

Macular Gradient Measurement in Myopic Posterior Staphyloma Using Optical Coherence Tomography

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Purpose: To evaluate clinical characteristics and the macular gradient in myopic posterior staphyloma with time domain (TD) optical coherence tomography (OCT).

Methods: Sixty-four staphyloma eyes of 40 patients were examined. Macular gradient (tangent θ) and the location of staphyloma were assessed with OCT imaging. The macular gradient was measured at points 1 mm and 2 mm distant from the fovea. The relationships of the macular gradient with age, axial length, and spherical equivalent were analyzed.

Results: In 8 eyes (12.5%), the bottoms of the staphylomas were in the fovea, and there was no macular gradient. However, in the other 56 eyes (87.5%), the bottoms of the staphylomas were not in the foveal area, and macular gradients existed. Staphylomas were commonly located in the infero-nasal retinal area. The mean macular gradient (tangent θ) was 0.26 ± 0.08 at 1 mm distance from the fovea and 0.28 ± 0.10 at 2 mm. No significant relationships were observed between macular gradient and axial length, patient age, or spherical equivalent.

Conclusions: TD OCT reveals staphyloma location. If the location is outside of the fovea, a macular gradient exists and can be measured by OCT. Axial length measurement error may occur in eyes with poor visual fixation and steep macular gradients.

Key Words: Macula, Myopia, Optical coherence tomography

Myopic posterior staphyloma is a depression of the posterior shell of the eye globe. Staphyloma is a pathognomic feature of degenerative myopia and is frequently observed in pathologic high myopia [1]. Staphyloma frequency clinically underestimated (10%) compared to histopathological findings (35%) [2]. Staphyloma and myopia are more common in Asian populations than in Caucasian [3]. Staphyloma locations are various, including nasal, macula-centered, disc-centered, and tiered staphylomas [4]. The deepest portion of the staphyloma is very diverse in locale. Myopic posterior staphylomas can be diagnosed with stereoscopic binocular indirect ophthalmoscopy and B-scan ultrasonography.

Despite the clinical importance and high prevalence of

staphyloma, few studies on staphyloma morphological features have been made since the time of Curtin's classification in 1977 [5]. The center of depression in staphyloma, namely, the deepest portion of the staphyloma, is not always in the center of the fovea. Some staphylomas are indeed in the foveal center [6], but most are located outside the foveal area.

When cataract surgery (which needs axial length calculation) is contemplated, axial length measurement error can occur if the deepest portion of the staphyloma is not in the center of the fovea with only a small consequent visual fixation change after surgery when compared with normal eyes.

Optical coherence tomography (OCT) is a procedure assisting in the diagnosis of retinal disease. OCT permits a detailed diagnosis of complex retinal diseases, such as foveoschisis [7], peripapillary intrachoroidal cavitation [8], and retinal vascular microfolds [9]. When the deepest portion of the staphyloma was extra-foveal in patients with myopic posterior staphyloma, we found tilted retinal images, the so-called macular gradient, on OCT. We measured the tilted macular gradient using tangent values in such patients by em-

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ploying a Stratus OCT instrument (Carl Zeiss Meditec, Dublin, CA, USA).

To our knowledge, no report on macular gradient in staphyloma patients has appeared. In this study, we assess the macular gradient in myopic posterior staphylomatous eyes using OCT and study the prevalence and characteristics of the condition.

Materials and Methods

For this retrospective consecutive case study, we reviewed 64 eyes of 40 patients with myopic posterior staphyloma who visited the Asan Medical Center, Seoul, Korea, from June to October 2008. All patients underwent ophthalmic examinations, including slit lamp examination, B-scan ultrasonography, binocular indirect ophthalmoscopy, axial length measurement, and OCT. An Ocuscan instrument (Alcon Laboratories, Fort Worth, TX, USA) was used to measure axial length.

The diagnosis of staphyloma was confirmed by binocular indirect ophthalmoscopy and B-scan ultrasonography, and OCT was next performed to detect other retinal problems. Eyes with media opacities such as vitreous opacity and se-

vere cataracts, making the posterior pole invisible, were excluded. Eyes with previous structure-changing surgical history (such as scleral buckling) or preexisting ocular disease were also excluded. Eyes with abnormal foveal structures, such as maculoschisis, macular detachment, epiretinal membrane, or macular dragging, were also excluded.

For myopic posterior staphylomatous eyes, we performed OCT and assessed the macular gradient and clinical characteristics of the staphyloma. Stratus OCT contains a software program, radial line scan map, which shows scanning images from various axes. We performed examinations on axes of 0° (180°) and 90° (270°). We performed three consecutive scans to obtain precise and reproducible images. The Stratus OCT instrument was operated with a 6 mm transverse scanning length and a 2 mm vertical scanning length in the radial line scan mode.

From each tilted macular gradient image on OCT, we assessed the macular gradient (Fig. 1). First, we measured the macular gradient at a point 1 mm distant from the fovea (using the tangent value) and then at a point 2 mm distant. We defined measured tangent values as macular gradients. Each OCT image was stored as a PDF file, and the macular gradient was measured with a Photoshop length-measuring pro-

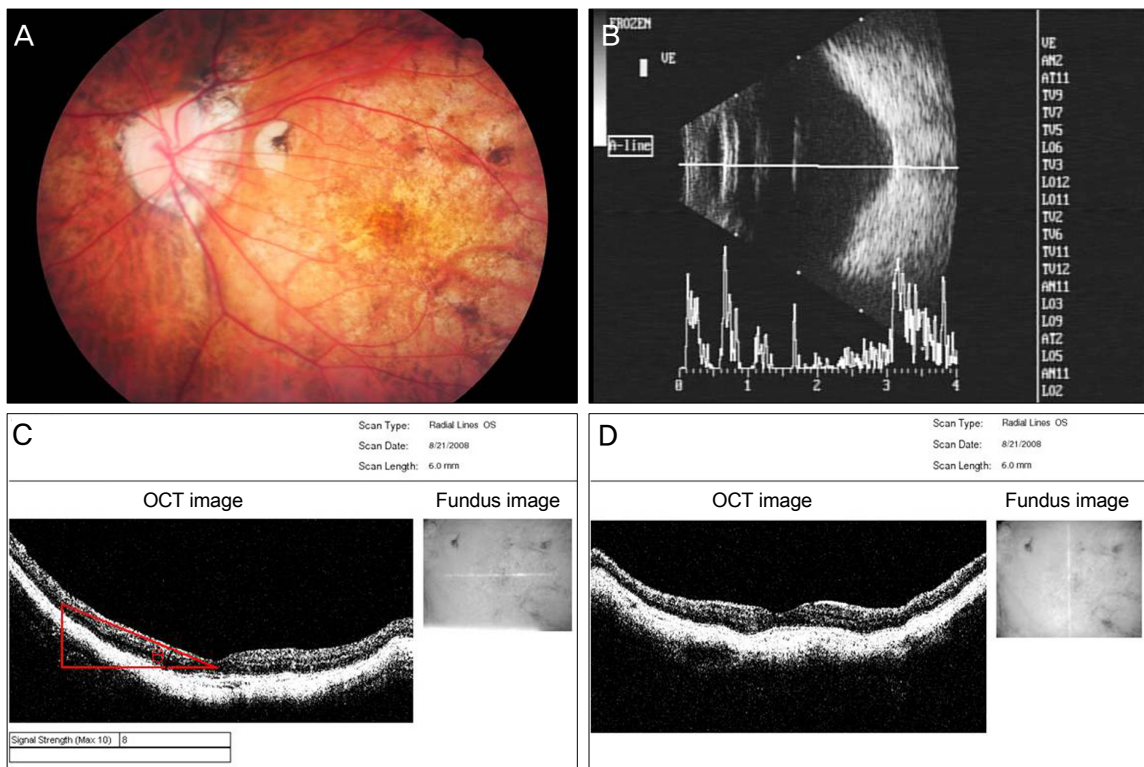


Fig. 1. Images showing posterior staphyloma. A 51-year-old woman with 20 / 40 visual acuity and a -11 diopter spherical equivalent. (A) Fundus photograph showing the posterior staphyloma. (B) On B-scan ultrasonography, a posterior staphyloma was detected. (C) An optical coherence tomography (OCT) scan showed the macular gradient. The scanning direction is transverse. Between the macula and the optic disc area, a steep macular gradient is observed, and the staphyloma protrudes toward the temporal retina. The macular gradient, between the macula and the optic disc, was measured (tangent θ). (D) On vertical scanning, symmetric posterior curvature of the retina was seen. From images of the two-axis OCT scans, the location of the staphyloma was confirmed to lie in the temporal area, with respect to the fovea.

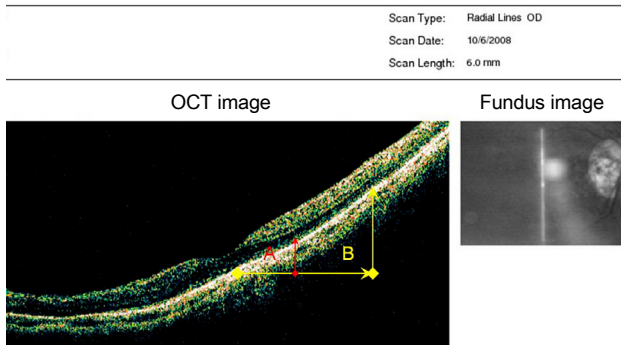


Fig. 2. Image showing a radial line scan optical coherence tomography (OCT) map. The transverse scan length (6 mm) and the vertical scan length (2 mm) are features of the Stratus OCT program. We measured the macular gradient at points 1 mm (A) and 2 mm (B) distant from the base of the fovea.

gram (Adobe Systems Incorporated, San Jose, CA, USA) (Fig. 2).

We also identified the location of staphylomas using two different axis scans (90° and 180°). Staphylomas were classified as central, temporal, nasal, superior, inferior, supero-temporal, infero-temporal, supero-nasal, or infero-nasal with reference to the foveal center. For example, in Fig. 1, the transverse scan shows the image tilted toward the temporal retina, and the vertical scan shows symmetrical curvature of the retina; we thus classified this case as a temporal area staphyloma. The locations of all staphyloma sites were assessed by this method. Correlations between macular gradient and spherical equivalent, patient age, and axial length were assessed. All data were analyzed with the chi-squared test, the Kruskal-Wallis test, and the Pearson correlation coefficient using SPSS ver. 14.0 (SPSS Inc., Chicago, IL, USA), and the *p*-values < 0.05 were considered statistically significant.

Results

In 64 eyes of 40 patients (mean age, 58 ± 14 years), the average spherical equivalent was -12.4 ± 5.8 diopters and the mean axial length 29.7 ± 2.99 mm. Staphylomas were distributed unevenly with respect to the fovea (*p* < 0.001). The most common staphyloma site was the infero-nasal area (26.6%), followed by the nasal (25.0%) and inferior (21.9%) areas, with respect to the fovea (Fig. 3). In 8 of 64 eyes, the bottoms of staphylomas were in the foveal center, and there was no definite macular gradient on OCT.

Macular gradients were assessed using PDF files of radial line scan maps and a Photoshop length-measuring tool. Each total transverse scanning image length was 6 mm. At a point 1 mm distant from the fovea, the vertical elevated retinal pigment epithelium level was measured and the tangent value calculated. The mean macular gradient (tangent) was 0.26 ± 0.08. By the same method, the macular gradient measured 2 mm distant from the fovea averaged 0.28 ± 0.10 (Fig. 4).

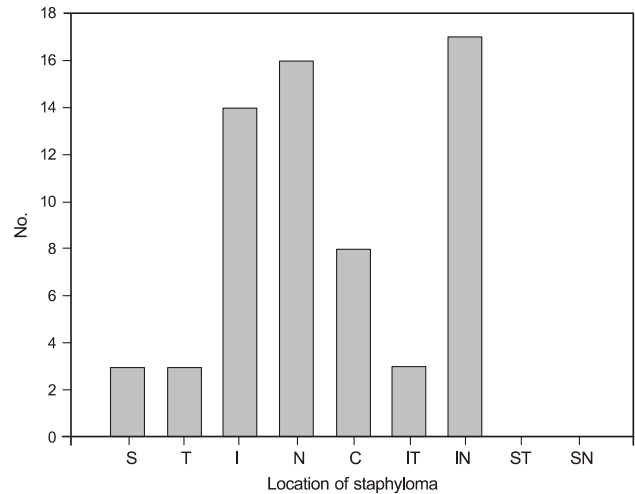


Fig. 3. The distribution of staphylomas, as shown by optical coherence tomography, in 64 eyes. Most staphylomas were distributed in the inferior and nasal retinal areas, with respect to the fovea. S = superior; T = temporal; I = inferior; N = nasal; C = center of fovea; IT = infero-temporal; IN = infero-nasal; ST = supero-temporal; SN = supero-nasal.

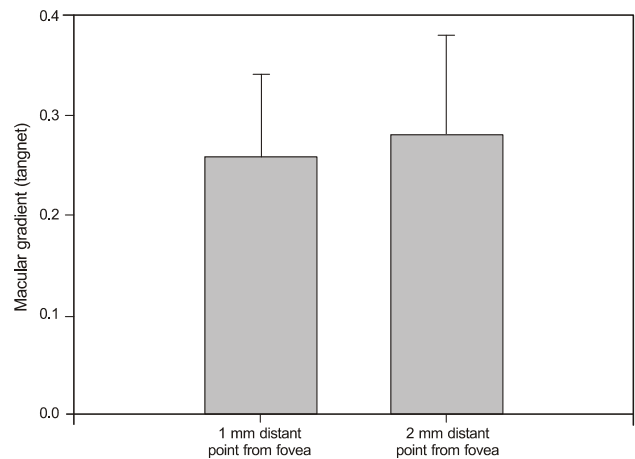


Fig. 4. Macular gradients 1 mm and 2 mm distant from the fovea. Macular gradient at 1 mm was 0.26 and 0.28 at 2 mm. At 2 mm, the tangent value was greater than at 1 mm, but this was not statistically significant.

There was no statistically significant difference between these measurements.

We assessed correlations between the macular gradient and spherical equivalent, patient age, and axial length. There was no clinically significant association (spherical equivalent *p*-value, 0.728; age, 0.244; axial length, 0.799) (Fig. 5).

Discussion

Posterior staphyloma has various clinical manifestations. Posterior staphyloma underlying the macula is commonly associated with decreased vision [10], whereas when staphyloma occurs in other locations in the posterior pole, central vision may not be affected. Rarely, a serous retinal detach-

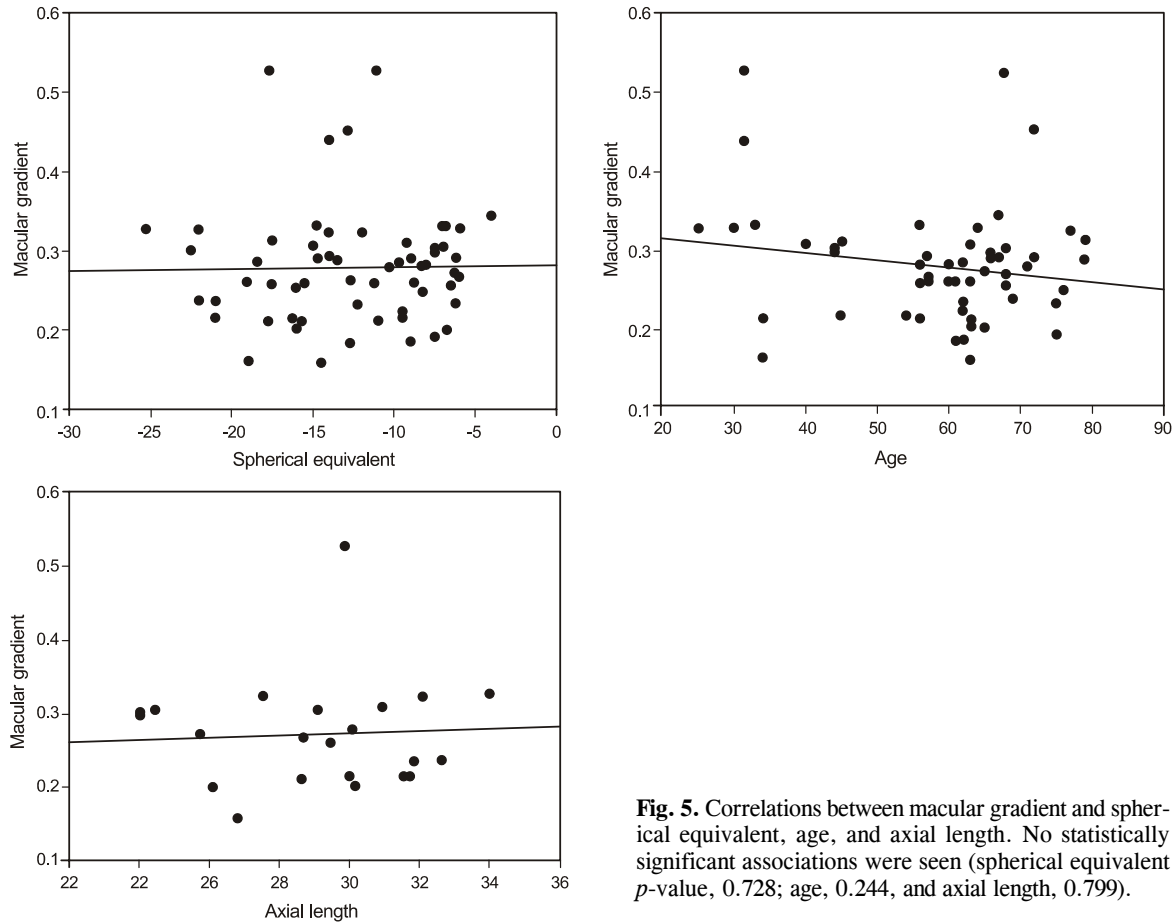


Fig. 5. Correlations between macular gradient and spherical equivalent, age, and axial length. No statistically significant associations were seen (spherical equivalent *p*-value, 0.728; age, 0.244, and axial length, 0.799).

ment caused by deep leakage of the central serous chorioretinopathy type [11] overlies the crest of the staphyloma, and myopic choroidal neovascularization commonly occurs in patients with myopic posterior staphyloma [12,13]. Despite the clinical significance of myopic posterior staphyloma, few comprehensive studies on the morphologic features of posterior staphyloma have appeared. Such clinical features are various, complex, and pathognomic, making study of the condition difficult.

Previously, posterior staphyloma was assessed with B-scan ultrasonography and binocular indirect ophthalmoscopy [1,3,14]. B-scanning is, however, time-consuming and bothersome for patients because the B-scan probe contacts the eyeball and emulsion oil is used. Binocular indirect ophthalmoscopy is relatively easier, but the results are subjective, and staphyloma size is not measured.

OCT is widely used to assess various retinal anatomical structures. OCT is essential for diagnosis and follow-up of retinal problems, such as maculopathy, retinal detachment [15], and other retinal diseases. And, as previously shown [6], OCT can be used to assess and define structural eye characteristics. Kusuvara et al. [16] analyzed macular hole configuration using OCT. These authors constructed a macular hole index using OCT cross-sectional images and predicted the postoperative visual outcome of macular hole

surgery. Gaucher et al. [6] found dome-shaped staphylomas by OCT. The adjective ‘dome-shaped’ was applied to a staphyloma showing elevation of the foveal area with peripheral depression.

As defined above, we describe the tilted deviation of the macular area on OCT as a macular gradient. We considered that description of an OCT macular gradient without confirmation of posterior staphyloma would be meaningless. Thus, we identified and confirmed the presence of posterior staphyloma using B-scan ultrasonography and binocular indirect ophthalmoscopy. We performed OCT examinations on three consecutive occasions to obtain reliable results. If the results of three consecutive examinations were not consistent, we excluded that patient. We believe this approach produces reliable and reproducible results.

The purpose of our study was not to measure axial length error accurately, because OCT is not an axial length-measuring instrument, but rather to identify any risk factor for axial length measurement error.

In our study, 56 of 64 eyes showed a mean 0.26 tangent value of the macular gradient from the foveal center to a point 1 mm distant and 0.28 to a point 2 mm distant. In such patients, if abnormally poor fixation occurs, incorrect axial length measurement may result. Therefore, in staphylomatous eyes of high macular gradient value, careful axial

length measurement is strongly recommended.

There were no significant relationships between macular gradient value and age, axial length, or spherical equivalent. Hsiang and colleagues reported that morphologic features of staphyloma worsen as patients age [1]. However, there was no correlation between age and staphyloma pattern in our study. These authors assessed staphyloma size and clinical characteristics by B-scanning. However, we used OCT to assess staphyloma characteristics. If the staphyloma is too small, both OCT and ultrasonography can detect the staphylomatous lesions. However, if the staphyloma is large, B-scanning obtains the whole image, whereas OCT finds only a part of the staphyloma because of the relatively short scanning length (6 mm). Differences between study results can thus be explained by use of distinct measurement methods (B-scanning and OCT).

Few comprehensive studies have addressed the distribution of posterior staphyloma. In our study, most staphylomas were distributed in the inferior and nasal areas of the retina, with respect to the foveal base. In 20 of our 64 study eyes, tilted discs, like fundi, were observed. Tilted disc syndrome is characterized by an oval optic disc with an oblique axis, an inferonasal crescent, and an inferior staphyloma. Such a condition confined the distribution of the staphyloma to the inferior and nasal areas.

In conclusion, we examined the macular gradient in the perifoveal area and measured macular gradient values. By combining data from two OCT scan image axes, we confirmed staphyloma locations. In patients with high macular gradient, ophthalmologists should consider the possibility of axial length errors.

Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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