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ORIGINAL PAPER

Correlation of retinal sensitivity with visual acuity and macular thickness in eyes with idiopathic epimacular membrane

Murat Karacorlu · Hakan Ozdemir · Fevzi Senturk · Serra Arf Karacorlu · Omer Uysal

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Abstract The aim of this study was to analyze macular function by measuring the sensitivity of the macula with fundus-related microperimetry and to compare the results with the best corrected visual acuity (BCVA) and foveal retinal thickness measured by optical coherence tomography (OCT) in patients with idiopathic epimacular membrane. We prospectively reviewed 66 eyes with idiopathic epimacular membrane and 35 normal healthy eyes in patients who had undergone fundus-related microperimetry and OCT. The macular sensitivity was measured using the recently introduced fundus-related microperimeter, MP-1. The mean retinal sensitivities in the central 10° (central microperimetry, cMP-1) and in the paracentral 10–20° (paracentral microperimetry, pMP-1) areas were determined and correlated with the BCVA and OCT-measured foveal thickness. Eyes with epimacular membranes showed significantly lower log MAR BCVA ($P < 0.001$) and cMP-1 microperimetry sensitivity ($P < 0.001$) and significantly higher OCT foveal thickness ($P < 0.001$) than control eyes. There was a significant correlation between the BCVA and mean retinal sensitivity in the cMP-1 ($r^2 = 0.26$, $P < 0.001$) and the pMP-1 ($r^2 = 0.07$, $P = 0.008$) areas. A significant negative correlation was observed between the foveal thickness and the mean retinal sensitivity in the cMP-1 ($r^2 = 0.13$, $P < 0.001$) area. Retinal sensitivity in the central macular area determined by MP-1 microperimetry was significantly correlated with BCVA and with foveal thickness. The combination of OCT and microperimetry may help a better evaluation of the patients with idiopathic epimacular membrane.

Keywords Microperimetry · Idiopathic epimacular membrane · Macular function · Retinal sensitivity · OCT

M. Karacorlu (✉) · H. Ozdemir · F. Senturk · S. A. Karacorlu
The Istanbul Retina Institute, Hakkı Yeten Cad., Unimed Center, No 19/7, Sisli, 34349 Istanbul, Turkey
e-mail: retina@pobox.com

O. Uysal
Department of Biostatistics, Cerrahpasa School of Medicine, University of Istanbul, Istanbul, Turkey

Introduction

Epimacular membranes are cellular membranes that proliferate over the central macular region. These membranes are composed of fibroblasts, glial cells, macrophages, myofibroblasts, and retinal pigment epithelium [1]. They are common, typically affecting patients older than 50 years of age, and they may result from a variety of causes, including retinal tears, retinal vascular occlusions, and trauma [2]. Idiopathic epimacular membranes have no obvious cause, although most are associated with a posterior vitreous detachment. Diagnosis of epimacular membrane is

based on fundus biomicroscopy. Fluorescein angiography supplies additional information regarding fluorescein leakage and the possible presence of cystoid macular edema [3]. Optical coherence tomography (OCT) provides a means of evaluating the cross-sectional characteristics of the retina and neighbouring structures, such as slight detachment of the posterior hyaloid. It is also useful in demonstrating changes in the underlying neurosensory retina constricted by epimacular membranes. In most cases, OCT shows macular thickening resulting from constriction of the membrane, which results in the disappearance of the foveal depression [4].

Abnormalities of macular function have been demonstrated in eyes with epimacular membranes by subjective tests and also by objective methods, such as focal macular electroretinography (ERG) and multifocal electroretinography (mfERG) [5–7]. It is also possible to evaluate macular function by microperimetry. The recently introduced fundus-related microperimeter, MP-1, can be used to obtain quantitative and reliable measurements of retinal sensitivity by tracking eye movements while the patient fixates a target [8]. This system uses a tracking software which monitors fundus movements to ensure that the anatomic landmarks revealed in the fundus photographs are precisely aligned with the sensitivity maps generated by the perimeter. This instrument allows the overlaying of retinal sensitivities onto a real-color fundus image to indicate the retinal areas where visual defects coincide with visible structural anomalies [8].

The purpose of this study was to analyze macular function by measuring the sensitivity of the macula with the MP-1 microperimeter and to compare the perimetric results with the best corrected visual acuity (BCVA) and foveal retinal thickness measured by OCT in patients with idiopathic epimacular membrane.

Methods

Sixty-six eyes of 66 consecutive patients (26 men and 40 women) with idiopathic epimacular membrane were included. The mean age of patients was 67 years (range 40–79 years). The eligibility criteria for this study included: (1) the presence of idiopathic epimacular membrane on fundus examination, and (2) the presence of thin, highly reflective bands on the surface of the retina and macular thickening resulting from the constriction of the membrane, causing disappearance of the foveal depression on OCT. Because several diseases may influence microperimetry and BCVA, we excluded patients with moderate to dense lens opacity, corneal opacities, a history of refractive surgery, glaucoma or ocular hypertension, a history of intraocular inflammation such as anterior or posterior uveitis, multifocal choroiditis, a history of retinal detachment, a history of ocular trauma, and optic neuropathy. In this consecutive series, no eyes had pseudohole, vitreomacular traction or cystic retinal cavities on either fluorescein angiography or OCT examination. No patient had a relative afferent pupillary defect in their affected eyes. In all, 35 subjects, ranging in age from 46 to 81 (mean age = 67 years), without ophthalmic abnormalities comprised the normal control group. Written informed consent was obtained from all subjects, and the study was conducted in accordance with the tenets of the Declaration of Helsinki.

The patients underwent complete ophthalmic examination, including BCVA measurement (with ETDRS chart), slit lamp biomicroscopy, indirect ophthalmoscopy, color fundus photography, fluorescein angiography and OCT. Best corrected VA, expressed as log MAR, was obtained at a distance of 4 m. OCT examinations were performed using an OCT 3000 scanner (Carl Zeiss Ophthalmic System, Humphrey Division, Dublin, CA, USA). All OCT examinations were done by the same operator and all scans were done with a scan length of 6 mm. The foveal thickness was defined as the distance between the vitreoretinal interface and the retinal pigment epithelium in the centre of the fovea.

Macular sensitivity was evaluated by MP-1 microperimetry (Nidek Technologies, Italy). The recently developed MP-1 (Version MP1 SW 1.4.1 SP1, available in June 2003) was used for microperimetry. The MP-1 provides a 45° nonmydriatic view of the fundus with an automated correction for eye movements. Goldmann III stimuli and a 4-2 staircase strategy were used, and a circular test grid with 74 stimulus locations covering an area of 20° was applied. The mean retinal sensitivities at the 28 locations covering the central 10° (central microperimetry, cMP-1) and at the 48 locations covering the paracentral 10–20° (paracentral microperimetry, pMP-1) were determined.

The stimuli were projected on a white background with background luminance set to 1.27 cd/m^2 and a stimulus presentation time of 200 ms. The perimetric strategy of the current software version of the MP-1 starts at an initially defined threshold level for each stimulus. A 4-2 staircase strategy is then carried out, and the last seen threshold value is taken as the final threshold. Although the examiner can define the initial threshold value, the actual threshold of the examined eye remains unaccounted. In addition, the instrument tests the same luminance levels at all test locations before moving onto the next luminance level (i.e., at all locations 1 luminance level is projected after the other). Differential light threshold values were compared by calculating selected points, which were averaged automatically by the MP-1 microperimetry software program for mean sensitivity in a polygon.

Results from control eyes and eyes with epimacular membrane were compared by Student's *t* test. The correlation between BCVA and the mean retinal sensitivity of the cMP-1 and the pMP-1 and the correlation between the foveal thickness and the mean retinal sensitivity in the cMP-1 and pMP-1 were analysed with linear regression test.

Results

The BCVA (in log MAR units), OCT foveal thickness, and mean retinal sensitivity for cMP-1 and pMP-1 areas are presented in Table 1. Eyes with epimacular membranes showed significantly lower log MAR BCVA ($P < 0.001$) and cMP-1 microperimetry sensitivity ($P < 0.001$) and significantly higher ($P < 0.001$) OCT foveal thickness and show border significantly different pMP-1 microperimetry sensitivity ($P = 0.04$) than control eyes. The microperimetry test result and OCT image from a patient with idiopathic epimacular membrane are shown in Fig. 1.

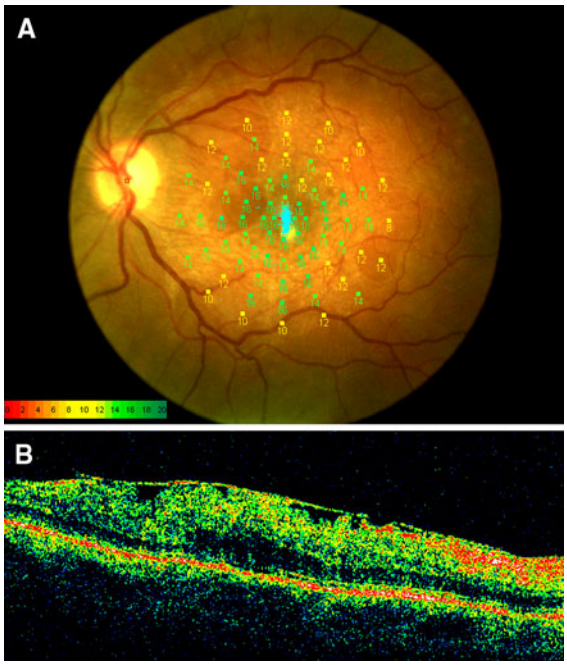

Fig. 1 **a** Microperimetry test result and **b** OCT image from a patient with idiopathic epimacular membrane. The color-coded, numeric scale shows the threshold in 2-dB steps from 0 to 20 dB

There was a significant correlation between BCVA and mean retinal sensitivity of the cMP-1 ($r^2 = 0.26$, $P < 0.001$) and the pMP-1 ($r^2 = 0.07$, $P = 0.008$) areas (Fig. 2).

A significant negative correlation was observed between the foveal thickness and the mean retinal sensitivity in the cMP-1 ($r^2 = 0.13$, $P < 0.001$) area (Fig. 3).

Table 1 BCVA (log MAR), foveal thickness, mean sensitivity of the central retina (*cMP-1*) and paracentral retina (*pMP-1*) in diseased and normal eyes

	Normal eyes (mean ± SD)	Eyes with epimacular membrane (mean ± SD)	*t*	*P*
BCVA (log MAR)	0.00 ± 0.00	0.34 ± 0.15	17.91	<0.001
Foveal thickness (μm)	214.11 ± 16.19	402.59 ± 79.52	18.50	<0.001
Mean retinal sensitivity (dB)				
CMP-1 (0°–10°)	14.39 ± 1.44	12.59 ± 1.52	4.56	<0.001
PMP-1 (10°–20°)	13.24 ± 1.47	12.59 ± 1.52	2.07	0.04

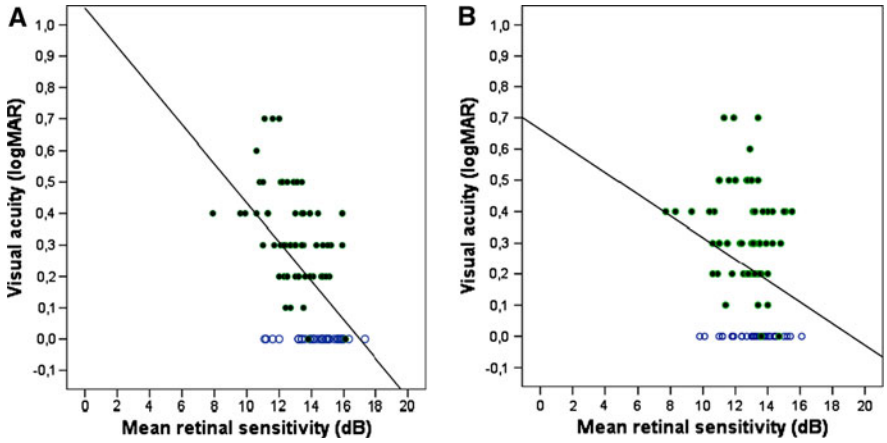

Fig. 2 **a** Relationship between mean central retinal sensitivity and BCVA in log MAR units for the diseased eyes (*closed circle*) and normal eyes (*open circle*). The linear regression line for all subjects is $y = 1.054 - 0.062x$ ($r^2 = 0.26$, $P < 0.001$). **b** Relationship between mean paracentral retinal sensitivity and BCVA in log MAR units for each of the diseased eyes (*closed circle*) and normal eyes (*open circle*). The linear regression line for all subjects is $y = 0.66 - 0.035x$ ($r^2 = 0.07$, $P = 0.008$)

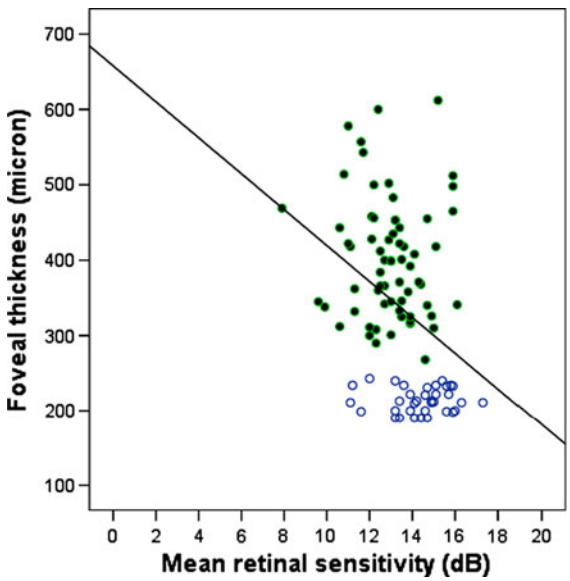

Fig. 3 Relationship between mean central retinal sensitivity and foveal thickness for the diseased eyes (*closed circles*) and normal eyes (*open circle*). The linear regression line for all subjects is $y = 657.73 - 23.84x$ ($r^2 = 0.13$, $P < 0.001$)

Discussion

Epimacular membranes are hypocellular, largely collagen structures caused by glial proliferation through a defect in the internal limiting lamina, usually caused by posterior vitreous detachment [1]. Most patients show a satisfactory recovery after successful removal of the membrane and BCVA improves in almost 75% of cases, although some patients complain of abnormal colour vision, metamorphopsia, and light sensation [9, 10]. This means that, despite the improvement in BCVA and the amelioration of metamorphopsia, central retinal function is not normal and other types of visual function tests must be adopted for the interpretation of retinal function [11]. In eyes with epimacular membranes, macular functions can be evaluated by electrophysiological and psychophysical methods. Focal ERG is an electrophysiological method that requires prolonged recording time and varying signal-to-noise ratios [5]. In addition, focal ERG was designed to assess the macular area within 10°, so it is impossible to evaluate the electrophysiologic response in the perimacular area by this method [5]. Using multifocal ERG, which is another electrophysiological method, it is possible to study simultaneously not only the macular area but also the retina extending 30° around the macula [12]. With both techniques, abnormalities of macular function have been demonstrated in eyes with epimacular membranes [4–6]. Tanikawa et al. [5] found a statistically significant reduction in the amplitude of the a- and b-waves and the oscillatory potentials in the focal macular electroretinogram of eyes with idiopathic epimacular membrane. The reduction in the amplitude of the oscillatory

potentials was significantly greater than that of the other two components. They stated that the abnormalities in eyes with epimacular membrane were similar to those of eyes with cystoid macular edema. This suggests that the epimacular membrane probably induced damage to the neurons in the inner retinal layers. Dysfunction of these neurons is one possible cause of visual impairment in this disease.

Niwa et al. [6] studied the function and morphology of the macula of the eye before and after the removal of an idiopathic epimacular membrane. Their findings confirm that a- and b-waves and oscillatory potentials in eyes with epimacular membrane are significantly lower than those in the normal fellow eyes. After surgery the amplitudes of b-wave and oscillatory potentials were still significantly smaller in the affected eyes. The mean foveal and parafoveal thicknesses were significantly less after surgery; however, the thickness was still greater in the affected eyes. They claimed that the decrease of the b-wave and oscillatory potentials in the 29 eyes examined after surgery could be due to the still thickened macular retina.

Watanabe et al. [13] examined whether OCT findings correlated with visual acuity and metamorphopsia in patients with epiretinal membrane. They found that the thickness of the inner nuclear layer ($A = 0.681$, $P = 0.001$) and the outer nuclear layer ($A = -0.708$, $P < 0.001$) of the retina was significantly correlated with visual acuity. Perimetry examines the light differential threshold, which is different than the minimal angle of spatial resolution (also termed as visual acuity). The latter markedly depends on the clearness of the optic media, while the light differential threshold mainly depends on the intactness of the photoreceptors. In our study, macular function, measured by the sensitivity of the macula with MP-1 microperimetry, was analysed and perimetric results were compared with the BCVA and the foveal retinal thickness. According to our results, there was a significant correlation between the BCVA and mean retinal sensitivity and a significant negative correlation between the foveal thickness and the mean retinal sensitivity. The negative correlation between the foveal thickness and retinal sensitivity may not be explained by only the elevation of the macula and the retinal distortion due to hypocellular contraction of the epimacular membrane [4]. Theoretically, the light filtering and the Stiles–Crawford effects caused by the epimacular membrane may lead to abnormal retinal function. The optical density of the epimacular membrane (light filtering effect) and the photoreceptor distortion caused by traction (Stiles–Crawford effect) may decrease the retinal sensitivity by reducing the amount of light absorbed by photoreceptors [7]. But it is probable that the photoreceptor damage secondary to epiretinal membrane might play a role in the reduced sensitivity of the macula. It may help the explanation of the Niwa's results [6] which showed that after surgery the amplitudes of b-wave and oscillatory potentials were still significantly smaller in eyes with epiretinal membrane.

In conclusion, retinal sensitivity of the macular area determined by MP-1 microperimetry was significantly correlated with BCVA and with foveal thickness revealed by OCT. The combination of OCT and microperimetry may provide a better evaluation of the patients with idiopathic epimacular membrane.

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