

# Clinical Investigations and Diagnosis of Peripapillary Intrachoroidal Cavitation

Subjects: **Ophthalmology**

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Peripapillary intrachoroidal cavitation (PICC) is a yellow-orange lesion, located at the outer border of the myopic conus. First described as a localized detachment of the retinal pigment epithelium, its intrachoroidal location was later revealed, justifying its current name. PICC is related to other myopic complications such as posterior staphyloma, but its pathogenesis is not clear to date. Although it has been considered a benign condition, most eyes with PICC show visual field defects, which leads to diagnostic uncertainty as these deficits resemble those seen in glaucoma. Furthermore, eyes with PICC may develop macular detachment with retinoschisis.

peripapillary intrachoroidal cavitation

border tissue

myopic complication

optical coherence tomography

angiography

## 1. Introduction

Peripapillary intrachoroidal cavitation (PICC) is a myopic complication of which the prevalence is expected to increase, due to the increasing prevalence of myopia.

PICC is a well-circumscribed yellow-orange lobular lesion, located at the outer border of the myopic conus [1]. Advances in optical coherence tomography (OCT) have revealed that PICC is a hyporeflective intrachoroidal thickening [2] with little or no deformation of the overlying plane of Bruch's membrane [3]. It appears as a neural-based triangular choroidal thickening in OCT sections crossing the optic nerve (ON) head [3][4]. A discontinuity in the border tissue of the choroid is often associated with PICC [3].

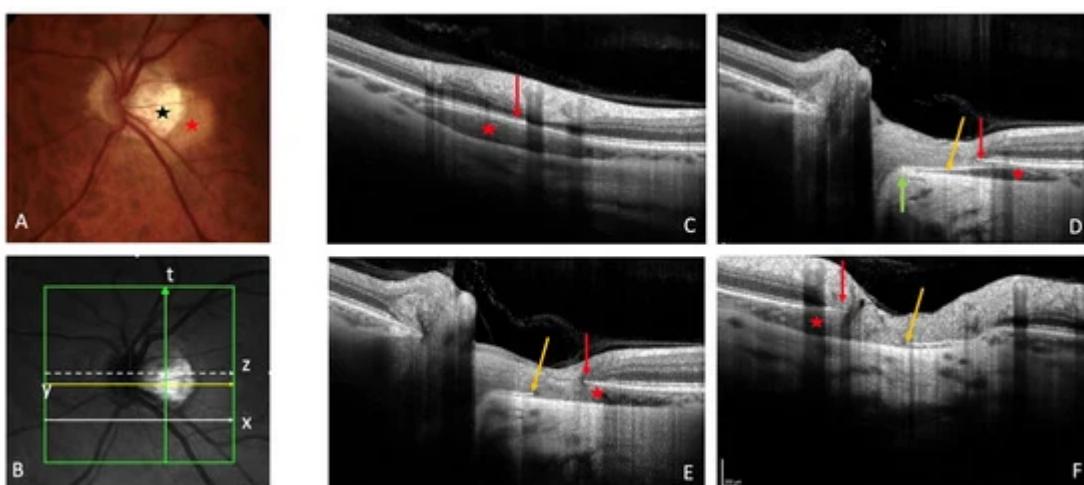
Visual field (VF) defects are reported in up to 73.3% of PICCs [5]. These VF deficits are similar to those observed in glaucoma [5], constituting a cause of diagnostic uncertainty. Additionally, macular detachment with or without retinoschisis can complicate the prognosis of PICC [6][7][8][9][10][11]. Knowledge of the PICC enables avoiding misdiagnosis as a metastatic choroidal tumor which can lead to unnecessary and anxiety-inducing investigations [1].

PICC is related to other myopic complications, namely posterior staphyloma and myopic tilted disc [4]. It is more common in eyes with a higher maculopathy category [12].

While the pathogenesis of PICC has been hypothesized for years, recent findings in the biomechanics of the ON have reopened the debate. Indeed, several methods have demonstrated high traction forces exerted by the ON sheaths on the peripapillary region of myopic eyes during ocular movements [13][14][15]. These biomechanical findings renew interest in the pathogenesis of myopic peripapillary changes because these pulling forces have been suggested as promoters of PICC [16].

## 2. Fundoscopy and OCT

The yellow orange ophthalmoscopic appearance of PICC [1][3][4][17][18] (Figure 1A) is obvious only in 46.7% to 53% of OCT-detected PICCs [4][18][19]. Therefore, OCT is the recommended tool for the screening of PICC.



**Figure 1.** Peripapillary intrachoroidal cavitation (PICC). (A) Fundus picture. PICC is the yellow-orange lesion at the outer border of the myopic conus (black star) (B). Infrared image showing the location of sections (C) to (F). (C–F) PICC is the hyporeflective space behind the plane of Bruch's membrane (BM). (C) Slice along the line x, below the optic nerve head (ONH). (D–F) Orange arrow = border tissue of the choroid (BT). (D) Section along the arrow y, through the ONH. The BT is continuous between the BM and the sclera (green arrow). (E) Section through the ONH, along the arrow z. The BT is discontinuous between the red and orange arrows. (F) Along the myopic conus (arrow t). The BT shows a discontinuity between the red and orange arrows. (A–F) Red star = PICC. (C–F) Red arrow = BM. The fundus picture was taken using VISUCAM® non-mydriatic camera (PRO NM Carl Zeiss Meditec, Jena, Germany). The device used for OCT is the Spectral Domain OCT Spectralis® OCT HRA-OCT, model S3300 (Heidelberg Engineering GmbH, Heidelberg Germany).

OCT reveals a spectrum of PICC appearances depending on the location and orientation of the section (Figure 1B). At the level of the peripapillary zone, it shows an aspect of hyporeflective intrachoroidal thickening [2] behind the plane of Bruch's membrane (Figure 1C). If the section is through the ON, the PICC shows a triangular choroidal thickening (Figure 1D) with the base at the ON head. The well-demarcated border tissue of choroid (Figure 1D) may show discontinuity (Figure 1E,F).

The lesion is mainly located below the ON head [1][2][3][5][12][17][18][20][21][22]. However, other peripapillary areas may also be involved [4][10][12][17][21][22], and the PICC may even surround the entire ON head [17][19]. Therefore, Shimada subdivided it into three grades based on its overall circumference around the ON head [17].

Using spectral domain OCT or swept-source OCT, the diagnostic features of PICC are currently well established [2][3][20][21][23], obviating the need for other more invasive modalities such as fluorescein or indocyanine green angiography, the characteristics of which are summarized below.

## 3. Fluorescein Angiography

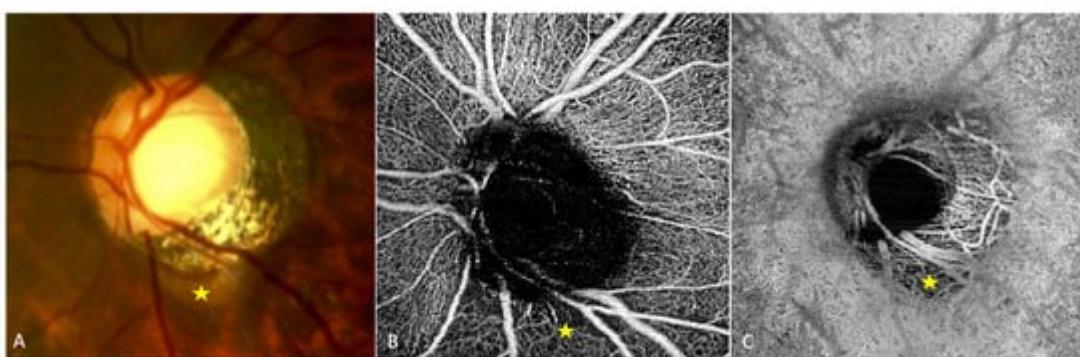
The sequence of fluorescein angiography shows early hypofluorescence followed by late hyperfluorescence without dye pooling in the area of PICC [1][2][17][21][24][25][26]. This angiographic sequence may be explained by structural choroidal changes. The early phase (hypofluorescence) results from disorganization, thinning, and loss of normal choroidal architecture while the late phase (hyperfluorescence) without dye pooling is related to the scleral impregnation by the dye, visible through the disorganized choroid [26].

## 4. Indocyanine Green Angiography

The area of PICC shows hypofluorescence throughout the indocyanine green angiography sequence [2][3][17][24]. This indicates slow or absent choroidal flow.

## 5. OCT-Angiography

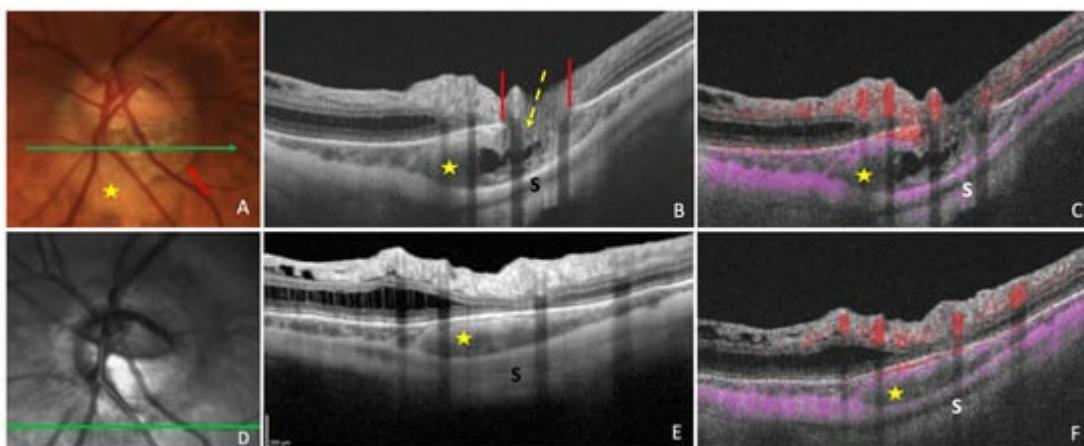
Analysis of highly myopic eyes showed that the vessel density of the radial peripapillary capillary network [27][28] (**Figure 2B**) and that of the ON head layers [27] were significantly reduced in eyes with (**Figure 2A**) than in those without PICC. Highly myopic and low myopic eyes also showed a reduced vessel density compared to non-myopic eyes [27].



**Figure 2.** OCT-angiography of a peripapillary intrachoroidal cavitation (PICC). (A–C) Yellow star = PICC. (A) Fundus image with a PICC. (B) En-face OCT-A at the level of the superficial radial peripapillary capillary. Reduced vascular density at the area of PICC is observed. (C) En-face OCT-A at the level of choroid. Reduced vascular

density is also seen at the area of PICC. The device used is the PLEX Elite® 9000 SS OCTA (Carl Zeiss Meditec AG, Jena, Germany). A 6 × 6 mm field of view centered on the papilla. The fundus picture was taken using VISUCAM® non-mydiatic camera (PRO NM Carl Zeiss Meditec, Jena, Germany). The device used for OCT-A is the PLEX Elite® 9000 SS OCTA (Carl Zeiss Meditec AG, Jena, Germany). A 6 × 6 mm field of view centered on the papilla.

In a study of 47 glaucomatous eyes with PICC, Kim et al., using En-face OCT-A images at the choroidal layer, described two main vascular features. First, they noted a well demarcated homogeneous area of vessel density reduction matching the location of PICC [22] (Figure 2C). Second, they observed in 89.4% of cases, a choroidal microvasculature dropout (i.e., a focal sector with no visible choroidal and choriocapillary network). These similar patterns were previously reported in two case-reports of non-glaucomatous PICCs [29][30]. Using B scans of the OCT-A, Kim et al. showed that the PICC maintains the choriocapillary signal against the posterior surface of the Bruch's membrane whereas it shows no signal in the intrachoroidal cavity [22] (Figure 3).



**Figure 3.** Optical coherence tomography (OCT) and OCT-angiography (OCT-A) in a case of peripapillary intrachoroidal cavitation (PICC). (A) Fundus image with a PICC at the outer border of the conus (red arrow). (B,C) Sections along the green arrow in (A). (B) OCT B-scan disclosing the PICC. Gamma peripapillary atrophy is between the two ends of the Bruch's membrane (red lines). The retinal layers (dashed yellow arrow) herniate through them. (C) B-scan OCT-A showing the absence of signal inside the choroid. There is a signal (in pink) against Bruch's membrane, corresponding to the choriocapillaris. Behind the intrachoroidal hyporeflective space, another signal corresponding to the sclera is perceived. The retinal vascular signal is red. (D) Infrared image with the green arrow indicating the location of sections. (E,F) The section is below the optic disc. (F) No signal is seen in the hyporeflective choroidal space between the sclera and the choriocapillaris. A signal is present at the level of choriocapillaris. PICC = yellow star. S = sclera. The fundus picture was taken using VISUCAM® non-mydiatic camera (PRO NM Carl Zeiss Meditec, Jena, Germany). The device used for OCT and infrared image is the Spectral Domain OCT Spectralis® HRA-OCT, model S3300 (Heidelberg Engineering GmbH, Heidelberg Germany). The device used for OCT-angiography is the Swept-source OCT Triton DRI Topcon corporation.

## 6. Other Modalities

Multimodal imaging [26][31][32] and three-dimensional reconstruction imaging [33] have been used in some cases of PICC, confirming the multiple facets of PICC. Azar et al. used fluorescein angiography and En-face OCT [26]; Chen et al. combined multicolor imaging, ocular B-scan ultrasonography, En-face OCT and enhanced depth imaging OCT [31]; Shen et al. used ocular ultrasonography A and B, fluorescein angiography and OCT [32].

By comparing conventional color fundus photography to multicolor imaging in a case of PICC, Venkatesh et al. found that the multicolor imaging would be less effective than conventional color fundus photography in diagnosing PICC in myopic eyes, which requires confirmation [34].

More recently, Fujimoto et al. developed a method of deep learning-based noise reduction and three-dimensional (3D) rendering of volumetric swept-source OCT images. Using this technology, they calculated the 3D volume parameter of PICC and assessed its value in detecting and understanding this condition. They found that the volume of PICC, as a new 3D parameter, reflects its influence on visual function [35].

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