Aniseikonia and Foveal Microstructure After Retinal Detachment Surgery

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The effectiveness of rhegmatogenous retinal detachment (RD) surgery has generally been assessed by the rates of retinal reattachment and the postoperative visual acuity.1-6 With the improved anatomical success rate of surgery for RD, increasing attention has been directed toward the quality of postoperative vision. Even after successful retinal reattachment and improvement of visual acuity, the postoperative quality of vision may be unsatisfactory in some cases. Aniseikonia is one of the common postoperative symptoms in patients after RD surgery, with 35% of patients complaining of aniseikonia by questionnaire.7

Aniseikonia, the difference in perceived image size between the two eyes, is believed to play a significant role in binocular function. Symptoms owing to aniseikonia include headache, asthenopia, photophobia, reading difficulty, and nausea.8,9 Symptoms develop in sensitive individuals at typical clinical value for percentage aniseikonia of 1% to 3%; symptoms and binocular impairment develop at 3% to 5%; and binocular vision typically becomes absent at more than 5%.10,11

Aniseikonia is generally associated with anisometropia, such as aphakia, pseudophakia, and corneal refractive surgery.12-17 In rare cases, however, aniseikonia can develop due to retinal diseases. Retina-induced aniseikonia may be caused by the stretching or compression of the retina, which changes the perceived image size because of the alteration in spacing between the photoreceptors.18 Aniseikonia due to retinal diseases such as epiretinal membrane (ERM)10,18-20 reattached retina,20-25 and macular edema24,25 has been reported.

Although some studies have reported on aniseikonia in RD patients, they included a relatively small number of patients (4-12 cases).20-23 In addition, no studies so far have investigated the relationship between the severity of aniseikonia and the foveal microstructure after RD surgery.

The purpose of the present study was to quantify the amount of aniseikonia and to assess clinical characteristics of aniseikonia after successful repair of RD. The relationship between aniseikonia and clinical factors, including those obtained with spectral-domain optical coherence tomography (OCT), was also investigated.

METHODS

We analyzed 106 patients (68 men, 38 women) following successful surgery for unilateral RD undertaken at the University of Tsukuba Hospital from October 2010 to December 2012. Their ages averaged 56.1 ± 10.9 years (means ± SD). This prospective study was conducted in accordance with the tenets of the Declaration of Helsinki, and the study protocol was approved by the institutional review committees. Prior to inclusion in the study, the nature of the study was explained to all patients, and their written informed consent was obtained. Exclusion criteria included patients with a...
previous history of vitreoretinal surgery and ophthalmic disorders except myopia of less than −10.0 diopters and severe cataract of more than grade 3 nuclear sclerosis or cortical opacity, and more than 2.0 diopters of anisometropia postoperatively. Eyes with complicated vitreoretinal diseases, such as proliferative vitreoretinopathy and RD resulting from giant retinal tears, macular hole, or ocular trauma, were also excluded.

Best-corrected visual acuity (BCVA) was measured, and the degree of aniseikonia was quantified using the New Aniseikonia Test (NAT; Handaya, Tokyo, Japan) 6 months after surgery. Best-corrected visual acuity measured with the Landolt chart was expressed as logarithm of minimum angle of resolution (logMAR) and used for the subsequent analyses.

The NAT, comprising a book and spectacles, measures aniseikonia by dissociating binocular vision with red and green filters. Each eye perceives a half-moon printed on the book page. Two half-moons of different sizes are arranged in a series in a pair; with the difference varying in increments of 1%. The subject, wearing red–green spectacles, views the plates to allow the right eye to see one of the half-moons in each pair, the left eye the other half-moon. Subjects indicate the pair in which both vertical and horizontal meridians and used their mean values for data analyses. Mean aniseikonia of +2% or more was defined as macropsia and mean aniseikonia of −2% or less as micropsia. Patients with logMAR BCVA > 1.0 were excluded since it was difficult for them to perceive the half-moon due to suppression.12

Retinal images were obtained with spectral-domain OCT (Cirrus high-definition OCT; Carl Zeiss, Dublin, CA, USA) 3 and 6 months after surgery. We performed the five-line raster scans in a horizontal and vertical manner on each eye using Cirrus analysis software version 3.0. Scans with signal strength of more than 7/10 were considered appropriate; from these a representative image was selected. Diagnosis of a disrupted photoreceptor inner and outer segment junction (IS/OS) was made based on loss and irregularity of the hyperreflective line corresponding to the IS/OS junction. Two graders (YS and TH) assessed the status of the IS/OS lines. Both graders were masked to the clinical findings of the patients, including their visual acuity and aniseikonia results.

Clinical data were collected, including age, sex, circumferential dimension of retinal tears, area of RD, macular status (on or off), surgical procedures (scleral buckling or vitrectomy), and difference of postoperative spherical equivalent between the two eyes, to determine factors related to aniseikonia.

Surgery was performed at our clinic by experienced vitreoretinal surgeons (FO and YO). The buckling surgery consisted of cryopexy and circumferential silicone sponge buckling (no. 506; MIRA, Waltham, MA, USA). The encircling was performed with a silicone band (no. 240; MIRA) or a silicone sponge (no. 506G; MIRA). Subretinal fluid drainage and air injection were performed when required. We carried out 23- or 25-gauge pars plana vitrectomy that comprised release of vitreous traction around the breaks, internal drainage of the subretinal fluid, a total fluid/gas exchange with air or 20% sulfur hexafluoride (SF6) for internal tamponade, and endolaser photocoagulation. None of the vitrectomy group had any additional external buckling elements. In both groups, patients treated with gas injection were instructed to maintain a fakedown position for 2 to 7 days.

The mean and standard deviations were calculated for degree of aniseikonia and other parameters. A paired t-test was performed to compare horizontal and vertical aniseikonia, and an unpaired t-test was done to compare differences in the amount of aniseikonia between sexes and surgical procedures (scleral buckling and vitrectomy). The associations between aniseikonia and clinical parameters and between horizontal and vertical aniseikonia were examined by the Spearman rank correlation test. Multivariate analysis with stepwise regression was performed to investigate the relationship between aniseikonia and clinical parameters. All tests of associations were considered statistically significant if P < 0.05. The analyses were carried out using StatView (version 5.0; SAS, Inc., Cary, NC, USA).

**Results**

The Table shows clinical characteristics, surgical procedures, and visual functions in patients undergoing surgery for RD. Preoperative logMAR BCVA was 0.51 ± 0.76, with 49 of 106 eyes being macula-off RD. Postoperative logMAR BCVA was 0.04 ± 0.18; postoperative spherical equivalent was −2.95 ± 2.97 diopters; and the difference in postoperative spherical equivalent between the two eyes was 0.69 ± 0.52 diopters.

**Clinical Features of Aniseikonia After RD Surgery**

The amount of mean aniseikonia ranged from −12.5% to +12.0% (Fig. 1). Of 106 patients, 28 (26%) had micropsia, 17 (16%) had macropsia, and 61 (58%) had no aniseikonia. The absolute value of mean aniseikonia in all patients was 2.3 ± 2.9%, while horizontal and vertical aniseikonia was 2.3 ± 2.9% and 2.5 ± 3.4%, respectively. No significant difference was observed between horizontal and vertical aniseikonia (P = 0.314), while a significant correlation was found between the two values (r = 0.805, P < 0.0001).

**Relationship Between Preoperative Macular Status and Postoperative Aniseikonia**

Of 57 macula-on RD patients, 3 had micropsia, 12 had macropsia, and 42 had no aniseikonia after surgery. Of 49 macula-off RD patients, 25 had micropsia, 5 had macropsia, and 19 had no aniseikonia postoperatively (Fig. 2).
Relationship Between Surgical Procedures and Postoperative Aniseikonia

Among the 106 RD patients, 79 underwent vitrectomy and 27 received scleral buckling surgery. In 57 patients with macula-on RD, 37 received vitrectomy and 20 scleral buckling. Of 37 macula-on RD patients who underwent vitrectomy, 1 had micropsia, 5 had macropsia, and 31 had no aniseikonia, whereas of 20 macula-on RD patients who underwent scleral buckling, 1 had micropsia, 6 had macropsia, and 13 had no aniseikonia.

In 49 patients with macula-off RD, 42 underwent vitrectomy and 7 scleral buckling. Of 42 macula-off RD patients who received vitrectomy, 24 had micropsia, 5 had macropsia, and 13 had no aniseikonia. Of 7 macula-off RD patients who underwent scleral buckling, 2 had micropsia, 2 had macropsia, and 3 had no aniseikonia. In macula-off RD patients, the incidence of postoperative micropsia tended to be higher with vitrectomy (57.1%) compared to scleral buckling (28.6%) (P = 0.16).

OCT Findings in Eyes With Aniseikonia

Of 28 eyes with micropsia after surgery, 6 eyes had cystoid macular edema (CME), 5 eyes had hyperreflective IS/OS line at the foveal region, 4 eyes had disruption of IS/OS, 3 eyes had subretinal fluid (SRF), 2 eyes had ERM, 1 eye had macular hole (MH), and the other 7 eyes exhibited no abnormal morphologic change (Figs. 3A–E). Six of 28 cases had CME at 3 months postoperatively; of these, CME resolved at 6 months postoperatively in 4 cases and no change was observed in the other 2 cases. Five of 28 cases developed hyperreflective IS/OS line at the foveal region at 3 months postoperatively; of these, the hyperreflective IS/OS line disappeared at 6 months postoperatively in 3 cases and no change was found in the other 2 cases.

Of 17 eyes with macropsia, 10 eyes had ERM and the other 7 exhibited no abnormal morphologic change (Fig. 3F).

Relationship Between Postoperative Aniseikonia and Clinical Parameters

The absolute value of mean aniseikonia showed a significant correlation with age (r = 0.265, P < 0.01), postoperative logMAR BCVA (r = 0.396, P < 0.0001, Fig. 4A), and the area of RD (r = 0.385, P < 0.0001, Fig. 4B). In contrast, a significant correlation was not observed between the absolute value of mean aniseikonia and circumferential dimension of retinal tears (r = −0.144, P = 0.150), postoperative spherical equivalent (r = 0.078, P = 0.424), or difference of postoperative spherical equivalent between the two eyes (r = 0.104, P = 0.290). A higher value of mean aniseikonia was significantly associated with disrupted IS/OS line (P < 0.05) and macula-off RD (P < 0.0001). No significant relationship was found between aniseikonia and sex (P = 0.233) or between aniseikonia and surgical procedures (P = 0.959). Multivariate analysis with stepwise regression revealed that the absolute value of mean aniseikonia was significantly correlated with postoperative logMAR BCVA (r = 0.357, F = 10.259) and the area of RD (r = 0.286, F = 7.396).

DISCUSSION

As shown in the above results, 45 of 106 patients (42%) exhibited aniseikonia after successful surgery for unilateral RD at 6 months into follow-up. Wright et al.7 investigated motility and binocularity in 40 patients after RD surgery, and found that 35% of patients complained of aniseikonia by questionnaire. However, their study did not quantify aniseikonia and also did not consider the influence of anisometropia due to silicone oil tamponade or compression of the globe by scleral buckling. In our present study, the influence of refractive error caused by intraocular or external ocular factors was excluded because patients with postoperative anisometropia had been excluded. The range of aniseikonia was broad, from −12.5% to +12.0%, consistent with the findings of previous reports that indicated a range from −12.3% to +10.4%.20–23 It has been reported that...
symptoms appear in binocular impairment at a typical clinical value of percentage aniseikonia at 3% to 5%, with binocular vision generally becoming absent at more than 5% \(^{10,11}\) In the present study, more than 3% and 5% aniseikonia was observed in 32 patients (30%) and 19 patients (18%), respectively, suggesting that postoperative quality of vision remains deteriorated in some patients due to aniseikonia even though retinal reattachment and visual recovery were attained.

**Figure 3.** Spectral-domain optical coherence tomography (OCT) images of eyes with aniseikonia after retinal detachment surgery. (A, B) Images of the right eye of an 80-year-old man with macula-off RD. Cystoid macular edema was seen at 3 months after surgery (A), which resolved by 6 months postoperatively (B). His visual acuity was 0.15 (logMAR), and mean aniseikonia was \(-10.5\)% of micropsia 6 months after surgery. (C) An image of the right eye of a 47-year-old man with macula-off RD. Optical coherence tomography showed hyperreflective photoreceptor inner and outer segment junction (IS/OS) line at the foveal lesion. His visual acuity was 0.00 (logMAR), and mean aniseikonia was \(-9.0\)% of micropsia. (D) An image of the right eye of a 61-year-old man with macula-off RD. Disrupted IS/OS line is displayed. His visual acuity was \(-0.08\) (logMAR), and mean aniseikonia was \(-4.5\)% of micropsia. (E) An image of the right eye of a 47-year-old man with macula-off RD. Optical coherence tomography showed subretinal fluid. His visual acuity was 0.30 (logMAR), and mean aniseikonia was \(-4.5\)% of micropsia. (F) An image of the right eye of a 53-year-old woman with macula-on RD. Epiretinal membrane was detected. Her visual acuity was 0.22 (logMAR), and mean aniseikonia was +4.0% of macropsia.

**Figure 4.** Correlation between absolute values of mean aniseikonia and postoperative logMAR best-corrected visual acuity (A) and the area of retinal detachment (B).
In patients with macula-on RD, 74% had no aniseikonia, but 12 of 15 patients with macula-off RD developed micropsia. In addition, approximately half of patients with macula-off RD developed micropsia, while only five presented macropsia. To sum up the previous four reports, most aniseikonia after RD surgery as micropsia (27 of 30 cases) was persistent at 6 months, postoperative CME, SRF, and IS/OS disruption, if any, might have been restored during the short postoperative period. Aniseikonia might have persisted owing to this kind of transient change. In addition, displacement of macula is common following vitrectomy for macula-off RD with gas tamponade, and is associated with complaints of distortion. Such displacement of the retina distorts distribution of photoreceptors, resulting in aniseikonia. In our study, the incidence of postoperative micropsia was higher with vitrectomy (57.1%) than with scleral buckling (28.6%) in patients with macula-off RD, and these findings suggested that aniseikonia occurred through displacement of the retina. Furthermore, foveal micromacular is impaired even in patients with macula-on RD. A previous study in RD patients revealed that retinal electroretinographic responses declined in both the reattached and detached retina. In view of these findings, a slight foveal dysfunction could cause aniseikonia.

Multivariate analysis showed that the amount of aniseikonia was significantly associated with postoperative visual acuity and the area of RD. Shiraigami et al. clarified that the extent of RD and macular status were significantly associated with postoperative displacement of the retina using fundus autofluorescence. They suggested that a large-extent macula-off RD could cause retinal translocation even after successful surgery, resulting in dislocation of the macula from its original location. In addition, there was a significant correlation between the presence of macula displacement and symptoms of distortion in the early period following RD surgery. In consideration of the previous reports, our results suggest that the wider the area of RD, the larger the retinal displacement and the amount of aniseikonia.

The limitations of this study include a short-term follow-up period and the resolution of OCT. We evaluated patients for 6 months postoperatively. Previous studies reported that visual acuity in patients with RD improved more even at 1 to 5 years postoperatively. Aniseikonia in patients after RD surgery also improves in the period between 7 and 45 months postoperatively. In addition, postoperative OCT findings, including CME, SRF, and status of the IS/OS line, may possibly change during follow-up of more than 6 months. Our OCT measurements were based only on five horizontal B-scan cross sections, and imaging inaccuracy might exist in the photoreceptor layer after RD. Future studies with a large sample size, longer follow-up period, and improved OCT image-capturing technologies will be needed.

In conclusion, 6 months after successful RD repair, 42% of patients showed aniseikonia of varying degrees. Postoperative micropsia was mainly observed in patients with macula-on RD, and postoperative micropsia in patients with macula-off RD. A major cause of micropsia was persistent and/or transient CME, SRF, and IS/OS change, and the principal cause of macropsia was ERM. The amount of aniseikonia was associated with visual acuity and the area of RD.

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References


