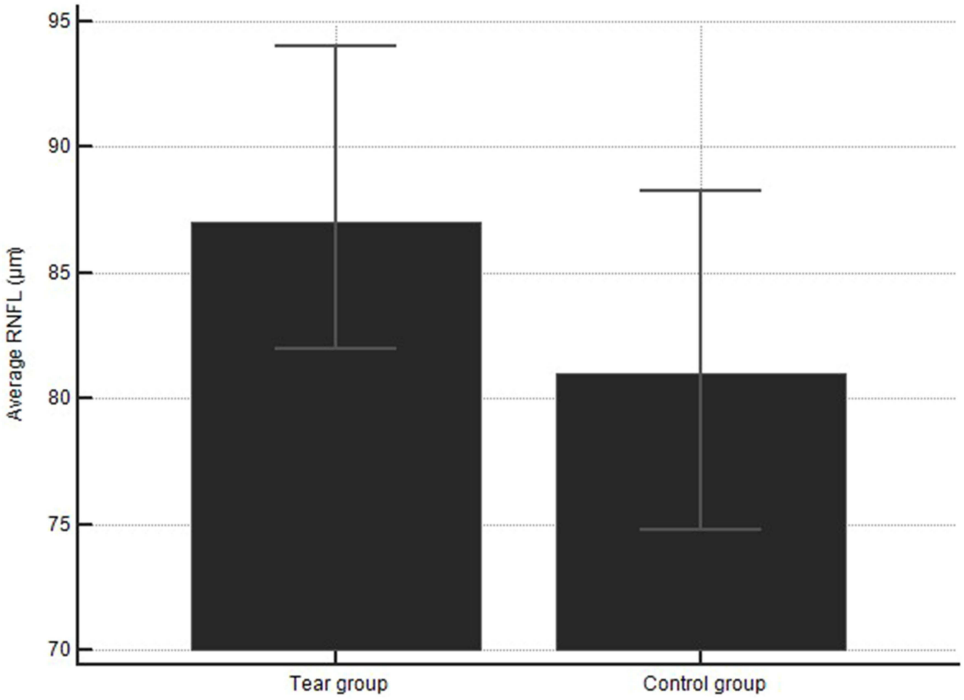

Figure 5 Comparison of RNFL thickness between groups.

Average RNFL thickness showed a significant decrease in linear regression analysis ($P = 0.029$) with increasing age; however, there was no significant difference in decreasing linear regression with age between the tear and control groups (Figure 6).

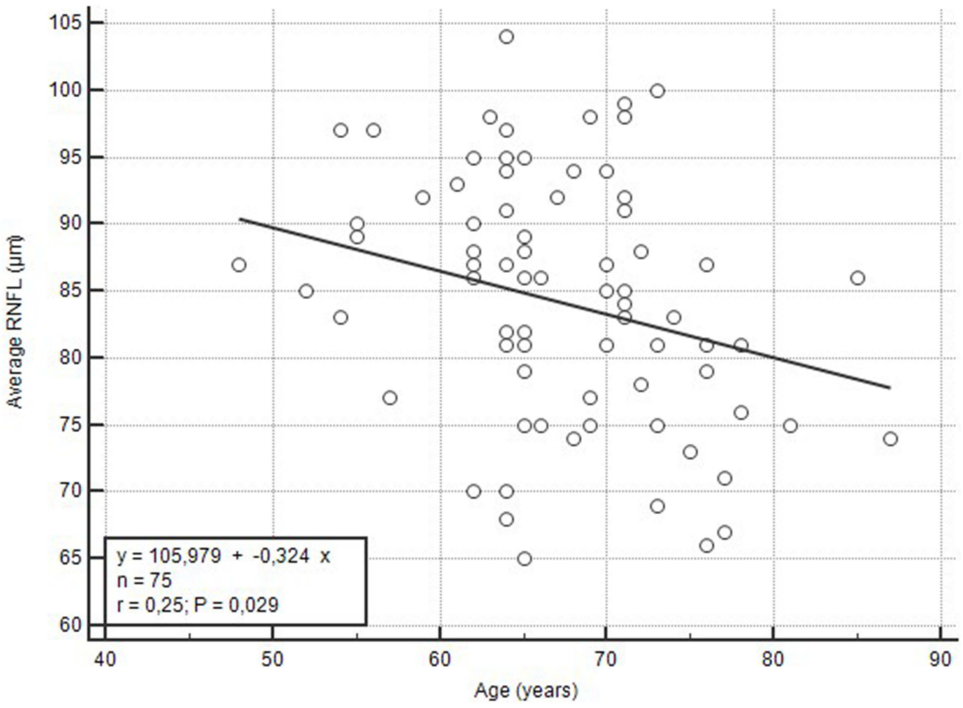

Figure 6 Relationship between RNFL thickness and age; a linear regression.

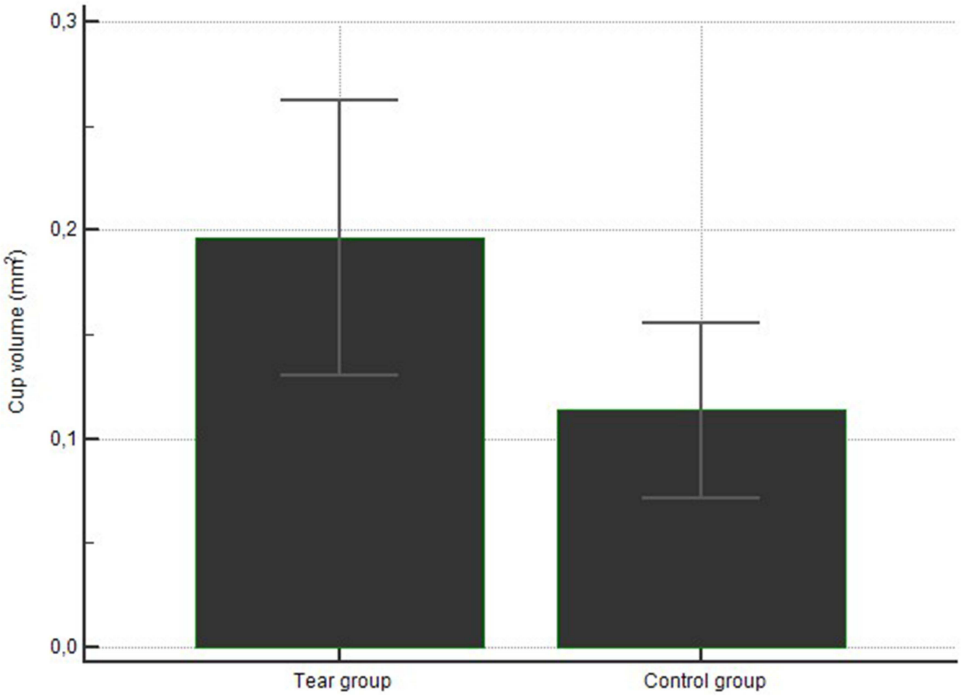

Figure 7 Comparison of cup volume between groups.

The size of cup volume (mm^3) was significantly different between the two groups (IQR, 0.06 to 0.22 vs 0.04 to 0.1, $P = 0.036$, Mann–Whitney U-test), as is shown in Figure 7.

Finally, there was no statistically significant difference between the tear and control groups when comparing rim area, disc area or cup-to-disc ratio parameters.

The distribution of retinal tears per quadrant is presented in Table 2.

Discussion

The current cross-sectional study of 75 patients found that the presence of a retinal tear following acute PVD was significantly related to a greater average RNFL thickness, as measured by OCT. In addition, it has been shown that patients with a retinal tear following acute PVD have a significantly larger cup volume in comparison to patients without a retinal tear. To our knowledge, this is the first study to assess the impact of optic disc configuration and peripapillary RNFL thickness on the occurrence of peripheral retinal tears in patients with symptomatic PVD.

It is well known that the force of adhesion of the vitreous body to the retina varies, with the greatest tension around the base of the vitreous body, at the optic disc, at the macular area and at large retinal blood vessels.[2] We speculated that the distribution of forces on the peripheral vitreoretinal interface depends on the velocity of the vitreous detachment from structures where its adhesion is strongest. Furthermore, we presumed that this velocity may vary due to different clinical

Table 2 Distribution of Retinal Tears per Quadrant

Quadrant	Total Number	Percentage
Upper temporal	27	71.1
Upper nasal	5	13.2
Lower temporal	4	10.5
Lower nasal	2	5.3

parameters that affect the optic disc configuration, becoming a risk-related factor for developing peripheral retinal tear during acute PVD.

The results showed that patients with retinal tears had a significantly greater average RNFL thickness in comparison to patients without retinal tears. Since PVD is a gradual process that can take substantial time to fully develop,[13] the changes in RNFL thickness also occur gradually over time.[11,12] Our presumption is that the changes present in the RNFL layer of the peripapillary zone that occur due to the spontaneous separation of the hyaloid membrane during PVD are equivalent to those that occur due to the surgically induced separation of the preretinal tissue in the form of the epimacular membrane from the internal limiting membrane (ILM), as observed in numerous studies evaluating retinal thickness after epiretinal membrane (ERM)/ILM peeling.[14–17] This is also a form of trauma that leads to inflammation and consequent thickening of the neurosensory retina in the same zone. Furthermore, we believe that a strengthened connection between the hyaloid membrane, as in the peripapillary zone, also exists in certain places on the retinal periphery and these same places are the zones where the retina opens, ie, the formation of retinal rupture.[13] The proportion of thickening may depend on the intensity of the mechanical and inflammatory processes during the early phases of posterior hyaloid separation. However, electron microscopy evaluation is mandatory to prove this thesis.

Although our study did not provide an exact explanation considering the design of the study, we showed that larger cup volume is significantly associated with an increased risk of a peripheral retinal tear in the scenario of acute PVD.

The axial length in patients with tears was significantly longer compared to controls. Axial myopia is broadly recognized as a significant risk factor for developing a retinal tear and is one of the most important features in the BRET score.[18,19] As seen in previous studies, we revealed a significant difference in age between the control and tear groups, with the tear group being statistically significantly younger.[20,21] Next, the distribution of retinal tears by quadrant shows that the superotemporal quadrant was affected most frequently (71.1%), followed by superonasal (13.2%), inferotemporal (10.5%) and inferonasal (5.3%) quadrants. Two previous studies found a similar distribution of peripheral retinal tears in retinal detachment in terms of a solitary tear, ie, it was most likely to present in the superotemporal quadrant (55%) and least likely in the inferonasal quadrant (6%).[22,23] Finally, our study supports the findings of Ramyashri et al, who showed a statistically significant decrease in average RNFL thickness in patients with increasing age.[24,25]

This study, which utilizes a cross-sectional design with a sample of 75 patients, has limited ability to provide close insights about the pathophysiological nature of the increased incidence of peripheral retinal tears in patients with a greater average RNFL thickness and larger cup volume, as measured by OCT, and may not be generalizable to the broader population due to potential selection bias and specific exclusions, resulting in a relatively healthy subset of patients, while the lack of long-term follow-up complicates the observation of changes over time. The wide age range of patients introduces additional variability in the results, and the use of specific measurement equipment may affect the reproducibility of findings in different settings.

Conclusion

Increased peripapillary average RNFL thickness in the case of PVD with peripheral retinal tears due to trauma and subsequent inflammation, possibly related to the more adherent posterior hyaloid membrane to the retina, may also indicate strengthened adhesions in the areas of the peripheral retina where retinal tears occur. This cross-sectional study showed that the optic disc configuration analyzed by OCT may be a valid prognostic tool to assess the risk for the development of peripheral retinal tears following acute PVD. However, further investigation into the underlying mechanisms of this complication is necessary to enhance our understanding and improve clinical outcomes.

Data Sharing Statement

The datasets used and analyzed during the current study are available from the corresponding author on reasonable request.

Ethics Statement

Ethical approval for this study (Ethical Committee No. 2181-147/01/06/LJ.Z.-23-02) was provided by the ethical committee of the University Hospital of Split (Chairperson Prof Lj. Znaor) on 21 July 2022. It was conducted in accordance with the principles of the Declaration of Helsinki.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

Disclosure

The authors report no conflicts of interest in this work.

References

1. Ankamah E, Sebag J, Ng E, Nolan JM. Vitreous antioxidants, degeneration, and vitreo-retinopathy: exploring the links. *Antioxid Basel Switz*. 2019;9(1):7. doi:10.3390/antiox9010007
2. Elmali A, Koc I, Ciftci SY, et al. Radiotherapy-induced alterations in vitreous humor: a new potential critical structure. *Exp Eye Res*. 2021;212:108802. doi:10.1016/j.exer.2021.108802
3. Thimons JJ. Posterior vitreous detachment. *Optom Clin*. 1992;2(3):1–24.
4. Hikichi T, Hirokawa H, Kado M, et al. Comparison of the prevalence of posterior vitreous detachment in whites and Japanese. *Ophthalmic Surg*. 1995;26(1):39–43.
5. Gishti O, van den Nieuwenhof R, Verhoekx J, van Overdam K. Symptoms related to posterior vitreous detachment and the risk of developing retinal tears: a systematic review. *Acta Ophthalmol*. 2019;97(4):347–352. doi:10.1111/aos.14012
6. Johnson MW. Posterior vitreous detachment: evolution and complications of its early stages. *Am J Ophthalmol*. 2010;149(3):371–382.e1. doi:10.1016/j.ajo.2009.11.022
7. Richardson PS, Benson MT, Kirkby GR. The posterior vitreous detachment clinic: do new retinal breaks develop in the six weeks following an isolated symptomatic posterior vitreous detachment? *Eye Lond Engl*. 1999;13(Pt 2):237–240.
8. Seider MI, Conell C, Melles RB. Complications of acute posterior vitreous detachment. *Ophthalmology*. 2022;129(1):67–72. doi:10.1016/j.ophtha.2021.07.020
9. Lamirel C, Newman NJ, Biousse V. Optical coherence tomography (OCT) in optic neuritis and multiple sclerosis. *Rev Neurol*. 2010;166(12):978–986. doi:10.1016/j.neurol.2010.03.024
10. Minakaran N, de Carvalho ER, Petzold A, Wong SH. Optical coherence tomography (OCT) in neuro-ophthalmology. *Eye Lond Engl*. 2021;35(1):17–32.
11. Hondur G, Göktaş E, Al-Aswad L, Tezel G. Age-related changes in the peripheral retinal nerve fiber layer thickness. *Clin Ophthalmol Auckl NZ*. 2018;12:401–409. doi:10.2147/OPTH.S157429
12. Trinh M, Khou V, Zangerl B, Kalloniatis M, Nivison-Smith L. Modelling normal age-related changes in individual retinal layers using location-specific OCT analysis. *Sci Rep*. 2021;11(1):558. doi:10.1038/s41598-020-79424-6
13. Koller EC, Kraker JA, Hwang ES. Progression of partial posterior vitreous detachment over time. *Retina*. 2021;41(7):1396–1402. doi:10.1097/IAE.0000000000003039
14. Lee SB, Shin YI, Jo YJ, Kim JY. Longitudinal changes in retinal nerve fiber layer thickness after vitrectomy for epiretinal membrane. *Invest Ophthalmol Vis Sci*. 2014;55(10):6607–6611. doi:10.1167/iovs.14-14196
15. Bae KW, Kim DI, Hwang DDJ. Long-term changes in retinal nerve fiber layer thickness after vitrectomy for epiretinal membrane using optical coherence tomography images. *Life*. 2023;13(9):1804. doi:10.3390/life13091804
16. Kumagai K, Hangai M, Larson E, Ogino N. Progressive changes of regional macular thickness after macular hole surgery with internal limiting membrane peeling. *Invest Ophthalmol Vis Sci*. 2013;54(7):4491–4497. doi:10.1167/iovs.13-11662
17. Romano V, Angi M, Scotti F, et al. Inflammation and macular oedema after pars plana vitrectomy. *Mediators Inflamm*. 2013;2013:971758. doi:10.1155/2013/971758
18. McCullagh D, Higham A, Best R. The BElfast retinal tear and detachment score (BERT Score). *Eye Lond Engl*. 2021;35(5):1427–1430.
19. Hanyuda A, Torii H, Hayashi K, et al. Relationship of choroidal thickness and axial length with posterior vitreous detachment in patients with high myopia. *Sci Rep*. 2022;12(1):4093. doi:10.1038/s41598-022-08101-7
20. Bond-Taylor M, Jakobsson G, Zetterberg M. Posterior vitreous detachment - prevalence of and risk factors for retinal tears. *Clin Ophthalmol Auckl NZ*. 2017;11:1689–1695. doi:10.2147/OPTH.S143898
21. Driban M, Chhablani J. Clinical findings in acute posterior vitreous detachment. *Graefes Arch Clin Exp Ophthalmol Albrecht Von Graefes Arch Klin Exp Ophthalmol*. 2022;260(11):3465–3469. doi:10.1007/s00417-022-05708-4
22. Shunmugam M, Shah AN, Hysi PG, Williamson TH. The pattern and distribution of retinal breaks in eyes with rhegmatogenous retinal detachment. *Am J Ophthalmol*. 2014;157(1):221–226.e1. doi:10.1016/j.ajo.2013.09.011
23. Abdolrahimzadeh S, Piraino DC, Scavella V, et al. Spectral domain optical coherence tomography and B-scan ultrasonography in the evaluation of retinal tears in acute, incomplete posterior vitreous detachment. *BMC Ophthalmol*. 2016;16(1):60. doi:10.1186/s12886-016-0242-0
24. Won JY, Kim SE, Park YH. Effect of age and sex on retinal layer thickness and volume in normal eyes. *Medicine*. 2016;95(46):e5441. doi:10.1097/MD.0000000000005441
25. Ramyashri S, Rao HL, Jonnadula GB, et al. Determinants of optical coherence tomography parameters in a population-based study. *Am J Ophthalmol*. 2021;224:163–171. doi:10.1016/j.ajo.2020.11.015