eye reports

The evaluation and correlation of subfoveal choroidal thickness and macular hole apical and basal diameters with enhanced depth imaging optical coherence tomography in patients with idiopathic macular hole

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Abstract

Purpose: To investigate the evaluation and correlation between apical and basal hole diameters and subfoveal choroidal thickness (SCT) in patients with idiopathic macular hole (IMH), using enhanced depth imaging optical coherence tomography (OCT).

Methods: This cross-sectional study included 30 eyes of 30 patients with IMH and 30 healthy controls eyes. The SCT of subjects were measured using enhanced depth imaging OCT and the results were compared. In the IMH group, the mean horizontal apical and basal diameters of IMH were calculated and the correlation between mean apical and basal diameters and SCT were investigated. All patients with IMH underwent vitreoretinal surgery and the SCT at third postoperative month was compared with the preoperative values.

Results: The mean age and gender distributions of the groups were similar ($p = 0.082$ and $p = 0.605$). The mean SCT was 241.73 ± 57.20 µm in the IMH group and 280.30 ± 72.22 µm in the control group. The SCT of the IMH group was thinner than that of the control group ($p = 0.025$). The mean apical and basal diameters of the IMH were 395.30 ± 190.71 µm and 920.70 ± 428.19 µm, respectively. There was a significant negative correlation between mean apical diameter and SCT of IMH ($r = -0.373$, $p = 0.042$) and there was no significant correlation between mean basal diameter and SCT of IMH ($r = -0.282$, $p = 0.131$). The mean SCT was 237.19 ± 43.61 at the third postoperative month and there was no significant difference between the postoperative and preoperative values of the IMH group ($p = 0.555$).

Conclusion: The SCT is thinner in IMH patients than that of healthy subjects, and there is a statistically-significant negative correlation between the apical hole diameter and SCT. In the early stage (three-month postoperative) after anatomical closure of IMH with vitreoretinal surgery, the SCT does not change significantly.

Introduction

The choroid is a dense tissue, which has important roles in the oxygenation, temperature regulation,

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positional state and the secretion of growth factors in the retina.[1] Enhanced depth imaging (EDI) spectral-domain optical coherence tomography (OCT) allows a cross-sectional view of the choroid in vivo.[2] In various studies performed with OCT, mean subfoveal choroidal thickness (SCT) has been found to be 270-354 µm in healthy subjects though it is quite variable. SCT decreases with increasing age, axial length, and myopia.[3-6] It can be affected by many ocular diseases. Previous studies have reported that central serous chorioretinopathy and Vogt-Koyanagi-Harada disease are associated with a thicker SCT, and age-related macular degeneration with a thinner SCT.[7-9] Some authors have suggested that changes in SCT are associated with changes in choroidal circulation or inflammation.[7,8,10]

A full-thickness retinal defect in the fovea associated with an anomalous posterior vitreous detachment was described as full-thickness macular hole, by the International Vitreomacular Traction Study Group.[11] A full-thickness macular hole is commonly referred to as an idiopathic macular hole (IMH) if it is not associated with high myopia, trauma, or other ocular conditions.[12] Surgical intervention consist of pars plana vitrectomy, commonly with internal limiting membrane peeling and long-acting gas tamponade injection. Despite favorable anatomic and functional results of surgery, the exact pathophysiology of IMH remains unknown.[13]

The aim of this study is to compare SCT in patients with IMH and healthy control subjects, to investigate correlations between apical and basal diameters of IMH and SCT of IMH, and to evaluate the changes after anatomic IMH closure with vitreoretinal surgery.

Patients and Methods

This cross-sectional study was performed in the University of Health Sciences, Ulucanlar Eye Training and Research Hospital, Ankara, Turkey, between June 2016 and June 2018. The study was approved by the Local Ethics Committee and the tenets of the Declaration of Helsinki were followed. Written informed consent was obtained from all subjects.

The inclusion criteria were 1) decreased vision for the last 6 months due to full-thickness macular hole based on the International Classification System for Vitreomacular Adhesion, Traction and Macular Hole,[11] 2) less than 3 D spherical and less than 1 D cylindrical refractive error, and 3) no cataract or less than grade 2 nuclear sclerotic cataract based on the Lens Opacification Classification System III.[14] The exclusion criteria were determined as 1) less than 20 and greater than 24 mm axial length, 2) history of ocular trauma or surgery (including cataract surgery, intravitreal injection, and retinal photocoagulation), 3) retinal vascular disease (retinal vein occlusion, diabetic retinopathy, etc.), 4) history of chronic ocular disease (uveitis, glaucoma, retinitis pigmentosa, senile macular degeneration, etc.), 5) concurrent use of topical steroid or prostaglandin analogs, 6) presence of any sign of past ocular inflammatory disease (keratic precipitates, posterior synechia, etc.), 7) any systemic inflammatory condition (rheumatoid arthritis, systemic lupus erythematosus, etc.), 8) any systemic ischemic condition (diabetes mellitus, sickle cell disease, etc.), and 9) history of cranial radiotherapy. Thirty eyes of 30 Caucasian patients with IMH were included in the study. The control group was formed of the right eyes of 30 age and gender-matched healthy Caucasian subjects.

Standard ophthalmological examinations including best corrected visual acuity with a Snellen chart, intraocular pressure with applanation tonometry, anterior segment and dilated posterior segment slit-lamp biomicroscopy, axial length measurement with a-mode ultrasonography, and enhanced depth OCT imaging (Spectralis, Heidelberg Engineering, Heidelberg, Germany) were performed on all participants. The SCT was measured manually from the posterior edge of the retinal pigment epithelium (RPE) to the choroidoscleral interface at the fovea. In the horizontal section, the apical diameter was measured as the minimum distance at the apex of the neurosensory retinal defect of the IMH, and the basal diameter was measured as maximal distance at the base of the IMH at the level of the RPE. The measurements of apical and basal diameters were performed manually using the caliper function (Figure 1). The SCT measurements were repeated for the IMH group at the end of the postoperative third month. All manual measurements were made by two researchers blinded to the study, and the average values were used for statistical analysis.

25-gauge pars plana vitrectomy, internal limiting membrane peeling, and long-acting gas (16% C_3F_8) injection (Constellation, Alcon, Fort Worth, Texas) was performed in the patients with IMH. Diluted triamcinolone acetonide (20% diluted form of 40 mg/mL; Kenacort-A, Istanbul, Turkey) was used to increase the visibility of the posterior hyaloid and remaining vitreous. The internal limiting membrane was peeled with Brilliant Blue G (BBG; Dorc International, Zuidland, The Netherlands) 2-disc diameter around the fovea with ILM forceps. C_3F_8 gas (Perfluoropropane, GOT C_3F_8 multi, Alchimia, Ponte San Nicolo, Italy) was diluted to a concentration of 16% before use in the operated eye. Phacoemulsification and intraocular lens implantation were also performed in the same session if necessary. Patients maintained a prone position for about one week after the surgery. All patients used topical moxifloxacin (Vigamox, Alcon, Fort Worth, Texas) and dexamethasone (Maxidex, Alcon, Fort Worth, Texas). All surgical patients achieved anatomic and functional success, with no postoperative complications (increased intraocular pressure, retinal hemorrhage, retinal tear or detachment, endophthalmitis, etc.) observed.

Descriptive statistics were performed as mean ± standard deviation and frequency distribution was examined. The Chi-square test was used in the analysis of categorical variables. Conformity of the data to normal distribution was assessed with the Kolmogorov–Smirnov test. To compare the two independent groups (IMH and control), an independent sample t-test was used. Pearson correlation analysis was performed to compare apical and basal diameters with SCT of patients with IMH. To compare the preoperative and third postoperative month SCT values of the patients with IMH, a paired sample test was used. Statistical significance was defined as $p<0.05$. Analysis of the data was performed using SPSS 22.0 (IBM, Chicago, Illinois) software.

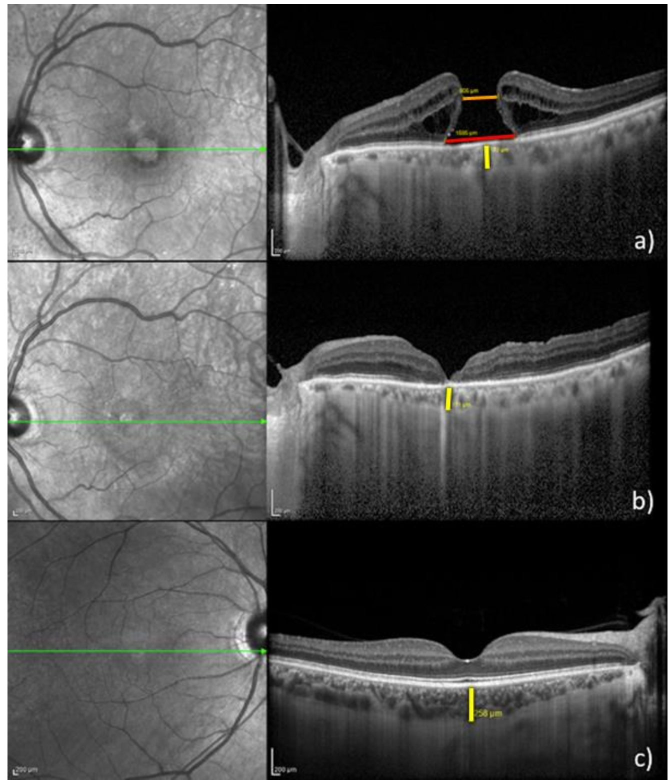

Figure 1
Enhanced depth OCT images [on left] through the fovea [identified by green line in enface infrared photographic images on right] disclose the subfoveal choroidal thickness (SCT) [yellow line], apical macular hole diameter [orange line] and basal macular hole diameter [red line] in: (a) a 63-year-old woman with a macular hole prior to surgical intervention, (b) the same patient after surgical intervention, and (c) a 59-year-old healthy gentleman without macular hole formation.

Results

The mean age was 61.83 ± 9.68 years in the IMH group and 58.03 ± 6.71 years in the control group. The male to female ratio was 13:17 in the IMH group and 15:15 in the control group. No significant differences were observed between the IMH and control groups in terms of the mean age and male to female ratio ($p = 0.082$ and $p = 0.605$, respectively).

The mean SCT was 241.73 ± 57.20 µm (146-350 µm) in the IMH group and 280.30 ± 72.22 µm (155-471 µm) in the control group. There was a significant difference between the IMH and control groups in terms of the mean SCT ($p = 0.025$).

The mean apical and basal diameters of the IMH group were 395.30 ± 190.71 µm (195-871 µm) and 920.70 ± 428.19 µm (335-1965 µm), respectively. A significant negative correlation was found between the apical diameter and SCT of the patients with IMH ($r = -0.373$ and $p = 0.042$). There was no significant correlation between basal hole diameter and SCT of the patients with IMH ($r = -0.282$ and $p = 0.131$).

The mean SCT was 237.19 ± 43.61 µm (161-328 µm) in the third postoperative month in the IMH group and there was no significant difference between the preoperative and third postoperative month SCT ($p = 0.555$).

Discussion

The choroid is the main blood supply of the neurosensory retina and it generally cannot be evaluated with dilated posterior segment slit-lamp or indirect biomicroscopy. EDI-OCT is a method of in-vivo quantitative evaluation of the choroidal thickness.[2] Many studies performed with OCT in IMH cases, have reported a decreased SCT.[15-18] Although anomalous posterior vitreous detachment and vitreomacular traction are the most important predisposing factors in the development of IMH, decreased SCT is also an important risk factor associated with IMH.[11-13] SCT is not directly correlated with pulsatile ocular blood flow or choroidal blood flow as measured by laser Doppler, but it has been claimed that decreased choroidal circulation and a thinner choroid might cause macular hypoperfusion and that deficits in various protective factors cause the macula to be sensitive to some types of damage.[19,20] Zeng, *et al.* suggested that choroidal hypoperfusion played a role in decreased SCT, which may predispose the affected eyes to develop IMH.[15] As with the results of the previous studies, the results of this current study show that patients with IMH have a decreased SCT when compared with healthy subjects. However, whether decreased SCT is a reason for or a result of IMH remains unknown.

A variety of metrics of IMHs, including minimum apical diameter and maximal basal diameter as well as others including maximal hole height, arm lengths, and angle between lifted tissue edge and RPE, have been evaluated in attempt to find correlations with macular hole closure and/or visual acuity outcomes following vitrectomy for IMH.[21] There are many conflicting reports in the peer-reviewed medical literature about the relationship between macular hole diameter and SCT. Reibaldi, *et al.* found no correlation between macular hole diameter and SCT.[16] In contrast, Zeng, *et al.* determined a mildly negative correlation between the apical hole diameter and SCT and between basal hole diameters and SCT.[15] Karkhaneh, *et al.* also found a negative correlation between the apical hole diameter and SCT as well as a negative correlation between the basal hole diameter and SCT.[18] In this current study, there is a negative correlation between apical hole diameter and SCT, and no correlation between basal hole diameter and SCT. These conflicting results may be a result of differences in the duration of the disease because chronicity of the macular hole directly affects the hole diameter and causes decreased SCT.[15] The current study did not include late stage IMH cases although the patients were selected on the basis of visual impairments for the last 6 months. This period may be considered to be relatively short and a longer treatment-free duration could cause an increase in macular hole diameter and a decrease in SCT. Therefore, the correlations between macular hole diameter and SCT can be variable depending on the duration of the disease.

Ahn, *et al.* reported a temporary increase in SCT one week after vitrectomy and this SCT increase subsequently decreased to the baseline value at the end of the first postoperative month.[22] In contrast, Fujiwara, *et al.* reported no change in SCT in the first postoperative week, first postoperative month, and third postoperative month.[23] Similarly, Schaal, *et al.* also reported no change in SCT at the end of the second postoperative month, and sixth postoperative month.[24] Bardak, *et al.* reported postoperative persistence of decreased SCT during a mean 12-month follow-up period.[25] In this current study, the SCT was evaluated at the end of the third postoperative month and no significant difference was determined between the preoperative and postoperative SCT values. Thus, the anatomic closure of the IMH does not affect the SCT in the early postoperative period.

There are several limitations to the current study. The most important is the absence of any objective information about the duration of IMH because chronicity of the disease could have affected all the quantitative results of the study. Therefore, the patient inclusion criterion based on the patient's visual symptoms alone cannot be considered completely reliable. A postoperative follow-up period of 3 months can provide information about the early results of surgery, but this period is insufficient to investigate the full impact of anatomic IMH closure on SCT. A further limitation is that the measurements of choroidal thickness were made manually rather than with automated software.

In conclusion, the results of this study demonstrate that the SCT in eyes with IMH is thinner than that of healthy subjects, and a statistically-significant negative correlation was determined between the apical hole diameter and SCT. In the early stage (three-month postoperative) after anatomical closure of IMH with vitreoretinal surgery, the SCT does not change significantly.

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