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**Wide-field indocyanine green fluorescein angiography findings in inferior posterior
staphyloma**

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26 **Key Messages :**

27 **What is Known**

28 ● Inferior posterior staphyloma (IPS) sometimes occurs subretinal fluid (SRF),
29 however the mechanism of its appearance and disappearance is unknown.

30 **What is new**

31 ● Indocyanine green angiography (ICGA) findings in IPS showed the downward shift
32 in the watershed, asymmetric dilated vortex vein (ADV), and choroidal filling
33 delay, which was also found in pachychoroid spectrum diseases (PDS).

34 ● Anastomosis between the superior and inferior choroidal veins across watershed
35 contributes to the resolution of SRF in that it reduces the overload as the anastomosis
36 progresses.

37 ● We suggest that the mechanism for the appearance and disappearance of SRF in IPS
38 may be due to the same mechanism that an imbalance in macular choroidal blood
39 flow and localized hyperperfusion as in PDS.
40

Inferior posterior staphyloma (IPS), typically associated with tilted disc syndrome, is a rare disease that characterized by posterior staphyloma within the inferior fundus, without pathological myopia.¹ Subretinal fluid (SRF) associated with IPS was first described by Cohen et al.² and occurs in approximately 30–40% of IPS cases,³ with minimal or no involvement of choroidal neovascularization. Although imbalanced choroidal blood flow at the IPS border is suspected to be involved in IPS pathophysiology,³ the precise mechanism underlying SRF development in IPS remains unclear. This study aimed to investigate choroidal circulation and morphological changes in IPS using wide-field indocyanine green angiography (ICGA).

This retrospective observational study adhered to the principles of the Declaration of Helsinki and was approved by the institutional review board of Hokkaido University Hospital (IRB number:024-0134) with an opt-out consent process. The study included 14 eyes (mean spherical equivalent: -2.48 ± 1.63 diopters) of 8 Japanese patients (mean age: 65.1 ± 13.0 years, 8 females) diagnosed with treatment-naïve IPS between 2020 and 2021 and underwent ophthalmic examinations and ocular imaging including wide-field ICGA (Spectralis HRA; Heidelberg Engineering, Heidelberg, Germany) and swept-source optical coherence tomography (OCT) (DRI OCT-1 Atlantis, Topcon, Tokyo, Japan). Exclusion criteria were: (1) high myopia with spherical

equivalent refraction of -7.00 diopter or greater and/or diffuse chorioretinal atrophy or
severer; (2) macular neovascularization or other macular diseases; (3) prior treatments
including medication, intravitreal injections of anti-vascular endothelial growth factor
agents, or photodynamic therapy; and (4) contrast media allergy or inability to undergo
ICGA.

The primary endpoints included the following ICGA findings: downward shift
of the horizontal watershed, asymmetric dilated vortex vein (ADV V), anastomosis
between the superior and inferior choroidal veins across watershed, and delayed choroidal
filling of the macula in the early phase. Differences in each finding between eyes with
and without SRF were also analyzed. Statistical tests were performed using the R
statistical package (version 3.6.1; R Foundation for Statistical Computing). The chi-
square test was used to analyze the differences in the ratio of ICGA findings with or
without SRF. Statistical significance was set at $P < 0.05$.

As Table 1 shows, a downward shift in the watershed was observed in 12 eyes
(85.7%) (Figures 1 A and B), all of which corresponded with the boundaries of the
funduscopy IPS. ADV V was found in 12 eyes (85.7%) (Figures 1 D and E), anastomosis
in eight eyes (57.1%) (Figures 1 G, H, and H'), and choroidal filling delay in 14 eyes
(100%) (Figures 1 J, and J'). SRF was present in seven eyes (Figures 1 C, F, and I). There

were no statistical differences in the ratio of downward shift of the watershed, ADVV, and delayed choroidal filling between eyes with or without SRF. However, the ratio of anastomosis connecting the superior and inferior choroidal veins was significantly higher in eyes without SRF compared to those with SRF ($P = 0.031$).

The downward shift in the watershed, ADVV, and choroidal filling delay observed with high probability in our IPS cases were the characteristic findings also observed in pachychoroid spectrum diseases (PSD)³⁻⁵. Our previous study reported that in central serous chorioretinopathy (CSC), a representative PSD, an imbalance in macular choroidal blood flow was observed, which resulted in localized hyperperfusion and subsequent SRF⁵. In our present study, choroidal blood flow was anatomically divided in IPS, and as ADVV showed, choroidal blood flow was relatively overloaded in the superior region. Importantly, anastomosis contributes to the resolution of SRF in that it reduces the overload as the anastomosis progresses.

The limitation of this study is small sample size. In addition to the rarity of IPS, cases assessed by ICGA are even fewer due to its invasive nature. A future study with a larger number of cases is warranted.

In conclusion, IPS showed a high prevalence of downward shift in the watershed, ADVV, anastomosis of vortex veins, and choroidal filling delay on ICGA. Anastomosis

95 of the choroidal veins across the watershed is likely to resolve the SRF in IPS, suggesting
96 that choroidal blood flow congestion may cause SRF in IPS through a mechanism similar
97 to that observed in PSD.

98

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Figure Captions

Fig. 1. Representative images of inferior posterior staphyloma (IPS) eyes. The representative case 1, Figures 1 A–C; the representative case 2, Figures 1 D–F; The representative case 3, Figures 1 G–J.

A, D, G: Color fundus photographs showing IPS with divided boundaries along its edges.

B, E, H: Early-phase indocyanine green angiography (ICGA) images showing a downward shift of the watershed in the superior region (red dotted lines in Figure 1B), asymmetric dilated of the vortex vein (yellow arrowheads in Figure 1E), and anastomosis of the superior and inferior choroidal vortex veins (red circles in Figure 1H and 1H').

J: Late-phase ICGA images showing choroidal filling delay in the macula (red squares in Figure 1J and 1J').

C, F, I: Vertical optical coherence tomography images from representative cases 1–3 showing subretinal fluid.

Figure
Fig.1

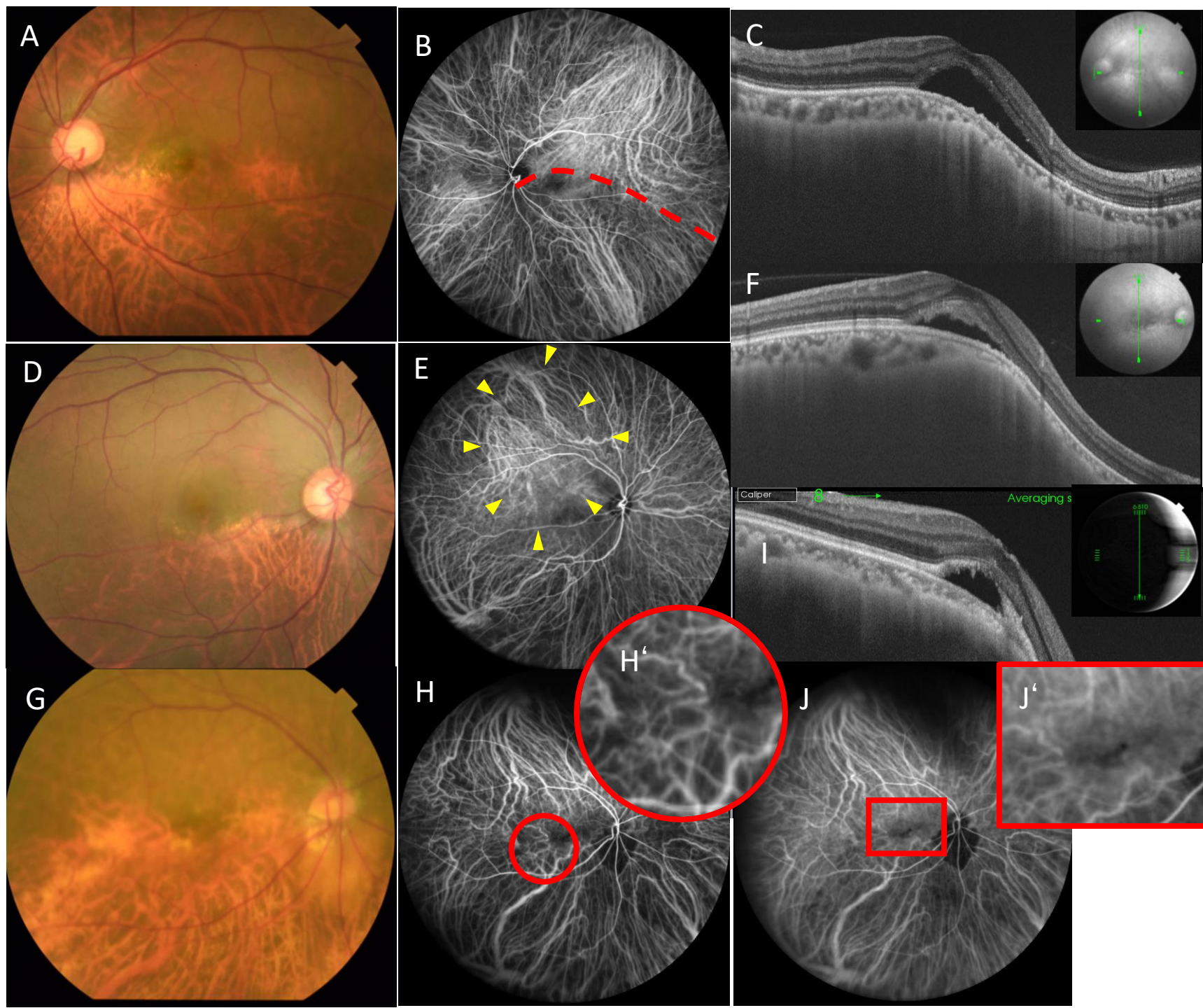


Table 1. The Ratio of Finding Depending on the Presence of SRF

	All eyes (14 eyes)	SRF(+) (7 eyes)	SRF(-) (7 eyes)	P score (Chi-squared test)
Downward shift of the watershed	12 (85.7%)	6 (85.7%)	6 (85.7%)	1
Asymmetric dilated vortex vein	12 (85.7%)	6 (85.7%)	6 (85.7%)	1
Anastomosis	8 (57.1%)	2 (28.6%)	6 (85.7%)	0.031
Choroidal filling delay	14 (100%)	7 (100%)	7 (100%)	1