



DOI: 10.14744/eer.2023.95967
Eur Eye Res 2023;3(3):139–144

EUROPEAN
EYE
RESEARCH

REVIEW

Optical coherence tomography angiography in myopic macular neovascularization

Selcuk Sizmaz,¹ Ebru Esen,² Puren Isik,² Nihal Demircan²

¹Department of Optometry, Acibadem University, Istanbul, Türkiye

²Department of Ophthalmology, Cukurova University, Adana, Türkiye

Abstract

Pathologic myopia is a severe sight-threatening disorder complicated with the presence of posterior staphyloma, myopic maculopathy, or vitreomacular interface pathologies. Myopic maculopathy is the most common cause of macular neovascularization (MNV) following age-related macular degeneration in the whole population. It is the most common cause of MNV in the presenile population. The diagnosis of MNV should be based on multimodal imaging. On the other hand, optical coherence tomography angiography (OCTA) is gaining popularity in the clinical course of patients with MNV. Its main advantage over dye angiography is the non-invasive nature. OCTA can show myopic MNV with very high sensitivity and specificity. It helps detecting the MNV under retinal hemorrhage. Since the image is not obscured by leakage, the neovascular tissue is depicted briefly with OCTA. According to the appearance, two types of myopic MNV have been described; one has a more regular structure with dense vascular hyperintensity and the other has a loose and disorganized appearance. More research is required to detect a clinical basis for these two types. Another advantage of OCTA is the ability of evaluating choriocapillaris which is supposedly takes part in the pathogenesis of myopic MNV and yet providing quantitative data on flow parameters.

Keywords: Myopic macular neovascularization; optical coherence tomography angiography; pathologic myopia; posterior staphyloma.

Myopia is becoming a major concern with the changing lifestyle trends. The estimated prevalence of myopia for 2050 is approximately 50% worldwide and nearly 10% of the world population is expected to have high myopia. The increasing prevalence is consequently associated with myopia-related visual loss, which is likely to cause a socioeconomic burden.^[1] The main vision-threatening complication of myopia is myopic maculopathy. Other potential causes of myopia-related blindness are cataract,

glaucoma, and retinal detachment.^[2,3] A study from Japan, revealed that 12.2% of visual impairment in the population was caused by myopic macular degeneration.^[4]

As studies with large cohorts are required, the particular prevalence of pathologic myopia – thus myopic maculopathy – is hard to estimate. Up to date, it is known to be more common in Eastern Asia.^[3] The prevalence of myopia is 2 times in Eastern Asia compared to white people of the same age group.^[5]



Cite this article as: Sizmaz S, Esen E, Isik P, Demircan N. Optical coherence tomography angiography in myopic macular neovascularization. Eur Eye Res 2023;3:139-144.

Correspondence: Selcuk Sizmaz, M.D. Department of Optometry, Acibadem University, Istanbul, Türkiye

Phone: +90 322 455 44 44 **E-mail:** selcuk.sizmaz@gmail.com

Submitted Date: 24.08.2023 **Revised Date:** 18.10.2023 **Accepted Date:** 03.11.2023

OPEN ACCESS This is an open access article under the CC BY-NC license (<http://creativecommons.org/licenses/by-nc/4.0/>).



When an eye has a refractive error of above six diopters or axial length of over 26 mm and the situation is complicated with posterior staphyloma or myopic maculopathy, pathologic myopia occurs. Myopic maculopathy comprises dome-shaped macula, tractional maculopathy, or myopic macular degeneration.^[6,7] Posterior staphyloma consequently increases the risk of myopic macular degeneration. Myopic macular degeneration includes diffuse or patchy macular atrophy with or without lacquer cracks (defects in Bruch's membrane) and macular neovascularization (MNV).^[8] Myopia is the most common cause of MNV in young adults. It is the second most common cause – following age-related macular degeneration – in the whole population.^[7,9]

According to the International Classification of Pathologic Myopia (META-PM) report, myopia-associated lesions are classified in five categories: No myopic retinal lesion (category 0), tessellated fundus only (category 1), diffuse chorioretinal atrophy (category 2), patchy chorioretinal atrophy (category 3), and macular atrophy (category 4). The additional “plus” signs are lacquer cracks, myopic MNV, and Fuchs' spot.^[10]

Greater axial length, older age, female sex, larger optic disk area, and family history were reported to be significant risk factors associated with pathologic myopia. For each increasing diopters of high myopia, the risk of developing pathologic myopia also increased.^[2] There is extreme thinning of the choroid.^[11] Furthermore, a genetic basis was investigated for pathologic myopia. Seven autosomal dominant loci on chromosomes 2, 4, 7, 12, 17, 18, and 21; 1 autosomal recessive locus on chromosome 14; 1 recessive locus on chromosome X were identified.^[12] One locus on chromosome 11 was reported in a Japanese cohort.^[13]

MYOPIC MNV

Myopic MNV lesion is usually small and generally classic lesion located in close proximity to fovea. It presents with visual loss, metamorphopsia, and central scotoma. Fundoscopy reveals a greyish subretinal membrane surrounded by a border of hyperpigmentation. Retinal hemorrhages might be present; however, lipid exudation does not exist.^[7]

The best corrected visual acuity in pathologic myopia is usually low due to the presence of posterior staphyloma. When a further sudden drop in vision occurs, MNV should be considered. The diagnosis of myopic MNV could be challenged with the presence of pigmentary changes, large choroidal vessels, lacquer cracks, chorioretinal atrophy, and scarring.^[9,14] There are three stages of the disease. In the active stage, there is retinal hemorrhage which could be complicated with serous retinal detachment. In the scar stage, fibrous scar develops; this – if becomes pigmented – is known as Fuchs' spot. The atrophic stage is characterized by formation of a hole in the Bruch's membrane. If left untreated or undertreated, myopic MNV results in scarring with subsequent chorioretinal atrophy.^[15]

Table 1 compares neovascularization in pathological myopia and age-related macular degeneration by means of clinical presentation.

Ancillary Testing in Myopic MNV

Fluorescein Angiography (FA)

Despite its invasive nature, FA provides precise data in the diagnosis of myopic choroidal neovascularization. Myopic MNV has a “classic” appearance on FA. At the early phase,

Table 1. The comparison clinical features of neovascularization in pathological myopia and age-related macular degeneration^[7]

		NV-PM	NV-AMD
Morphological features	Age	Younger	Older
	Gender	♀	♀
	Size	Small	Large
	Retinal hemorrhages	Scanty	Present
	Hard exudates	Often absent	Present
	Neurosensory detachment	Shallow and limited	Extensive
Fluorescent angiography	PED	Absent	Present
	Associated Lesion	Lacquer crack/patchy atrophy	Drusen/pigmentary changes
	Dye leakage	Predominantly classic	Occult/minimal classic
OCT	Location	Minimum	Profuse
	Sub/intra-retinal fluid	Type 2	Type 1
		Negligible	Massive

PM: Pathologic myopia

the lesion is hyperfluorescent with the filling of the neovascular membrane. Then, consequent leakage occurs. However, the leakage is not as remarkable as it is in age-related macular degeneration. Fibrovascular scars and pigmentation hyperfluorescent due to staining in the late phases of the angiogram.^[7] Fluorescein angiography is also useful to delineate simple retinal hemorrhage due to lacquer cracks from hemorrhage due to MNV. In case of bleeding due to MNV, there would be dye leakage in close proximity to the hypofluorescence of the hemorrhage.^[15]

Indocyanine Green Angiography

The role of indocyanine green angiography is limited in myopic MNV due to the lower activity. Nevertheless, as infrared light has deeper penetration, in case of hemorrhage, exudation, and high pigment density, it could be used as an adjunct to FA. Indocyanine green angiography also helps locating and demonstrating the extent of lacquer cracks and choroidal atrophy. These appear as hypocyanescent areas, which are associated with myopic MNV.^[7]

Optical Coherence Tomography

As stressed above, the vast majority of the neovascular lesions in pathologic myopia is classic; according to the optical coherence tomography (OCT) terminology: Type 2, above the RPE. In the active stage of MNV, there is a hyperreflective clumping above the RPE. At this stage, accumulation of fluid under the retina is minimal. At the scar phase, the lesion seems hyperreflective due to the accumulation of pigments with a shadowing affect beneath. When atrophy occurs, the lesion flattens and this time the hyperreflectivity results from the atrophic choroid. Due to the lack of normative data and possible image distortion, the central macular thickness measurements are not helpful with follow-up.^[7] On the other hand, OCT has utmost importance in the detection of other myopia-associated lesions like epiretinal membrane or retinoschisis.^[16]

Leveziel and coworkers reported that FA is superior to OCT in demonstrating the exudative features of myopic MNV. Thus, the authors suggested that FA is a must at the initial diagnosis of myopic MNV.^[17]

OCT Angiography (OCTA) in Myopic MNV

At present, with the advantage of the non-invasive nature, OCTA is gaining popularity in the diagnosis of retinal disorders with neovascularization. The major superiority of OCTA is that the image of the neovascular tissue can be captured without being obscured by leakage, which in this case becomes the shortcoming of FA. OCTA detected MNV in myopia with 97% sensitivity when FA was taken the stan-

dard tool.^[18] Since OCTA depicts the vessel depending on the blood flow signal in the vessel, it can demonstrate the MNV even in the scar and atrophic stages; where FA fails to show leakage.^[15,19]

The sensitivity and specificity of OCTA to detect myopic MNV were found to be 94.1% and 100%, respectively. The area of neovascularization did not significantly differ between OCTA and FA.^[20] Chhablani et al., reported in myopic MNV for FA and OCTA the sensitivity to be 47% and 58.8%, respectively, and the specificity 80.4% and 86.9%, respectively.^[14] In a study suggesting multimodal imaging for myopic MNV, the sensitivity of FA, OCT, and OCTA to depict active neovascularization was 85.2%, 85.2%, and 74.1%, respectively. The authors concerned that this diminished sensitivity was the result of small lesions with low flow and lesions with subretinal blood in their cohort.^[21]

Bruyere et al. reported the sensitivity of OCTA to detect myopic MNV to be 90%. They used manual segmentation for the best detection of the neovascular lesion, which was located between the Bruch's membrane and 30 μ underneath. The size of the neovascular tissue was comparable between OCTA and FA. The authors defined two forms of myopic MNV lesions: Well-organized, larger, "interlacing" and disorganized, small, and "vascular loop" patterns.^[9]

On the other hand, Querques et al. described the two patterns of MNV in pathologic myopia as "interlacing" and "tangled" by OCTA. The former one is a well-circumsized and dense vascular hyperintensity; whereas, the latter one has a loosely laced appearance. The authors report that while interlacing pattern is also in association with the images by FA and OCT, the tangled pattern is not associated with a neovascularization pattern in conventional techniques.^[22]

Based on the abovementioned characteristics, Querques et al. reported that 81.8% of active MNVs were interlacing; whereas, 66.7% of inactive lesions were tangled in OCTA. There was a significant correlation between activity of the lesion and the interlacing appearance. Furthermore, OCTA was useful to depict the absence of neovascularization when FA and OCT revealed no evidence of MNV. For OCTA in myopic MNV, a sensitivity of 90.5% and a specificity of 93.8% were reported.^[23]

Figures 1 and 2 demonstrate two distinct cases of MNV.

Not only the sclera, the choroid as well, might play an important role in the development of posterior staphyloma. The vascular density and the choriocapillaris perfusion areas were lower in eyes when posterior staphyloma occurred.^[24]

In a study by OCTA evaluating choriocapillaris flow in high

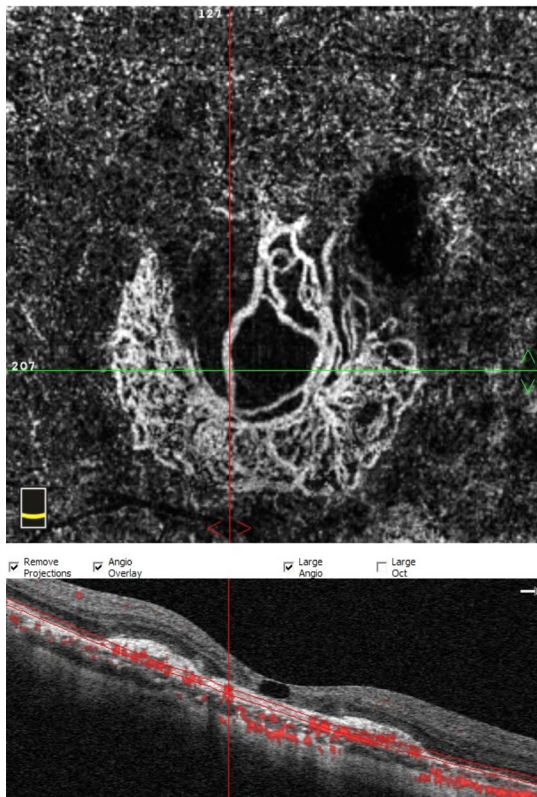


Fig. 1. A tangled type myopic macular neovascularization in the atrophic stage. Note the flow in the B-scan.

myopic eyes without evidence of neovascularization, the choriocapillaris flow deficit was greater in high myopes compared to moderate ones. Furthermore, they assumed that the larger spacing between capillaries of the choriocapillaris would result in a diminished metabolic exchange between the outer retina, retina pigment epithelium, and the choriocapillaris. Based on these findings, the authors speculated that the diminished choriocapillaris blood flow could play an important role in the pathogenesis of pathologic myopia.^[25]

Choriocapillaris flow deficit was evident in eyes with pathologic myopia. The deficit tended to increase as myopic maculopathy progressed. The deficit was evident in all eyes with diffuse or patchy chorioretinal atrophy, and even in some of the eyes with tessellated fundus only. The flow deficit strongly correlated with axial length and subfoveal choroidal thickness; it also tended to be in correlation with poor vision.^[19] Thus, it could be argued that the thinning of choriocapillaris plays a particular in the pathogenesis of myopic MNV.

Scleral perforated vessels were depicted to be continuous with the neovascular tissue via OCTA in 75% of eyes in pathologic myopia. This was evident for all phases (active, scar, or

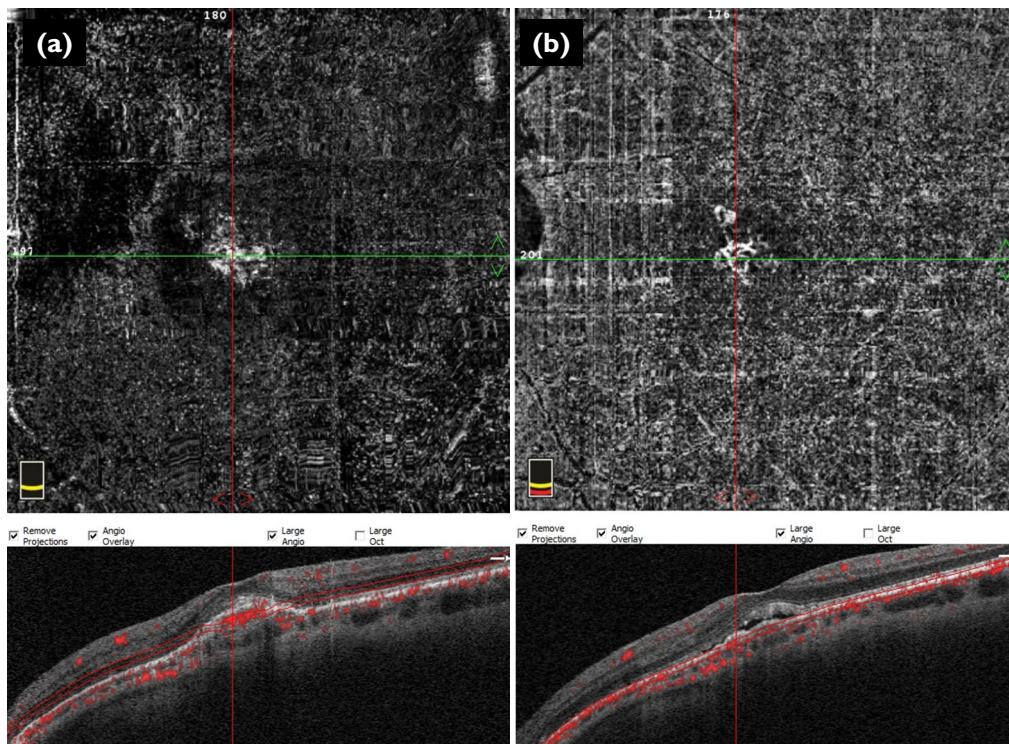


Fig. 2. A small myopic macular neovascularization in the en-phase image is associated with subretinal fluid and flow in the B-scan (a). Following treatment, in the scar stage, the neovascularization is disorganized, subretinal fluid no more exists; however, flow is detected (b).

atrophic) of neovascularization without significant difference. As these vessels were shown to fill in the choroidal arterial phase, they were considered to be intrascleral arteries branching from short posterior ciliary arteries.^[26] The relationship between perforating vessels and myopic MNV was also demonstrated in a recent study. This study also reported a significant decrease in MNV size and signal 1 month after the treatment.^[27] The relationship between perforating vessels and MNV was either in a direct contact or through the thin choroid. These are proposed to be the feeder vessel of the neovascular tissue.^[26,27] Perhaps, this hypothesis should be justified by histopathological studies. There are limitations for OCTA in myopic MNV. First of all, the low vision due to pathologic myopia causes diminished image quality causing major segmentation errors. Gaze fixation is important for obtaining optimal images. Moreover, chorioretinal atrophy, posterior staphyloma, and thinning of the choriocapillaris also result in deviation in automatic segmentation; hence, manual segmentation is recommended to depict the lesion underneath the Bruch's membrane.^[9,19,20,23] OCTA could fail to depict small neovascular lesions and also neovascular lesions accompanied by subretinal blood.^[21]

Conclusion

Myopia and particularly pathologic myopia is becoming a health-care problem that should be taken into consideration. Continuously, increasing effort is spent especially in the field of diagnosis which would in turn lead to more accurate management. OCTA, like in other retinal disorders, is a promising too with this regard. The main advantages of OCTA are the non-invasive nature, lack of potential side effects, being fast and repeatable, and thus being sustainable. Even small lesions could be detected through OCTA. Furthermore, OCTA – without being obscured – could depict the neovascular tissue in the scar or atrophic phases of the disease, as well as the neovascular tissue under retinal hemorrhage. Perhaps, some general limitations like artifacts could be counted. Yet, OCTA seems to be a promising tool in the diagnosis and follow-up of myopic MNV.

Peer-review: Externally peer-reviewed.

Authorship Contributions: Concept: S.S., E.E., P.I., N.D.; Design: S.S., E.E., P.I., N.D.; Supervision: S.S., E.E., P.I., N.D.; Resource: S.S., E.E., P.I.; Materials: S.S., E.E., N.D.; Data Collection and/or Processing: S.S.; Analysis and/or Interpretation: S.S., N.D.; Literature Search: S.S., P.I.; Writing: S.S.; Critical Reviews: S.S., E.E., P.I., N.D.

Conflict of Interest: None declared.

Financial Disclosure: The authors declared that this study received no financial support.

References

- Zou M, Wang S, Chen A, Liu Z, Young CA, Zhang Y, et al. Prevalence of myopic macular degeneration worldwide: A systematic review and meta-analysis. *Br J Ophthalmol* 2020;104:1748–54. [\[CrossRef\]](#)
- Wong TY, Ferreira A, Hughes R, Carter G, Mitchell P. Epidemiology and disease burden of pathologic myopia and myopic choroidal neovascularization: An evidence-based systematic review. *Am J Ophthalmol* 2014;157:9–25.e12. [\[CrossRef\]](#)
- Holden BA, Fricke TR, Wilson DA, Jong M, Naidoo KS, Sankaridurg P, et al. Global prevalence of myopia and high myopia and temporal trends from 2000 through 2050. *Ophthalmology* 2016;123:1036–42. [\[CrossRef\]](#)
- Yamada M, Hiratsuka Y, Roberts CB, Pezzullo ML, Yates K, Takano S, et al. Prevalence of visual impairment in the adult Japanese population by cause and severity and future projections. *Ophthalmic Epidemiol* 2010;17:50–7. [\[CrossRef\]](#)
- Pan CW, Dirani M, Cheng CY, Wong TY, Saw SM. The age-specific prevalence of myopia in Asia: A meta-analysis. *Optom Vis Sci* 2015;92:258–66. [\[CrossRef\]](#)
- Arlanzon-Lope P, Campos MA, Fernandez-Bueno I, Coco-Martin RM. Does PLEX® elite 9000 OCT identify and characterize most posterior pole lesions in highly myopic patients? *J Clin Med* 2023;12:1846. [\[CrossRef\]](#)
- Neelam K, Cheung CM, Ohno-Matsui K, Lai TY, Wong TY. Choroidal neovascularization in pathological myopia. *Prog Retin Eye Res* 2012;31:495–525. [\[CrossRef\]](#)
- Németh J, Tapasztó B, Aclimandos WA, Kestelyn P, Jonas JB, De Faber JH, et al. Update and guidance on management of myopia. European Society of Ophthalmology in cooperation with International Myopia Institute. *Eur J Ophthalmol* 2021;31:853–83. [\[CrossRef\]](#)
- Bruyère E, Miere A, Cohen SY, Martiano D, Sikorav A, Popeanga A, et al. Neovascularization secondary to high myopia imaged by optical coherence tomography angiography. *Retina* 2017;37:2095–101. [\[CrossRef\]](#)
- Ohno-Matsui K, Kawasaki R, Jonas JB, Cheung CM, Saw SM, Verhoeven VJ, et al. International photographic classification and grading system for myopic maculopathy. *Am J Ophthalmol* 2015;159:877–83.e7. [\[CrossRef\]](#)
- Spaide RF. The choroid. In: Ohno-Matsui K, Yannuzzi LA, editors. *Pathologic Myopia*. New York: Springer; 2014. p. 113–32.
- Montero JA, Ruiz-Moreno JM. Treatment of choroidal neovascularization in high myopia. *Curr Drug Targets* 2010;11:630–44. [\[CrossRef\]](#)
- Nakanishi H, Yamada R, Gotoh N, Hayashi H, Yamashiro K, Shimada N, et al. A genome-wide association analysis identified a novel susceptible locus for pathological myopia at 11q24.1. *PLoS Genet* 2009;5:e1000660. [\[CrossRef\]](#)
- Chhablani J, Deepa MJ, Tyagi M, Narayanan R, Kozak I. Fluorescein angiography and optical coherence tomography in myopic choroidal neovascularization. *Eye (Lond)* 2015;29:519–24. [\[CrossRef\]](#)
- Ohno-Matsui K, Ikuno Y, Lai TY, Gemmy Cheung CM. Diag-

- nosis and treatment guideline for myopic choroidal neovascularization due to pathologic myopia. *Prog Retin Eye Res* 2018;63:92–106. [\[CrossRef\]](#)
16. Jo Y, Ikuno Y, Nishida K. Retinoschisis: A predictive factor in vitrectomy for macular holes without retinal detachment in highly myopic eyes. *Br J Ophthalmol* 2012;96:197–200. [\[CrossRef\]](#)
 17. Leveziel N, Caillaux V, Bastuji-Garin S, Zmuda M, Souied EH. Angiographic and optical coherence tomography characteristics of recent myopic choroidal neovascularization. *Am J Ophthalmol* 2013;155:913–9. [\[CrossRef\]](#)
 18. García-Layana A, Salinas-Alamán A, Maldonado MJ, Sainz-Gómez C, Fernández-Hortelano A. Optical coherence tomography to monitor photodynamic therapy in pathological myopia. *Br J Ophthalmol* 2016;90:555–8. [\[CrossRef\]](#)
 19. Wong CW, Teo YC, Tsai ST, Ting SW, Yeo YS, Wong WK, et al. Characterization of the choroidal vasculature in myopic maculopathy with optical coherence tomographic angiography. *Retina* 2019;39:1742–50. [\[CrossRef\]](#)
 20. Miyata M, Ooto S, Hata M, Yamashiro K, Tamura H, Akagi-Kurashige Y, et al. Detection of myopic choroidal neovascularization using optical coherence tomography angiography. *Am J Ophthalmol* 2016;165:108–14. [\[CrossRef\]](#)
 21. Bagchi A, Schwartz R, Hykin P, Sivaprasad S. Diagnostic algorithm utilising multimodal imaging including optical coherence tomography angiography for the detection of myopic choroidal neovascularisation. *Eye (Lond)* 2019;33:1111–8.
 22. Querques G, Corvi F, Querques L, Souied EH, Bandello F. Optical coherence tomography angiography of choroidal neovascularization secondary to pathologic myopia. *Dev Ophthalmol* 2016;56:101–6. [\[CrossRef\]](#)
 23. Querques L, Giuffrè C, Corvi F, Zucchiatti I, Carnevali A, De Vitis LA, et al. Optical coherence tomography angiography of myopic choroidal neovascularisation. *Br J Ophthalmol* 2017;101:609–15. [\[CrossRef\]](#)
 24. Li H, Wang Q, Liu Y, Wang X, He Q, Chen Y, et al. Investigation of macular structural and microcirculatory characteristics of posterior staphyloma in high myopic eyes by swept source optical coherence tomography angiography. *Front Physiol* 2022;13:856507. [\[CrossRef\]](#)
 25. Su L, Ji YS, Tong N, Sarraf D, He X, Sun X, et al. Quantitative assessment of the retinal microvasculature and choriocapillaris in myopic patients using swept-source optical coherence tomography angiography. *Graefes Arch Clin Exp Ophthalmol* 2020;258:1173–80. [\[CrossRef\]](#)
 26. Ishida T, Watanabe T, Yokoi T, Shinohara K, Ohno-Matsui K. Possible connection of short posterior ciliary arteries to choroidal neovascularisations in eyes with pathologic myopia. *Br J Ophthalmol* 2019;103:457–62. [\[CrossRef\]](#)
 27. Sayanagi K, Hara C, Fukushima Y, Sakimoto S, Kawasaki R, Sato S, et al. Flow pattern and perforating vessels in three different phases of myopic choroidal neovascularization seen by swept-source optical coherence tomography angiography. *Graefes Arch Clin Exp Ophthalmol* 2021;259:2615–24. [\[CrossRef\]](#)