Age-related Changes in the Foveal Bulge in Healthy Eyes

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Abstract:

BACKGROUND: Intact foveal bulge has been associated with good visual outcome in retinal diseases. The aim of this study was to study the variation in foveal bulge with age.

METHODS: It was an observational cross-sectional study conducted between October 2014 and December 2015. Totally, 101 eyes of 101 healthy volunteers were studied in a tertiary care center. All individuals had best corrected visual acuity of 20/20 or better. High myopia (>6 D), high hyperopia (>4 D), unstable fixation, media opacities and retinal disorder like diabetic retinopathy, retinal vein occlusion were the exclusion criteria. Spectral domain optical coherence tomography was used to identify foveal bulge. The height of foveal bulge was measured as the distance between inner border of retinal pigment epithelium and outer border of inner segment – outer segment line (ellipsoid zone) at fovea. Main outcome measures were a correlation between the height of the foveal bulge and age of the participants.

RESULTS: Foveal bulge was present in 61 (60.4%) and absent in 40 (39.6%) eyes. Mean age of patients with and without foveal bulge was 33.3 ± 16.2 years and 44.1 ± 20.5 years respectively (P = 0.02). Mean height of foveal bulge was 41.1 ± 6.4 µ (range: 23–51 µ). The height of the foveal bulge showed a negative correlation with the age of the participants (r = −0.15).

CONCLUSION: Foveal bulge was more commonly seen in younger individuals and its height decreased with age. Age matching across groups should be undertaken in studies using foveal bulge as prognostic tool.

Keywords: Age, aging, foveal bulge, normal vision

Introduction

Foveal bulge is the term used for the bulge in the inner segment-outer segment (IS-OS) line at the center of fovea seen on spectral domain optical coherence tomography (SDOCT).

According to International Nomenclature of Optical Coherence Tomography Panel, the IS-OS line has been newly designated as ellipsoid zone (EZ).

Hence, foveal bulge can be defined as the bulge in the EZ at the center of fovea. Foveal maturation sees centrifugal migration of inner retinal layers away from fovea and centripetal migration of cone photoreceptors toward the center of fovea.

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intact foveal bulge after retinal reattachment surgery for rhegmatogenous retinal detachment was correlated with better final visual outcome.[7,8]

Correlation of foveal bulge with visual acuity is still being elucidated.[1,7] Although foveal bulge was absent or attenuated in 60% of amblyopic eyes in a study done by Al-Haddad et al., the remaining 40% amblyopic eyes did have intact foveal bulge.[5] Further, in their study which was based in Lebanon, they have noted intact foveal bulge in 71% of normal eyes whereas 29% of eyes with normal vision did not have foveal bulge.[5] It may mean that there were other factors influencing the presence or absence of foveal bulge in an eye which need to be identified to conclusively use it as a marker of better visual acuity. Age of the person may be such a confounding factor which may change the appearance of foveal bulge.[1,5] No study so far has reported any variation in the foveal bulge in healthy eyes. Our study reports the age-wise trend of the prevalence of foveal bulge in normal subjects from India.

**Methods**

The study was conducted in accordance with the tenets of the Declaration of Helsinki, and it was approved by the Institutional Review Board where it was conducted. The study was conducted between October 2014 and December 2015. We recruited healthy volunteers who agreed to participate in the study. All the individuals had best corrected visual acuity of 20/20 or better. Individuals with high myopia (more than 6 D), high hyperopia (more than 4 D), unstable fixation, media opacities and any retinal disorder such as diabetic retinopathy, retinal vein occlusion were excluded from the study. Inadequate image quality was another exclusion criterion.

All subjects underwent comprehensive ophthalmic examination including refraction, slit lamp examination, and fundus evaluation with indirect ophthalmoscopy and slit lamp biomicroscopy and intraocular pressure measurement. Identification of foveal bulge was done with Heidelberg SDOCT (Heidelberg Engineering, Heidelberg, Germany) using raster scan centered at the fovea. The height of the foveal bulge was determined by measuring photoreceptor OS length at the center of the fovea. Photoreceptor OS length was measured as the distance between inner border of retinal pigment epithelium (RPE) and outer border of photoreceptor EZ at the center of fovea [Figure 1]. Central foveal thickness (CFT) was measured automatically with the calliper function as the distance between the internal limiting membrane (ILM) and the outer of border of RPE [Figure 2]. The measurements were taken by two authors (PS and KS) independently and were averaged for statistical analysis. In case of more than 10% difference in the values between two authors; opinion was taken from third author (RR) whose measurement values were considered final. CFT was measured with the help of automated calliper system in SDOCT machine which measures it as the distance between ILM and outer border of RPE layer at the center of fovea.

Statistical analysis was done using SPSS Statistical Software, version 18 (IBM Corp. USA). A P < 0.05 was considered statistically significant.

**Results**

A total of 101 eyes of 101 healthy volunteers were included in the study. There were 64 male and 37 female participants. Mean age of participants was 39.77 ± 19.28 years (range: 8–77 years). Mean height of foveal bulge was 41.1 ± 6.4 µ (range: 23–51 µ). Average CFT was 268.1 ± 24.3 µ (range: 199–382 µ). Foveal bulge was present in 61 (60.4%) and absent in 40 (39.6%) eyes. Mean spherical equivalent was 0.85 ± 1.28.

The average age of patients with and without foveal bulge was 33.3 ± 16.2 years and 44.1± 20.5 years, respectively. This difference was statistically significant with a P = 0.02 (independent sample t-test).

Mean CFT in eyes with foveal bulge present was 266.12 µ whereas in eyes with absent bulge the mean CFT was 261.6 (P = 0.56; independent sample t-test). Using Pearson correlation, the height of the foveal bulge showed a negative correlation with age of the subjects and spherical equivalent (r = −0.15 and −0.19, respectively)

**Discussion**

Foveal bulge is a novel marker whose presence has been correlated with better vision in different retinal diseases.[1,5,7] However, those eyes which do not have foveal bulge may also have normal visual acuity.[10] Our study has shown that foveal bulge was present only
in over half (60.4%) of the normal eyes of individuals recruited in the study. This is in keeping with Al-Haddad et al. who had noted foveal bulge in 71% of normal eyes.\[5\]

Hasegawa et al. have noted that there was a lack of data on age-associated incidence of foveal bulge.\[1\] They have found that presence of foveal bulge was associated with better visual outcome in eyes with macular edema due to BRVO. However, any variation in the incidence of foveal bulge with age would affect the interpretation of this finding.\[1\] Our study attempts to answer this question. We have found a negative correlation between age and incidence of foveal bulge. Foveal bulge was less likely to be seen with increasing age even in eyes with normal vision. This may mean that while using foveal bulge as a marker for better visual outcome in different retinal conditions; matching of the groups for age should be done to avoid the confounding effect.

The reason for decreased incidence of foveal bulge is unclear. Foveal cone photoreceptors undergo various morphological changes due to aging.\[9‑11\] These changes include decrease in the number of cone photoreceptors and misalignment of OS membranes of individual cone photoreceptors.\[9‑11\] Cone OSs undergo gradual loss from birth to 40 years of age after which the rate of this loss increases.\[10,11\] These changes in cone OS may be responsible for decreased height of foveal bulge with age. However, exact mechanism behind this finding needs to be elucidated.

Our study was a single center study with small sample size which may be considered as drawbacks of our study. However, it still provides first data on age-associated prevalence of foveal bulge. The fact that patients with foveal bulge were younger and height of foveal bulge decreased with age may mean that age matching should be done in any study using foveal bulge as a prognostic tool.

**Conclusion**

Foveal bulges shows variation with age and age matching should be a prerequisite for using foveal bulge as a prognostic marker.

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**Conflicts of interest**

There are no conflicts of interest.

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