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Indocyanine Green Angiographic Findings of Chorioretinal Folds

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Purpose: To analyze indocyanine green (ICG) angiographic findings of chorioretinal folds.

Methods: Eight patients (9 eyes) in whom chorioretinal folds had been diagnosed were enrolled in this study. Color photography, fluorescein angiography (FA) and ICG angiography (IA) were performed.

Results: Indocyanine green angiography demonstrated choroidal venous congestion and a filling delay of the choroidal vessels in one case with an orbital tumor. In one posterior scleritis case, IA showed a filling delay of choroidal vessels in the early phase and multiple patchy hypofluorescent lesions scattered in the posterior pole during the late phase. Idiopathic cases showed choroidal venous dilatation. No abnormalities of the choroidal vasculature in the form of radial folds, were revealed in two cases of AMD. Linear hyperfluorescent areas suggestive of chorioretinal folds seen on IA were less numerous and wider than those observed on FA in some eyes. On the other hand, they were equally numerous and wider on IA than those on FA in other eyes.

Conclusion: Indocyanine green angiography is useful for evaluating both pathological conditions of the choroidal vasculature and the width of chorioretinal folds at the level of the choroidal vasculature. **Jpn J Ophthalmol 2001;45:293–300** © 2001 Japanese Ophthalmological Society

Key Words: Chorioretinal folds, fluorescein angiography, indocyanine green angiography.

Introduction

Any condition that reduces the inner surface area of the sclera will cause the inner portion of the choroid, including Bruch's membrane, the overlying retinal pigment epithelium (RPE), and the outer retinal layers, to be thrown into a series of folds.[1] Chorioretinal folds develop secondary to the mechanical stress produced within these tissues.[2] Norton described the fluorescein angiographic features of chorioretinal folds.[3] Fluorescein angiography (FA) is useful for evaluating abnormalities at the level of the RPE, in contrast to indocyanine green (ICG) angiography (IA), which is excellent for detecting choroidal abnormalities. To date, there have been no reports detailing the ICG angiographic findings of chorioretinal folds. Herein, we describe the ICG angiographic findings of chorioretinal folds and the choroidal circulation in patients with chorioretinal folds produced by various mechanisms. We also compare ICG angiographic findings with those of FA.

Materials and Methods

Eight patients (9 eyes) in whom chorioretinal folds had been diagnosed were enrolled in this study. The causes of the chorioretinal folds included: an orbital tumor in 1 eye, posterior scleritis in 1 eye, idiopathic choroidal folds in 5 eyes, and age-related macular degeneration (AMD) in 2 eyes. The study was conducted according to the principles established in the Declaration of Helsinki. Informed consent was obtained from each patient. Color photography, FA, and IA, using a fundus camera (TRC 50-IA; Topcon Instruments, Tokyo) connected to a digital imaging

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Table 1. Indocyanine Green Angiography Findings of Choroidal Circulation

Case No.	Etiology	Choroidal Circulation	Mechanism
1	Orbital tumor	Choroidal venous tortuousness, dilatation, loop formation Filling delay of choroidal vessels	Tumor exerts pressure on the choroid
2	Posterior scleritis	Filling delay of choroidal vessels Multiple patches of hypofluorescence	Edema and inflammatory cell infiltration
3		Choroidal venous dilatation	Possibility of abnormal drainage through choroidal veins, into the vortex veins, due to structural alterations within the scleral wall
4	Idiopathic	Normal	
5		Normal	
6		Normal	
7		Normal	
8	Age-related macular degeneration	No abnormal findings	Traction involving mainly the RPE and superficial layer of the choroid
9		No abnormal findings	

RPE: retinal pigment epithelium.

system (Topcon Image Net) were performed on all patients. Fluorescein angiography was carried out by rapidly injecting 5 mL of a 10% solution of sodium fluorescein into the cubital vein through a three-way cannula, and IA was performed by rapidly injecting 25 mg of dye (Diagnogreen; Daiichi Pharmaceutical, Tokyo) dissolved in 1 mL of balanced saline solution, into the cubital vein in the same way as the fluorescein dye. The initial injection was observed on a television monitor and recorded at 5,10,15, 20, 25, and 30 minutes thereafter. The ICG angiographic findings were evaluated and compared with those of FA.

Results

The findings in the early phase of IA, demonstrating filling of the large choroidal vessels, differed depending on the cause of the choroidal folds. Choroidal venous congestion and filling delay of the choroidal vessels were observed in 1 case with an orbital tumor. The posterior scleritis case showed a filling delay of choroidal vessels on IA. Choroidal venous dilatation was observed in only 1 of the 5 eyes with idiopathic choroidal folds. No abnormalities of the choroidal vasculature were detected in the 2 eyes with AMD. Findings corresponding to choroidal folds were prominent in the late phase of IA (Table 1). Linear hyperfluorescent lesions suggestive of choroidal folds were less numerous and wider than those seen on FA in the eye with the orbital tumor and in 3 eyes with idiopathic choroidal folds. In the 2 eyes with AMD and 2 eyes with idiopathic choroidal folds, the linear hyperfluorescent areas seen on IA were equal in number to those observed on FA but were wider (Table 2).

Table 2. Comparison of Chorioretinal Folds on Indocyanine Green Angiography (IA) and Fluorescein Angiography (FA)

Case	Etiology	Width of Hyperfluorescent Lesions Indicating Folds		No. of Hyperfluorescent Lesions Indicating Folds
		FA	IA	
1	Orbital tumor	15	5	Wide
2	Posterior scleritis	2	2	Narrow*
3		8	6	Wide
4		6	4	Wide
5		11	8	Wide
6	Idiopathic	3	3	Wide
7		6	6	Wide
8	Age-related macular degeneration	27	27	Wide
9		8	8	Wide

*Indicates width of hypofluorescent lesions representing folds.

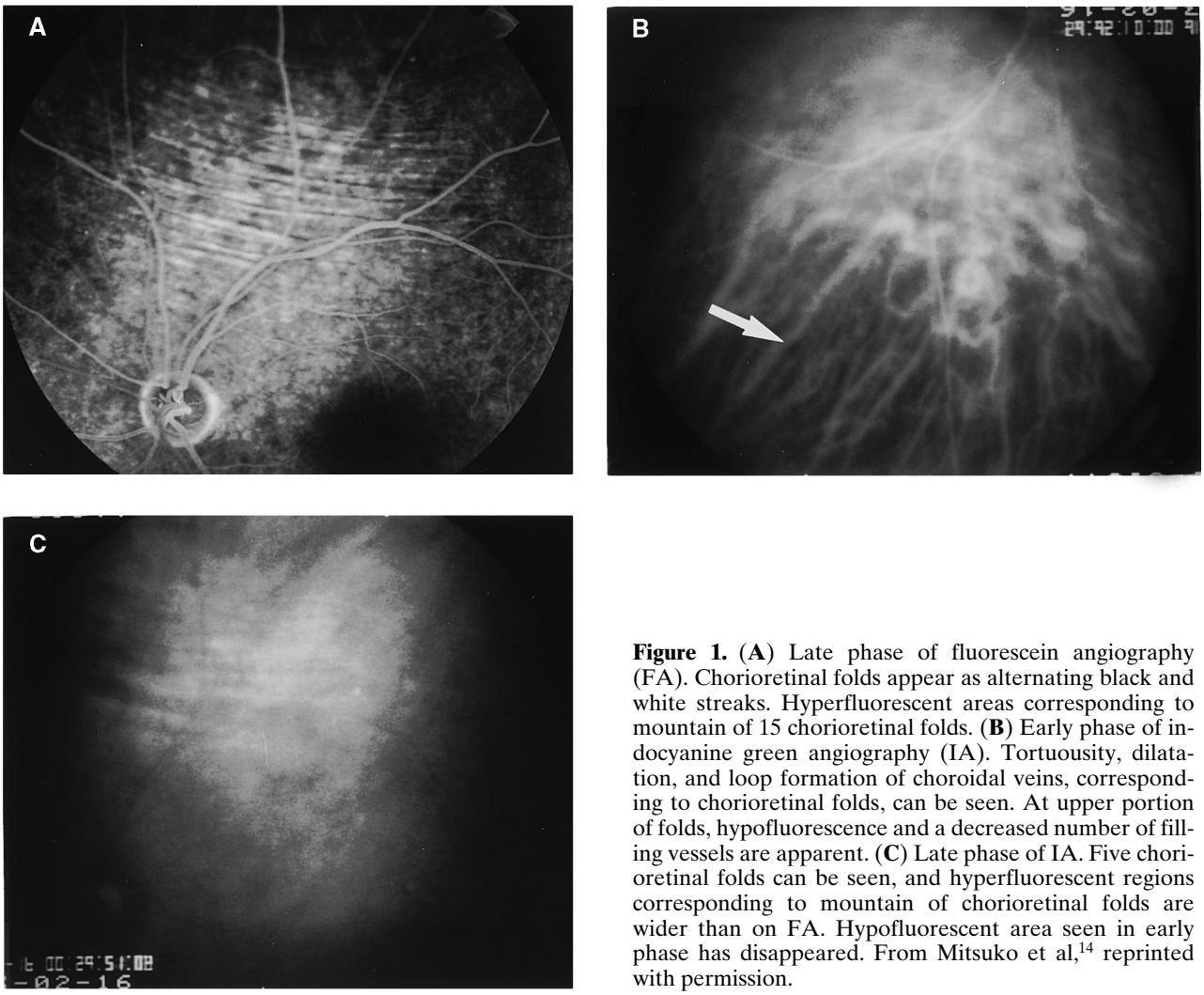

Figure 1. (**A**) Late phase of fluorescein angiography (FA). Chorioretinal folds appear as alternating black and white streaks. Hyperfluorescent areas corresponding to mountain of 15 chorioretinal folds. (**B**) Early phase of indocyanine green angiography (IA). Tortuousity, dilatation, and loop formation of choroidal veins, corresponding to chorioretinal folds, can be seen. At upper portion of folds, hypofluorescence and a decreased number of filling vessels are apparent. (**C**) Late phase of IA. Five chorioretinal folds can be seen, and hyperfluorescent regions corresponding to mountain of chorioretinal folds are wider than on FA. Hypofluorescent area seen in early phase has disappeared. From Mitsuko et al,[14] reprinted with permission.

Representative Cases

Case 1: Orbital tumor. A color fundus photograph revealed many folds located within the superior temporal quadrant of the fundus, with the convex side pointing toward the posterior pole and the optic nerve. Alternating dark and light streaks were observed. On FA, the folds appeared as alternating black and white streaks, and the folds numbered 15 (Figure 1A). The early phase of IA showed choroidal venous tortuousity, dilatation, and loop formation at the site of the folds. At the superior portion of the folds, the number of filling choroidal vessels decreased within the darker choroidal fluorescence (Figure 1B). The hypofluorescent area seen in the early phase gradually disappeared. The disappearance of the hypofluorescent area during the course of IA indicated a filling delay of the choroidal vessels. The late phase of the IA showed obvious, alternating streaks of black and white, but the number of folds was 5, ie, fewer than on FA, and the hyperfluorescent lines were wider than those observed on FA (Figure 1C).

Case 2: Posterior scleritis. A color fundus photograph demonstrated several folds located near the fovea, running a horizontal course. Fluorescein angiography showed two faint hyperfluorescent lines in the early phase (Figure 2A), which became more obvious in the late phase (Figure 2B). The dots of hyperfluorescence represented microaneurysms caused by diabetic retinopathy (Figure 2A). The early phase of IA showed a filling delay of the choroidal vessels and a decrease in the number of filling vessels in the posterior pole (Figure 2C).The late phase of IA showed two faint hyperfluorescent folds and multiple patchy hypofluorescent lesions scattered in the posterior pole (Figure 2D).

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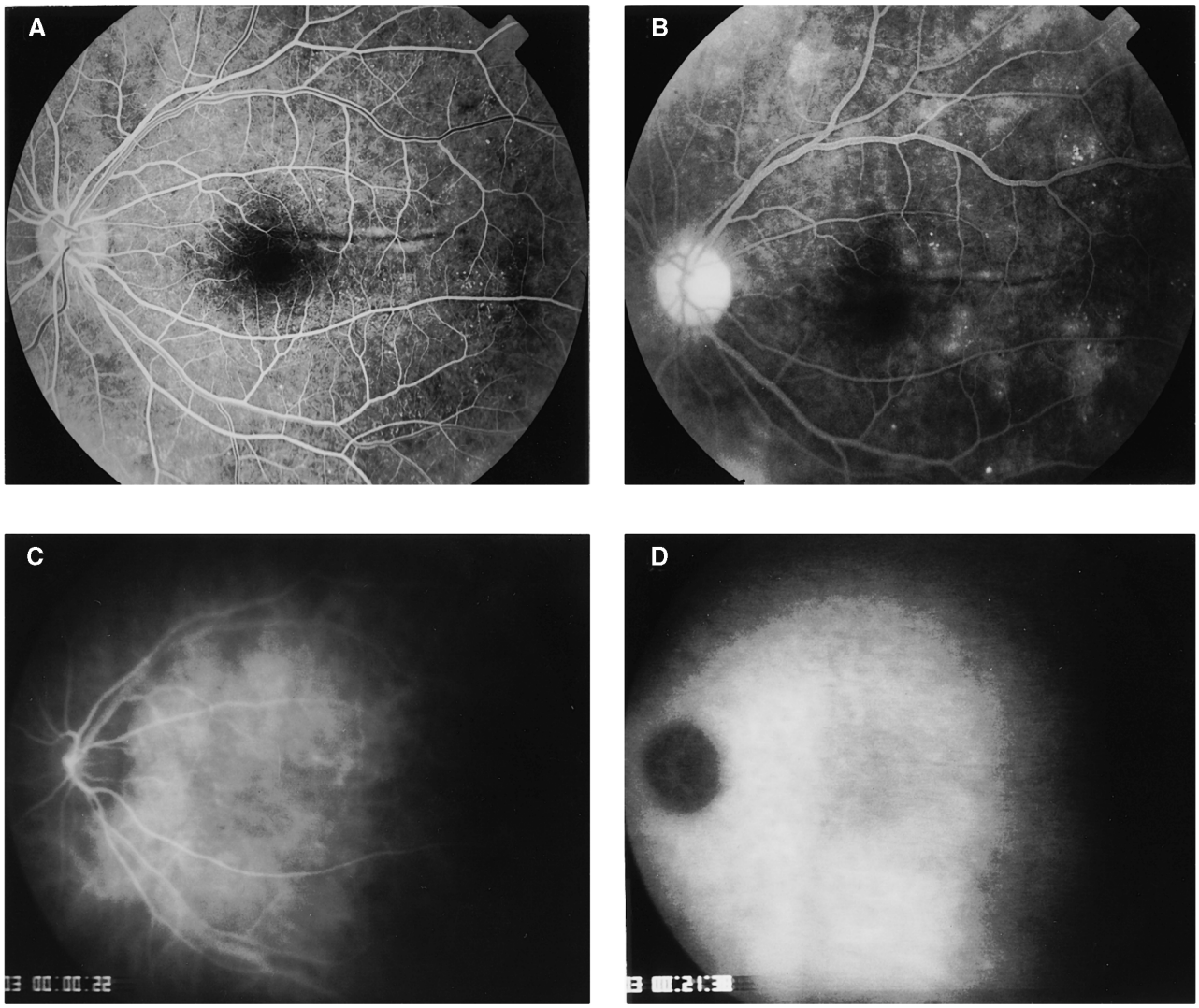

Figure 2. (**A**) Early phase of fluorescein angiography (FA). Two faintly hyperfluorescent areas indicate chorioretinal folds. Hyperfluorescent dots represent microaneurysms due to diabetic retinopathy. (**B**) Late phase of FA. Hyperfluorescent lines become obvious. (**C**) Early phase of indocyanine green angiography (IA). Choroidal vessel shows filling delay and decreased number of choroidal vessels in posterior pole. (**D**) Late phase in IA. Two faint areas of hyperfluorescence corresponding to chorioretinal folds and multiple patchy hypofluorescent lesions scattered in posterior pole.

Case 3: Idiopathic choroidal folds. A color fundus photograph showed folds that were located between the optic nerve head and the macular region, and were horizontal in their course. On FA, the folds appeared as alternating black and white streaks, and the number of hyperfluorescent areas suggested a mountain of 8 folds (Figure 3A,B). In the early phase, IA showed choroidal venous dilatation (Figure 3C). In the late phase of IA, the hyperfluorescent lines were wider than those seen on FA (Figure 3D). The number of folds was 6.

Case 9: AMD. A color fundus photograph revealed folds radiating from a white-yellow lesion in the macula. On FA, the folds appeared as alternating black and white streaks, and numbered 8 (Figure 4A). The early phase of IA showed neither an abnormal course nor abnormal filling of the choroidal vessels (Figure 4B). In the late phase, IA demonstrated the same number of alternating black and white streaks, but the hyperfluorescent lines located temporal to the macula were wider than those seen on FA (Figure 4C).

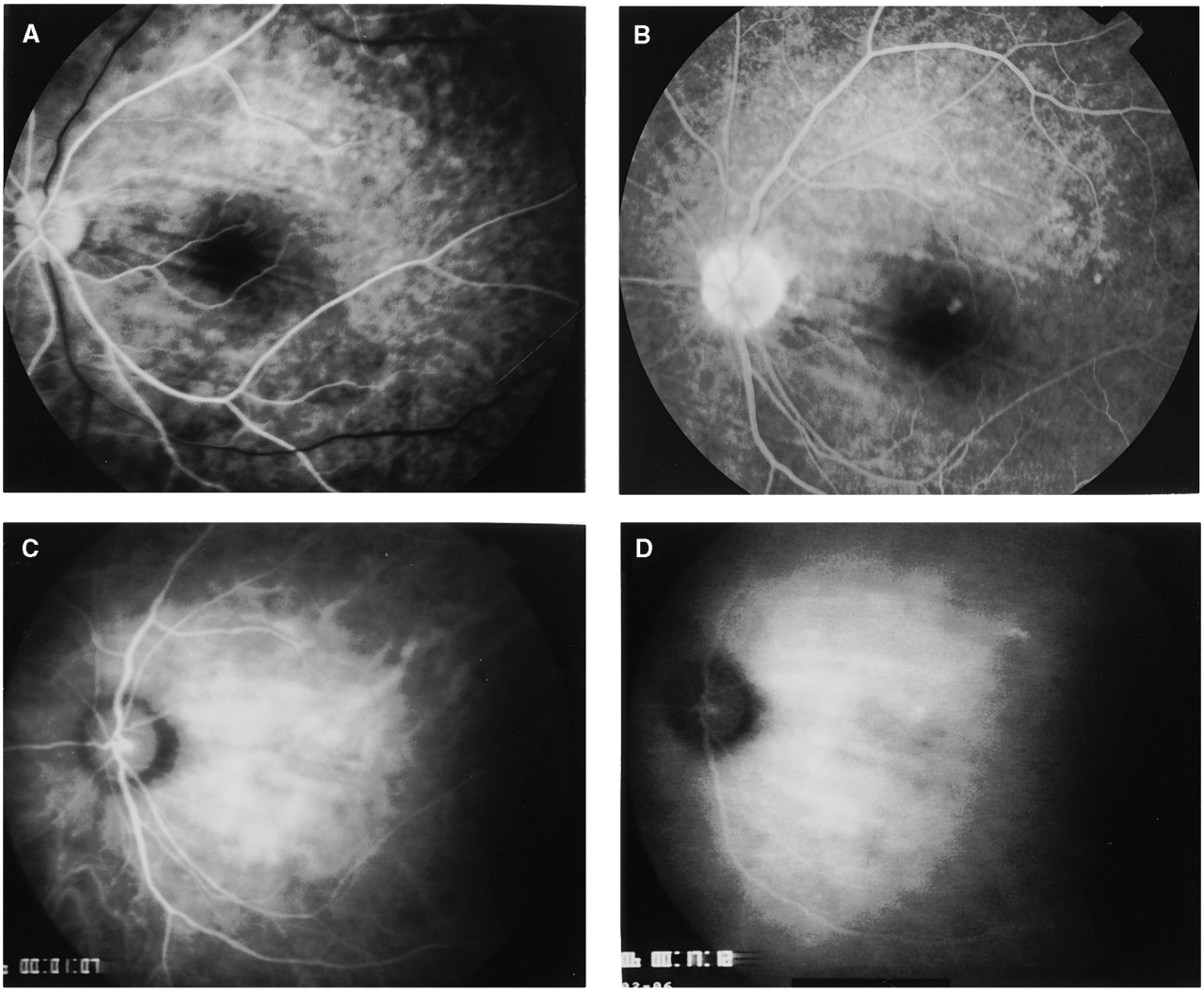

Figure 3. (**A**) Early phase of fluorescein angiography (FA). Chorioretinal folds appear as alternating black and white streaks. (**B**) Late phase of FA. Chorioretinal folds, 8 in number, appear as alternating light and dark streaks. (**C**) Early phase of indocyanine green angiography (IA). Choroidal vein shows congestion in posterior pole. (**D**) Late phase of IA. Hyperfluorescent lines are wider than on FA, and folds number 6. From Mitsuko et al,[14] reprinted with permission.

Discussion

Chorioretinal folds are associated with many different diseases.[4] On FA, these folds were seen as alternating lines of hyper- and hypofluorescence, but the choroidal condition could not be evaluated due to the masking effect of the RPE. In contrast, IA was useful for demonstrating the choroidal condition because the near-infrared light absorbed by ICG readily penetrates normal ocular pigments. No reports, to date, have described detailed ICG angiographic findings of chorioretinal folds. The authors analyzed ICG angiographic findings in eyes with choroidal folds and compared them with the findings in FA of the same eyes.

In one case with an orbital tumor, choroidal venous tortuousity, dilatation, and loop formation at the sites of corresponding folds, as well as filling delays of the choroidal vessels at the superior portion of the folds, were demonstrated by IA. Wolter suggests that shortening of the sclera, papilledema, and choroidal congestion are all factors that contribute to the development of choroidal folds.[4] The folds observed with choroidal tumors appear to be attributable to the tumor pushing the choroid outward.[4] Abnormalities in choroidal filling and dilatation were both thought to have resulted from congestion secondary to this effect of the tumor on the choroid.

In eyes with posterior scleritis, a filling delay of choroidal vessels and a decrease in the number of

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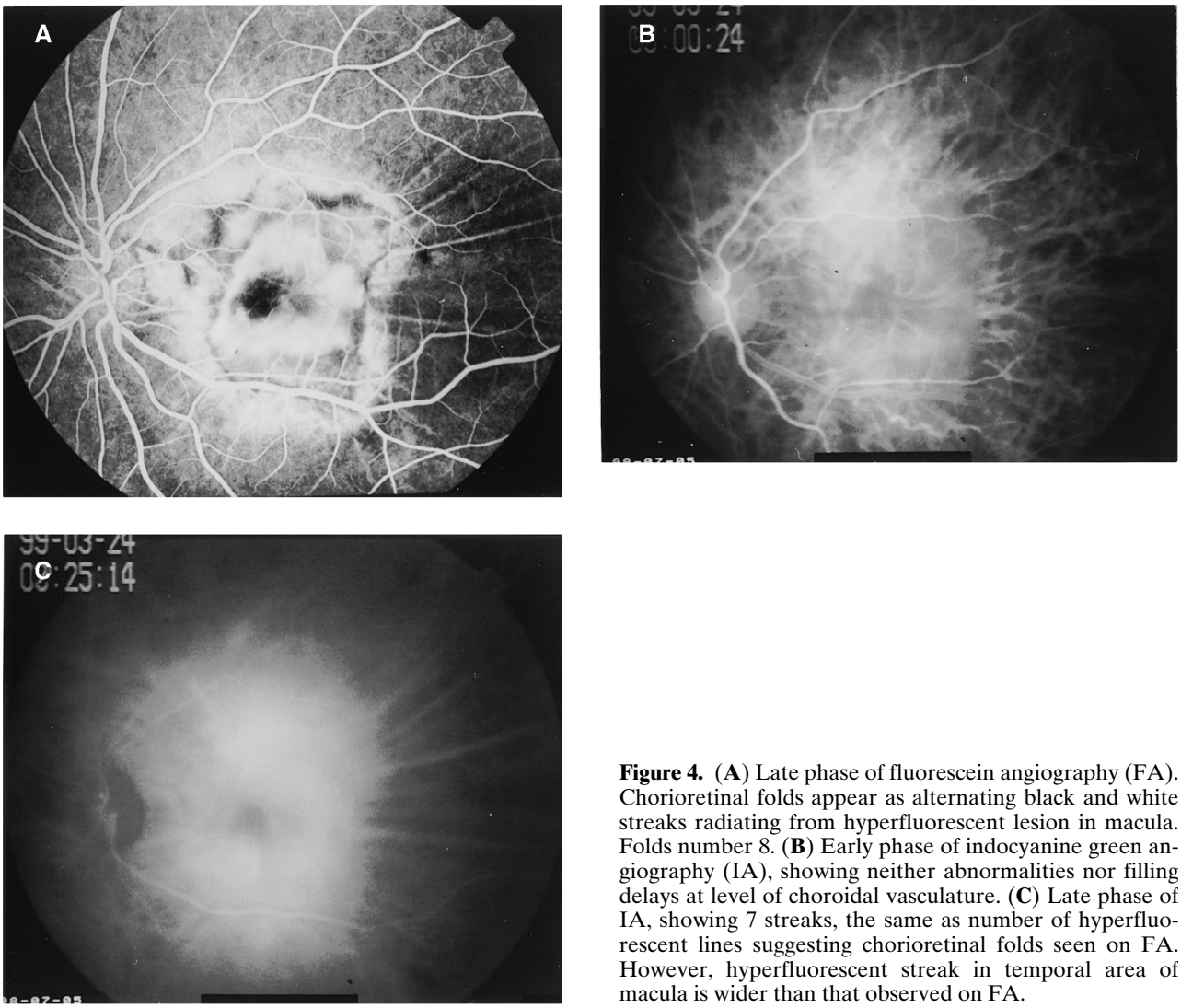

Figure 4. (**A**) Late phase of fluorescein angiography (FA). Chorioretinal folds appear as alternating black and white streaks radiating from hyperfluorescent lesion in macula. Folds number 8. (**B**) Early phase of indocyanine green angiography (IA), showing neither abnormalities nor filling delays at level of choroidal vasculature. (**C**) Late phase of IA, showing 7 streaks, the same as number of hyperfluorescent lines suggesting chorioretinal folds seen on FA. However, hyperfluorescent streak in temporal area of macula is wider than that observed on FA.

filling vessels were observed in the posterior pole during the early phase of IA. The late phase of IA showed multiple patchy hypofluorescent lesions scattered in the posterior pole. We noted that these IA findings were similar to those observed in Vogt-Koyanagi-Harada disease.[5–11] Oshima et al[9] report that in Vogt-Koyanagi-Harada disease, the choroid may become edematous and infiltrated by inflammatory cells, such as lymphocytes, macrophages, and giant cells. Furthermore, they considered choroidal vessels to be compressed by edema, resulting in increased vascular resistance and decreased arterial blood flow. The mechanism of fold formation in an inflammatory condition such as scleritis, involving the choroid, appears to resemble that in Vogt-Koyanagi-Harada disease. However, Carlos and Herbort[12] reported that the hypofluorescent dark dots seen in posterior scleritis differed from the dark dots seen in Vogt-Koyanagi-Harada disease, based on their random distribution, their fainter aspect in the intermediate phase, and their disappearance in the late phase of angiography.

Idiopathic choroidal folds can develop in a patient with no apparent ocular or orbital disorder. Most patients are male and commonly present with acquired hyperopia of 3D or less. Computed tomographic findings in these eyes may reveal thickening of the sclera, posterior pole flattening, enlargement of the optic nerve image, and the presence of a space between the optic nerve and its meninges. The mechanisms producing these alterations are unclear. It has been suggested that drainage though the choroidal

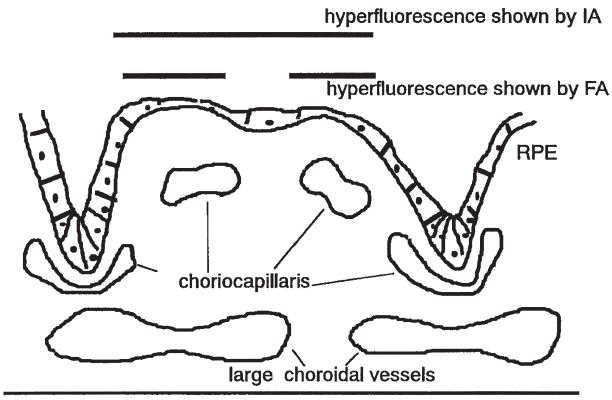

Figure 5. Relationship between hyperfluorescence on both fluorescein angiography (FA) and indocyanine green angiography (IA) in cross-sectional view of choroid and retinal pigment epithelium (RPE). Hyperfluorescent lesions suggesting chorioretinal folds are less numerous and wider on IA than on FA.

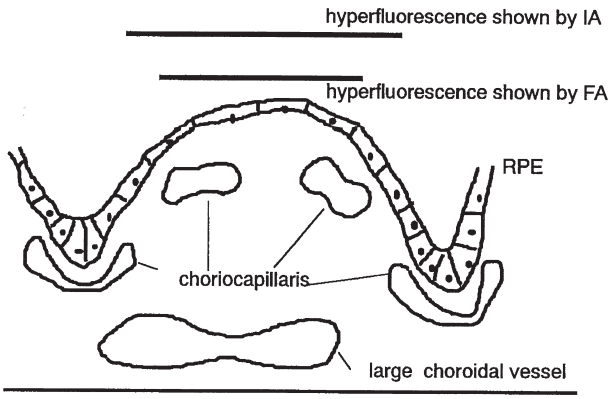

Figure 6. Relationship between hyperfluorescence on both fluorescein angiography (FA) and indocyanine green angiography (IA) in cross-sectional view of choroid and retinal pigment epithelium (RPE). Number of folds is same but folds are wider on IA than on FA.

venous plexus and into the vortex veins is compromised due to structural alterations within the scleral wall. In other cases, posterior scleritis or other local inflammatory conditions may have first produced the fold, which then persists long after the inflammation has resolved.[2] One of the 5 eyes in our own study with idiopathic choroidal folds showed choroidal venous congestion in the early phase of IA. We considered the possibility of drainage through the choroidal venous plexus and into the vortex veins, ie, abnormal drainage due to structural alterations within the scleral wall.[2] However, IA revealed no choroidal vasculature abnormalities in 4 of the eyes. The differences from IA findings suggest that idiopathic choroidal folds diagnosed clinically represent diseases of different etiology.

No abnormalities in choroidal filling were observed in the 2 eyes with AMD. Folds radiating from a macular lesion were thought to be traction folds, consisting mainly of the retinal pigment epithelium and superficial layer of the choroid. Therefore, filling of the large choroidal vessels seen on IA was not influenced by these folds.

Choroidal folds showed alternating black and white lines on FA. The white portion corresponded to the crests of the folds transmitting choroidal fluorescence, while the black portion corresponded to the valleys of the folds and transmitted the choroidal fluorescence poorly.[13] Norton[3] assumed that the increased transmission of the crests was related to atrophy of the overlying pigment epithelium, while the decreased fluorescence of the valleys was related to their failure to reflect light well, resulting in an increased thickness to the pigment layer. The hyperfluorescent lines corresponding to folds showed two patterns on IA, versus only one on FA. The first IA pattern consisted of less numerous and wider hyperfluorescent lines than those seen on FA (Figure 5). The hyperfluorescent lines of the second IA pattern were just as numerous as those seen on FA but were wider (Figure 6). We considered the first IA pattern to indicate that the valley was shallow and that the near-infrared light had penetrated the RPE, so that hyperfluorescence reflected choroidal fluorescence and was being observed through the RPE in that area. This resulted in broad hyperfluorescent lines less numerous than those seen on FA. During FA the RPE served as an efficient fluorescence filter, so that multiple narrow hyperfluorescent lines were observed. We assumed that the second IA pattern represented the condition in which the valleys were deeper. The number of folds observed was the same, but the folds were wider on IA than on FA (Figure 6). We considered FA to show the hyperfluorescence of the window defect, reflecting only the crests of the folds corresponding to the stretched RPE. On the other hand, IA showed broad hyperfluorescence corresponding to the underlying congested choroidal filling of wide areas of chorioretinal folds. We consider IA to be useful for evaluating both pathologic conditions of the choroidal vasculature, which are closely related to the genesis of choroidal folds, and the width of folds in the choroid. Once ICG angiographic findings of choroidal folds have been fully characterized, based on examining larger numbers of eyes with chorioretinal folds of various etiologies, we anticipate that IA will be useful for identifying the cause of

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chorioretinal folds. We plan to examine a larger number of cases with choroidal folds attributable to the above-mentioned disorders as well as to other causes.

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