Correlation between Status of Foveal Inner Segment/Outer Segment Line and External Limiting Membrane Layer Integrity and Visual Outcome in Acute Central Serous Chorioretinopathy

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Abstract

***Purpose*:** To evaluate the correlation between inner segment/outer segment (IS/OS) line and external limiting membrane (ELM) layer integrity at foveal center and visual outcome and to investigate the prognostic factors in optical coherence tomography (OCT) that related to final visual acuity (VA) and recovery time in acute central serous chorioretinopathy (CSC)

***Methods*:** We prospectively studied 108 consecutive patients (114 eyes) with acute CSC. The status of IS/OS line and ELM layer in the foveal center were assessed using OCT at initial and follow-up observation. OCT parameters including subretinal fluid (SRF) height (h), SRF width (w), central retinal thickness (r), total central foveal thickness (f), macular volume, and SRF surface were measured.

***Results*:** Ninety-four eyes (49 OD and 45 OS) from 88 patients (70 men and 18 women) were enrolled. No correlation was found between the total central foveal thickness at the center of the fovea and the final best corrected visual acuity (BCVA) levels (p=0.51). Final BCVA in patient with intact IS/OS junction and intact ELM at the fovea was significantly greater compared with absent or interrupted groups. We found significant correlation between the BCVA at the first visit and the final levels (p≤0.0001; r=0.69). Also there was significant correlation between final BCVA and recovery period (p≤0.0001; r=0.47). Although, there was no correlation between the recovery period and subretinal fluid volume, SRF height, SRF width, and SRF surface area, but there was correlation between the recovery period with SRF height to width ratio (p=0.0052; r=0.26).

***Conclusion*:** We reported that absence or interruption of foveal IS/OS junction and ELM layer, poor VA at initial visit, systemic diseases, use of certain drugs, and SRF height to width ratio in OCT is associated with poor final VA or longer duration of recovery time which in turn causes poor final VA in acute CSC.

***Keywords*:** External Limiting Membrane, Acute Central Serous Chorioretinopathy, Visual Outcome

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Introduction

Central serous chorioretinopathy (CSC) is an idiopathic condition characterized by serous retinal detachment secondary to the leak at the level of the choriocapillaris.[1,2] It occurs most commonly in healthy men of 25-55 years of age.[3-5] The clinical diagnosis is confirmed by fluorescein angiography (FA) and optical coherence tomography (OCT).[6] The pathogenesis of CSC remains incompletely understood.[7,8] Following the natural course, in 80-90% of cases subretinal fluid resolves within 3-4 months without any treatment.[9] These eyes achieve full recovery of visual acuity (VA), but some eyes show poor visual recovery and visual recovery may be restricted in 22-40% of patients, even after complete absorption of subretinal fluid.[10] In recurrent and chronic cases, irreversible visual attenuattion can be seen with the development of retinal pigment epithelium (RPE) atrophy,[1] cystoid macular degeneration,[11] and foveal atrophy.[12]

OCT has contributed to our understanding of the importance of the outer aspect of the foveal photoreceptor layer in visual function in macular diseases,[13-15] specially High-definition OCT that gives us extensive information regarding precise topographic and layer-specific localization of discrete morphological changes indicating the presence of subretinal pathologies or retinal maladjustment caused by the underlying pathology.[16] Increasingly, reports have shown the importance of the inner segment/outer segment (IS/OS) line as a hallmark of integrity of the outer photoreceptor layer.[13-18] Ojima et al showed that a large defect of the outer segments of the foveal photoreceptors is correlated with poor visual outcome in eyes with resolved CSC.[16] In another study,[19] they showed that eyes with good VA at resolution of the CSC, even those with an absent IS/OS line, probably have well-preserved foveal photoreceptor cells and are most likely to show restoration. Eyes with resolved CSC that have poor VA, however, often show no restoration of the IS/OS line and have a poor visual prognosis.

In this study, we evaluated correlation between IS/OS junction layer and external limiting membrane (ELM) integrity at foveal center and visual outcome in acute CSC. We investigated the prognostic factors in OCT that related to final VA and recovery time for acute CSC as well.

Methods

In a prospective study, 108 consecutive patients (114 eyes) with acute CSC was evaluated at the retina service, Department of Ophthalmology, Farabi Eye Hospital, Tehran, Iran, between February 2009 and September 2010, and followed them for at least 6 months before any intervention. At the initial visit, all patients showed active CSC with serous retinal detachment in the posterior pole, none of the patients had yet to be treated, and all were within one months of subjective symptom onset. All patients underwent an ophthalmologic examination, including measurement of uncorrected visual acuity (UCVA), best corrected visual acuity (BCVA), slit-lamp biomicroscopy, determination of intraocular pressure, indirect ophthalmoscopy and slit-lamp biomicroscopy with +90 D lens.

Patients with other ocular abnormalities, such as neovascular maculopathy, drusen, intraocular inflammation, posterior segment tumor or any other condition that could cause a serous retinal detachment unrelated to CSC, those with history of ocular problems in past, eyes with history of trauma, those in which we could not confirm with OCT that serous retinal detachment associated with CSC affected the fovea at the initial visit and those that had not complete follow-up were excluded from our study. Patients that should be treated during 6th month of presentation or did want to be treated were excluded. VA was measured with an ETDRS chart. After a comprehensive ophthalmologic examination fundus autofluorescance (FAF) and OCT (Cirrus HD-OCT, Carl Zeiss) were performed on each patient. FA, using a confocal laser scanning system (HRA-2, Heidelberg Engineering, Dossenheim, Germany) and indocyanine green angiography (ICG) was done in suspicious cases to rule out PCV and CNV. This study was adhered to the Helsinki tenet and approved by the Ethics Committee of Tehran University of medical science. Informed consent was obtained from all patients.

The diagnosis of CSC was based on results of the fundus examination, FA, OCT and ICG in suspicious cases. At the initial

visit, all eyes showed focal serous retinal detachment by fundus examination and OCT. All patients underwent observation to resolve their subretinal fluid. After the initial examination, the patients were reexamined monthly for at least 6 months. Only patients who showed some improvement within the first 3 months in VA and decrease in fluid volume were followed for 6 months if not they were excluded to undergo intervention. At each follow-up visit, all patients underwent a comprehensive ophthalmologic examination, including measurement of BCVA, and OCT.

OCT parameters that we measured were as follows: subretinal fluid (SRF) height (h), SRF width (w), central retinal thickness (r), total central foveal thickness (f), macular volume, and SRF surface (Figure 1). The SRF height was defined as the maximum distance between the photoreceptor layer and the RPE layer; the SRF width was defined as the maximum width of the SRF in the vertical or horizontal OCT scans; the central retinal thickness was defined as the distance between the internal limiting membrane (ILM) layer and the photoreceptor layer; the total central foveal thickness was defined as the distance between the ILM layer and the RPE layer at the fovea; and SRF surface was defined as the maximum surface area between photoreceptor layer and RPE layer in the OCT scans. OCT quantitative measurements including “h”, “w”, and “r” were performed manually using the caliper function in the OCT scans at the vertical and horizontal meridians; the macular volume and total central foveal thickness was generated automatically by the OCT machine using the retinal thickness map function. SRF surface measurements were performed with Image J software, a public-domain, Java-based program (developed by Wayne Rasband, National Institutes of Health, Bethesda, MD; available at http://rsb.info.nih.gov/ij/index.html).

The status of the third high reflectance band (HRB), which has been reported to show reflection derived from the junction between inner and outer segments (IS/OS) of the photoreceptors, and ELM layer (Figure 2) in the OCT scans were interpreted by two of the authors separately that were masked to other clinical data of patient.

The Statistical analysis was performed with SPSS version 16.0 for Windows. $P<0.05$ was considered statistically significant.

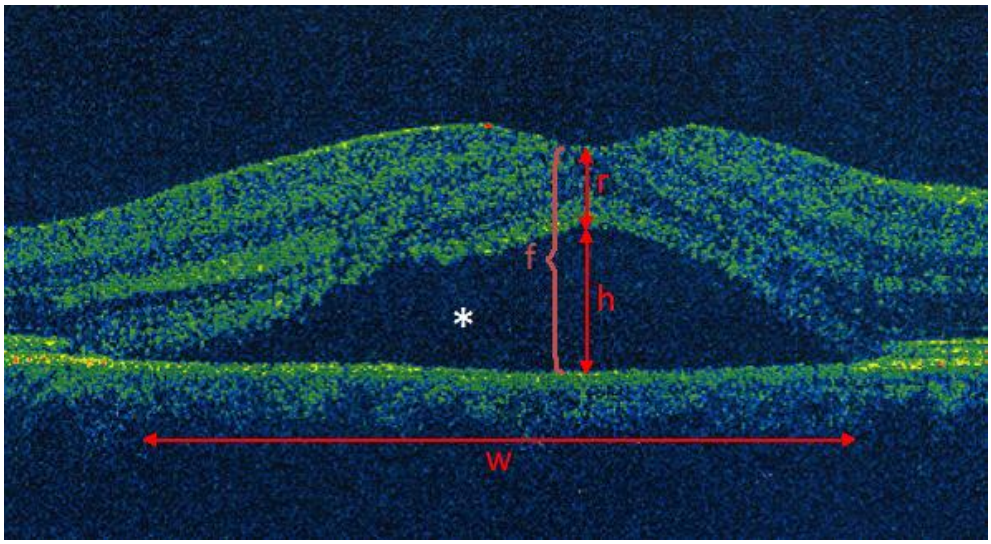


Figure 1. Example of vertical optical coherence tomography scan in an eye with acute central serous chorioretinopathy. The following measurements were performed: subretinal fluid height (h), subretinal fluid width (w), central retinal thickness (r), total central foveal thickness (f), and subretinal fluid surface (*).

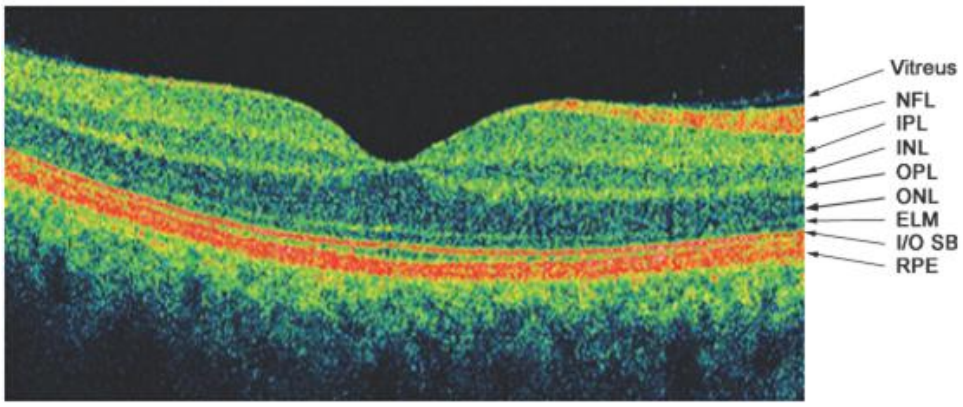


Figure 2. High-definition optical coherence tomography scans of a healthy subject. Anatomic layers of retina can be displayed in high detail.
NFL: Nerve fibre layer, IPL: Inner plexiform layer, INL: Inner nuclear layer, OPL: Outer plexiform layer, ONL: Outer nuclear layer, ELM: External limiting membrane, I/O SB: Inner cone/outer cone segment barrier, RPE: Retinal pigment epithelium (From Ahlers et al study, Acta Ophthalmol 2009:87(5):511-6).

Results

At the time of study, 101 patients with acute CSC (108 eyes) accorded to our inclusion and exclusion criteria's referred to our clinic. Two patients were pregnant and refused to perform OCT and therefore excluded from study. Eleven patients (12 eyes) did not complete follow-up and excluded. Ninety-four eyes (49 OD and 45 OS) from 88 patients (70 men and 18 women) were enrolled. Table 1 shows the demographic and clinical characteristics of the patients.

Seven patients had systemic diseases (two had hypertension, two had DM, one had migraine, one had depression and one had rheumatoid arthritis) and 7 patients (9 eyes) took drugs (one for diabetes mellitus, one took Viagra, three took corticosteroid, and 2 for hypertension and depression) were excluded from the study. In 52 eyes (55.3%) IS/OS junction was intact (Figure 3), in 29 eyes (30.9%) was interrupted (Figure 4), and in 13 eyes (13.8%) was absent (Figure 5). Table 2 shows the clinical characteristics of the intact and absent IS/OS junction groups.

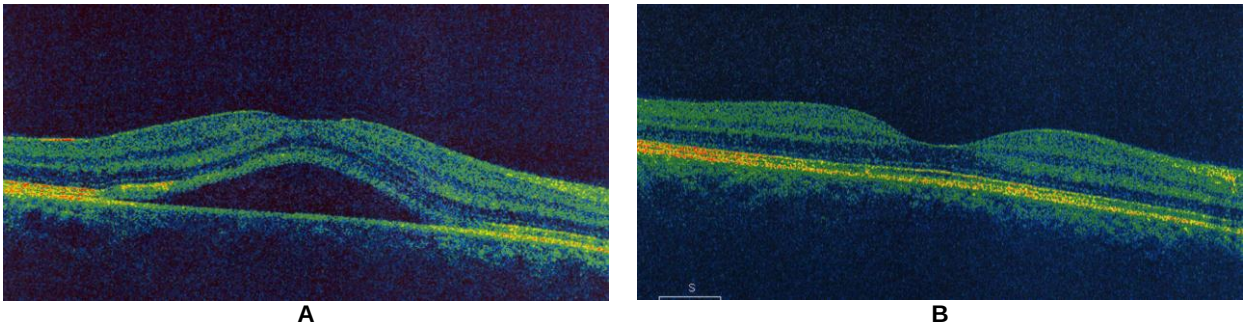
ELM in 64 eyes (68%) was intact, in 23 eyes (24.5%) was interrupted, and in 7 eyes (7.5%) was absent. 12.2 percent of patients had RPE abnormality in OCT, including retinal pigment epithelium detachment (PED) and RPE hypertrophy. At final examination in nine patients (ten eyes) serous retinal detachment had not resolved completely during 6th month follow-up period. Table 3 shows the OCT parameters of patients.

No correlation was found between the total central foveal thickness at the center of the fovea and the final BCVA levels (p=0.51). Final BCVA in patient with intact IS/OS junction and intact ELM at the fovea was significantly greater compared with absent or interrupted groups (Table 2, Table 4).

Final BCVA in patient with negative drug history was significantly greater compared with positive group (p<0.001), but there was no difference in final BCVA in patient with systemic disease, in different seasons, and different gender. We found significant correlation between the BCVA at the first visit and the final BCVA levels (p≤0.0001; r=0.69). Also there was significant correlation between final BCVA and recovery period (p≤0.0001; r=0.47). No correlation was found between the final BCVA and subretinal fluid volume, SRF height, SRF width, SRF surface area, and SRF height to width ratio (Table 5).

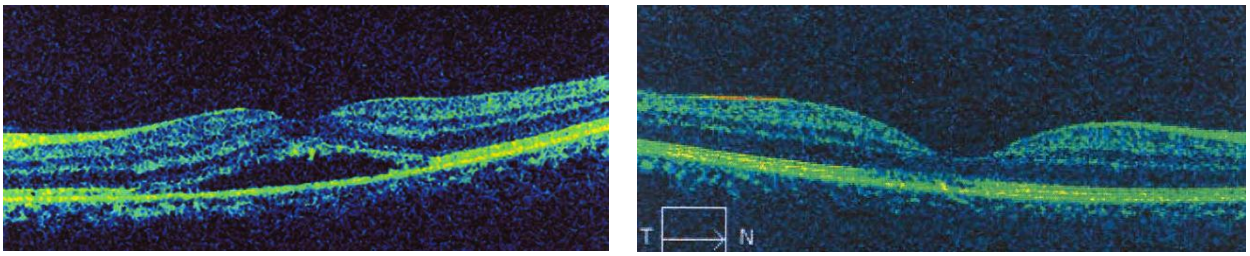
Although, there was no correlation between the recovery period and subretinal fluid volume, SRF height, SRF width, and SRF surface area, but there was correlation between the recovery period with SRF height to width ratio (p=0.005; r=0.26) (Table 5). Recovery period in patient with systemic disease (4.07±1 months) and positive drug history (5.5±1.0 months) was significantly greater compared with other groups (5.5±1.0,

p=0.007; 0.07±1.0, p=0.007). No correlation was found between the integrity of IS/OS junction and ELM at the fovea and the recovery period.



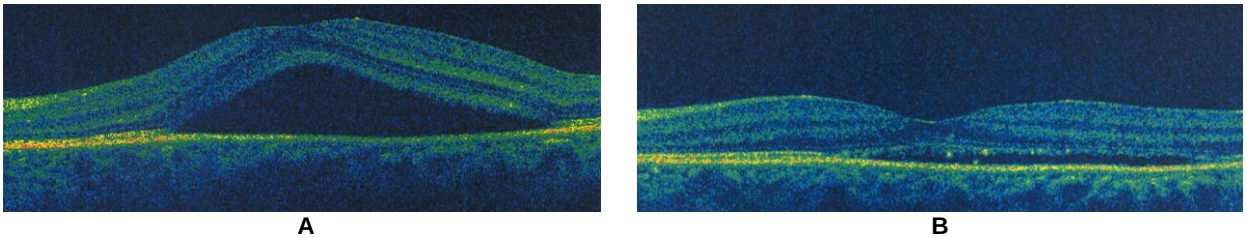
A B

Figure 3. Central serous chorioretinopathy during the acute phase (A) and after resolution of subretinal fluid (B) in a 39-year-old man (case 25). The best corrected visual acuity at first visit was $^{5}/_{10}$ and in final visit $^{9}/_{10}$. As seen inner segment/outer segment junction is intact in both initial and final optical coherence tomography scans. The recovery time was 3 months.



A B

Figure 4. Central serous chorioretinopathy during the acute phase (A) and after resolution of subretinal fluid (B) in a 41-year-old man (case 20). The best corrected visual acuity at first visit was $^{5}/_{10}$ and in final visit $^{7}/_{10}$. As seen inner segment/outer segment junction is interrupted in both initial and final optical coherence tomography scans. The recovery time was 3.5 months.



A B

Figure 5. First and second visit optical coherence tomography scans of case 56 (a 39-year-old women without any systemic disease). The best corrected visual acuity at first visit (symptoms had started since 2 weeks ago) was $^{8}/_{10}$ with +0.75 sphere correction. As seen the IS/OS junction and external limiting membrane layer is absent. At initial (A) optical coherence tomography total foveal thickness was 538 µm (SRF height=302 µm, central retinal thickness=236 µm); the SRF width at horizontal and vertical scans was 3,357 µm and 2,403 µm. At second visit (4 weeks later), the best corrected visual acuity was $^{9}/_{10}$; optical coherence tomography parameter at second visit: total foveal thickness=251 µm, SRF height=25 µm, central retinal thickness=226 µm, SRF width at horizontal=2,574 µm, SRF width vertical scans=1,747 µm. SRF volume had decreased 1.5 mm^3. At final visit (6 weeks after first visit), the best corrected visual acuity unchanged and was $^{9}/_{10}$. This shows that the SRF height had decreased significantly greater than SRF width with time. In this case recovery time since beginning of symptoms was 8 weeks, regardless of the absent of IS/OS junction and external limiting membrane layer.
SRF: Subretinal fluid, IS/OS: Inner segment/outer segment

Table 1. The demographic and clinical characteristics of the patients with acute central serous chorioretinopathy

	Mean±SD	Range
Age (years)	37.94±7.9	18-65
Spherical equivalent refractive error (diopter)	+0.5±0.54	0.00-2.00
logMAR visual acuity at initial visit	0.26± 0.25	0.0-1.0
Duration of symptoms before initial visit (days)	15.3±9.9	2-30
logMAR visual acuity at final visit	0.07±0.16	0.0-1.0
Recovery time (months)	4.15±1.04	2-6

Table 2. Patients characteristic by integrity of the inner segment/outer segment junction at the first visit

	Intact IS/OS junction (n=52)	**Absent IS/OS junction (n=13)**	**p**
Age (years)	35±7.3	41±7.3	0.93
Gender (men/women)	42/10	11/2	0.54
Spherical equivalent refractive error (diopter)	0.51±0.51	0.31±0.57	0.71
logMAR visual acuity at initial visit	0.187±0.174	0.217±0.201	0.72
Duration of symptoms before first visit (days)	13.9±10.0	16.2±10.7	0.70
LogMAR visual acuity at final visit	0.020±0.039	0.10±0.125	0.010*
Total central foveal thickness (µm) at initial visit	502±129	390±113	0.84
Recovery time	3.97±0.67	3.86±1.77	0.001*
SRF height (µm)	305±137	264±129	0.73
SRF width (µm)	3,353±1,307	3,152±1,265	0.97
SRF volume (mm^3)	2.10±1.96	1.56±0.82	0.26
SRF height to width ratio	0.09±0.031	0.086±0.36	0.61

SRF: Subretinal fluid
*: This values are statistically significant.

Table 3. Optical coherence tomography measurements of the 94 eyes with central serous chorioretinopathy

Optical coherence tomography parameters	**Mean±SD**	**Range**
SRF height (µm)	307±140	70-595
SRF width (µm)	3,364±1,250	707-6582
Total central foveal thickness (µm)	482.5±135	221-772
Central retinal thickness (µm)	211±12.3	179-239
SRF surface (μm^2)	76,100±34,547	12,530-166,966
SRF volume (mm^3)	2.04±1.72	0.1-8.7
SRF height to width ratio	0.09±0.03	0.03-0.15

SRF: Subretinal fluid

Table 4. Correlation between the integrity of inner segment/outer segment junction and external limiting membrane at the fovea and the final logMAR best corrected visual acuity

	Final BCVA	**p**
IS/OS junction		
Intact*	0.02±0.04	
-Interrupted	0.19±0.27	0.010
-Absent	0.1±0.12	<0.001
ELM layer		
Intact*	0.035±0.05	
-Interrupted	0.22±0.31	<0.001
-Absent	0.13±0.14	0.008

IS/OS: Inner segment/outer segment
ELM: External limiting membrane
BCVA: Best corrected visual acuity
* : Final best corrected visual acuity in intact groups is compared with interrupted and absent groups.

Table 5. Correlation between logMAR best corrected visual acuity with optical coherence tomography parameters in eyes with central serous chorioretinopathy

Optical coherence tomography parameters	Spearman ρ	p
SRF height (μm)	0.05	0.69
SRF width (μm)	-0.04	0.75
Total central foveal thickness (μm)	- 0.03	0.85
Central retinal thickness (μm)	0.09	0.56
SRF surface (μm^2)	0.12	0.36
SRF volume (mm^3)	0.12	0.36
SRF height to width ratio	0.15	0.26

SRF: Subretinal fluid

Table 6. Correlation between recovery time with optical coherence tomography parameters in eyes with central serous chorioretinopathy

Optical coherence tomography parameters	Spearman ρ	P
SRF height (μm)	0.24	0.07
SRF width (μm)	0.15	0.28
Total central foveal thickness (μm)	0.09	0.51
Central retinal thickness (μm)	0.08	0.24
SRF surface (μm^2)	0.25	0.07
SRF volume (mm^3)	0.20	0.14
SRF height to width ratio	0.26	0.052*

SRF: Subretinal fluid
*: This correlation is not statistically significant, but may be significant with increasing of the sample volume.

Discussion

In a typical acute CSC duration of symptoms and/or retinal detachment is less than six months.[20-24]

It would be of great value to be able to predict final visual outcome in macular diseases. Several studies have reported that the status of the IS/OS junction in the fovea is related closely to VA in eyes with branch retinal vein occlusion (BRVO), retinitis pigmentosa, and neovascular age-related macular degeneration.[25-28] Thus integrity of the photoreceptor layer as a possible marker is attracting a great deal of attention.

Ota et al[25] studied the correlation between integrity of the photoreceptor layer after resolution of macular edema associated with BRVO and final VA and showed that integrity of the foveal retinal photoreceptor layer is associated with good VA, while incomplete visualisation of the third HRB in the fovea could suggest deterioration or disorganisation of photoreceptor cells and is associated with poor final visual outcome. In eyes with retinitis pigmentosa, Sandberg et al[28] reported that decreased VA associated with decreased visualization of the third HRB in the fovea. Eandi et al[10] evaluated the correlation between foveal thickness and anatomical changes within the fovea in the OCT and VA in patients with unilateral resolved CSC. They showed that inability to observe a discrete signal corresponding to the IS/OS junction layer and the ELM layer was more common in involved eyes and was significantly associated with decreased VA. Piccolino et al[17] described the OCT findings in the photoreceptor layer associated with macular detachment in CSC, and reported that that changes within the foveal photoreceptor layer appear to correlate with VA during active disease and can predict the visual outcome after macular reattachment.

In our study, IS/OS junction layer in 52 eyes (55.3%) was intact, in 29 eyes (30.9%) was interrupted, and in 13 eyes (13.8%) was absent. ELM layer in 64 eyes (68%) was intact, in 23 eyes (24.5%) was interrupted, and in 7 eyes (7.5%) was absent. Final BCVA in patient with intact IS/OS junction layer at the fovea was significantly greater compared

with interrupted group (p=0.001) and absent group (p=0.002). Also, final BCVA in patient with intact ELM layer at the fovea was significantly greater compared with absent of it (p=0.002) or interrupted group (p≤0.0001). This finding is compatible with other studies results. No correlation was found between the integrity of IS/OS junction layer and ELM layer at the fovea and the recovery period. Ojima et al[19] reported that in eyes with active CSC, disappearance of the IS/OS junction layer may not always indicate that the photoreceptor segments are substantially destroyed. Even if an eye with active CSC does not show a distinct IS/OS junction layer beneath the fovea, good VA is often obtained when the SRF is resorbed. In our study, only 3 patients showed restoration of IS/OS junction layer in final OCT, and had a poor final visual outcome.

In cases that outer retinal layers and therefore IS/OS junction were damaged, by using the ELM line as a reference, varying features in the IS/OS line were delineated. This finding suggests that the disruption of the IS/OS line is not enough for assessment of the degree of photoreceptor damages that results in the visual impairment.[16] Eandi et al[10] reported an association between absent of the ELM and IS/OS in eyes with atrophic foveas and poor VA, but in the Ojimi et al[16] study, the ELM line was visible even in eyes with atrophic foveas, and therefore, they concluded that the relationship between each feature and visual dysfunction could not be determined. In our study absence of the ELM was associated with poor final visual outcome and is compatibe with Eandi et al[10] study.

Eandi et al[10] found that there was a statistically significant correlation between the foveal thickness and the VA, even in eyes with relatively good VA. Yip et al[29] showed that logMAR BCVA did not correlate with any of the OCT parameters including central SRF thickness, central retinal thickness, total central foveal thickness, SRF diameters, and macular volume. In our study, no correlation was found between the final BCVA and subretinal fluid volume, subretinal fluid height, subretinal fluid width, central retinal thickness, total central foveal thickness, subretinal fluid surface, and subretinal fluid height to width ratio. Also, there was no correlation between this OCT parameters, except for subretinal fluid height to width ratio, and recovery time. We found that lower SRF height to width ratio associated with shorter recovery time (p=0.052; r=0.26). In most of the patients (78%), the first prominent change in OCT parameters at follow-up was decrees of SRF height, and decrees in width of SRF was slow. Even in three patents, although the SRF volume did not decreased after 4 months, but the SRF height was decreased, and SRF width increased. This finding may be able to help us in better understanding a feature of pathogenesis of CSC.

It seems that a necessary condition for extension of serous detachment beyond the leakage site is an intact tight junctional RPE barrier under the elevated retina (except directly over the areas of leakage). An altered capacity for absorption of SRF by RPE cells in CSC would explain why SRF under a large retinal detachment can be absorbed within 24 hours after placement of a scleral buckle, but the fluid under the serous detachment in CSC may require weeks to be absorbed even after the leakage has been stopped by photocoagulation. It seems that with time the SRF height to width decreases, and this change may help to altered RPE to work in increased area, as a compensatory mechanism.[30,31]

At present, it is thought that the primary pathology of acute CSC is disruption of the choroidal circulation. Choroidal vascular abnormalities and subsequent RPE alterations, allowing exudation from the choroidal vasculature to pass into the subretinal space, resulting in detachment of the neurosensory retina.[32] In the ophthalmic literature, there are limited information about the relationship between choroidal vascular abnormalities and RPE abnormalities such as RPE hypertrophy, small RPE bulging and pigment epithelial detachments (PEDs) in eyes with CSC in literature. It has been reported that eyes with asymptomatic active CSC or asymptomatic fellow eyes of active CSC often show small serous PED. Hirami et al[33] reported that RPE abnormalities were within areas of choroidal vascular hyperpermeability. In the current study, we observed RPE abnormalities in 12.2% of eyes with acute CSC including PEDs, small RPE bulging and RPE hypertrophy. There might be a defect in the RPE layer that allows passage

of fluid from the sub-RPE to the subretinal area, although OCT has not documented such a defect. It was recently reported that eyes with acute CSC often showed a small bulge of RPE on OCT images, consistent with a leaking point seen by FA,[32] but we didn't find any correlation between RPE abnormality and leaking point. Also there was no correlation between RPE abnormalities and final visual outcome and recovery time.

The main limitation in this study may be the referral bias. In fact, all of our patients referred from other centers and the mild cases may have not been referred or refused the follow-up. Another limitation was that the BCVA in some cases is not good measurement to show visual impairment. In some cases the first VA was $^{20}/_{20}$, but patient described visual alteration. In the other hand, although the correlation between structural changes and VA is established, determination of VA in CSC may not solely represent the changes in visual functions, and despite a slight reduction in BCVA, patients may show scotoma in their fundus perimetry or microperimetry.[34]

Conclusion

Our study showed that absence or interruption of foveal IS/OS junction and ELM layer, poor VA at initial visit, use of certain drugs, and some OCT parameters associated with poor final VA or longer duration of recovery time which in turn causes poor final VA in acute CSC. In these situations early interventions such as intravitreal Bevastizumab or photodynamic therapy may be useful to achieve better final visual outcome.

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