

Article ▶ Diagnosis and Treatment of Aniseikonia: A Case Report and Review

James Kundart, OD, MEd, Pacific University College of Optometry, Forest Grove, Oregon

ABSTRACT

Background: Aniseikonia is a condition in which there are different image sizes in the two eyes. Post-surgical anisometropia from corneal transplant, cataract surgery, or epiretinal membrane peel continues to be the primary cause and sometimes is large enough to remain symptomatic even after contact lens (CL) correction. Clinical measurement of aniseikonia is rare and uses obsolete instrumentation long out of production. This case report details the diagnosis and treatment of a symptomatic patient with significant anisometropia, pseudophakia OS, and post-penetrating keratoplasty OU secondary to keratoconus. Treatment included using size lenses and common clinical equipment.

Case Report: A 62-year-old female presented with diplopia and blurry vision. Due to her irregular astigmatism, the manifest refraction was unreliable. The patient was fit with a large-diameter corneal gas-permeable CL OD (-11.50 DS) and a scleral CL OS (-2.50 DS) to correct her irregular astigmatism OU. Best-corrected acuities were 20/20 OD and 20/30 OS. After contact lens correction, the patient noted poor depth perception, clumsiness, and non-specific asthenopia. Using the Brecher test, aniseikonia was diagnosed.

Aniseikonia was measured at 6% larger retinal image OS using plano magnifiers (size lenses). A 6% size lens was prescribed for the OD with a 2 prism diopter base-in correction. A 10 D base curve (BC) spectacle lens in CR-39 (n=1.498) and standard 1.5 mm center thickness was prescribed OD, matching the BC of the plano magnifier accepted on trial framing over the patient's contact lens correction for residual post-surgical aniseikonia. The following year, the aniseikonia measured at 7%, but the patient preferred the thinner 6% magnifier since it still allowed fusion. Horizontal prism correction was changed to 4 prism diopters base out.

Conclusions: The Brecher test combined with a size lens set, lens clock, and specialty CL can be used to diminish or to eliminate aniseikonia without requiring additional mathematical calculation of spectacle base curve or center thickness.

Keywords: aniseikonia, keratoconus, size lenses, ophthalmic prism

Case Description

Office Visit #1

Subjective:

A 62-year-old Caucasian female presented with blurry vision OS after full-thickness penetrating keratoplasty and cataract surgery OU one year prior. She reported a loss of peripheral vision on the lower left side since that time. She was a successful corneal gas permeable contact lens wearer OD.

Review of systems for this patient was remarkable for Type II diabetes mellitus (controlled by glipizide, metformin, and insulin analog injection), ulcerative colitis (controlled by mercaptopurine), and systemic hypertension (controlled with atenolol, lisinopril, and verapamil). The patient was also taking citalopram for depression, simvastatin for hyperlipidemia, and aspirin daily. The patient reported enjoying exercise in the form of swimming and weight lifting.

Objective:

Uncorrected visual acuity was >20/400 OD and 20/100 OS. Standard refraction was not possible due to a hard-to-neutralize scissors reflex on retinoscopy and distortion seen on keratometry OU. Pinhole acuity improved to 20/40 OU, indicating that refractive improvement was possible. The apparent irregular astigmatism, in which the power and axial

meridia are not at right angles to each other, was confirmed on corneal topography (Figure 1). Note the absence of the bow-tie appearance of the more typical with-the-rule or against-the-rule astigmatism.

Assessment:

Refractive:

- 1) Myopia OD > OS
- 2) Irregular astigmatism OD < OS
- 3) Absolute presbyopia

Binocular:

- 1) low exophoria at near, no diplopia Ocular Health:
- 1) Status-post penetrating keratoplasty OU
- 2) Left inferior quadrantanopia OU

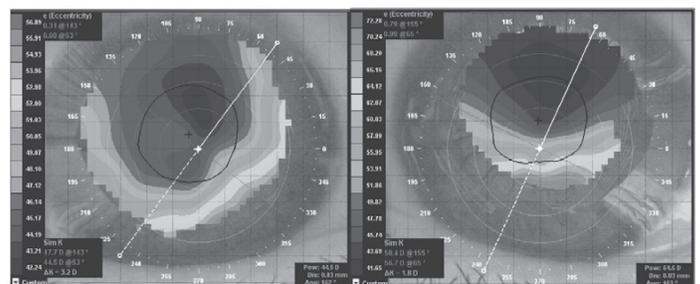


Figure 1. Corneal topography of OD (left) and OS (right)



Figure 2. Brecher test for aniseikonia without size lenses (left) and with neutralizing size lens OS (right). Photo credit: Brandon Reed, OD, MS
Source: <http://bit.ly/2MnmXUV>

Plan:

The patient was fit with large-diameter RGP OD and scleral contact lens OS

- OD: -11.50 sph BC 8.04 Dia 10.5 mm VA 20/20-1 OD
- OS: -2.00 sph BC 6.14 Dia 16.5 mm VA 20/30+2 OS

Office Visit #2

Both contact lenses fit well, but with best correction, the patient noted poor depth perception, clumsiness, and non-specific asthenopia. Because these are known symptoms of aniseikonia, the patient was referred to the 3D Performance Clinic for an aniseikonia workup.

The patient was assessed for aniseikonia using the Brecher test. The Brecher Test consists of a Maddox rod and two penlights used to diagnose and to quantify aniseikonia (Figure 2). If aniseikonia is found, size lenses (plano magnifiers) are used over the eye with the smaller image in order to neutralize it. Prism neutralization of the phoric posture may be necessary first.

Results

The aniseikonia was measured over the contact lenses at 6% OD (the image was 6% larger OS) using plano magnifiers (iseikonic or size lenses) with a best-corrected visual acuity of 20/20 OD and slightly worse best-corrected acuity of 20/40 OS. A 6% size lens was prescribed for the right eye with 2 prism diopters base in and 1 prism diopter base down. A 10 D BC spectacle lens in CR-39 (n=1.498) and 1.5 mm center thickness was prescribed OD, matching the BC of the plano magnifier used over the patient's contact lens correction for residual post-surgical aniseikonia (Figure 3).

The following year, the aniseikonia measured 7% OD, but the patient preferred the thinner 6% magnifier since it still allowed fusion and comfortable vision. Horizontal prism correction was changed to 4 prism diopters base in. The patient was asymptomatic with the spectacles over her contact lenses.

In summary, for this patient, there were three optical conditions that needed correction beyond sphere, cylinder, axis, and add power. Specifically, they were:

- 1) Aniseikonia with 6-7% larger image OS
- 2) Basic exophoria, 4Δ base in at far and near
- 3) Vertical heterophoria, 1Δ right hyperphoria

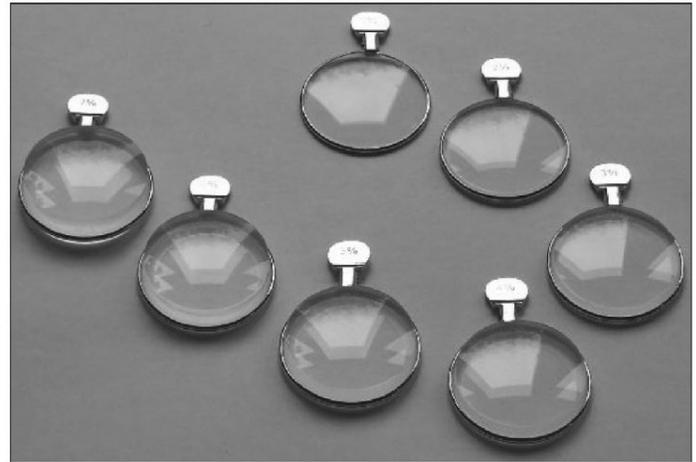


Figure 3. Iseikonic (plano size) magnifiers, from 1-7% in 1% steps
Source: <http://bit.ly/2Mi915x>
Photo credit and permission from: Gerard de Witt, PhD, Optical Diagnostics

The combination of ophthalmic prism with size lenses is common in these cases for reasons that will be explained below.

Aniseikonia: Definition and Symptoms

Aniseikonia, or different image sizes between the two retinas or in the cortex, can be visually disabling. Most patients likely have a small amount (less than 1%) of image size difference, resulting simply in sensory eye dominance. This type of subclinical aniseikonia occurs commonly when the monocular cortical cells wired to the dominant eye slightly outnumber those wired to the non-dominant eye.

Aniseikonia of 2% or more is considered clinically significant, and 3-5% aniseikonia is generally highly symptomatic.¹ Some patients with large amounts of aniseikonia (>10%) are less symptomatic than those with lesser amounts, presumably because there is no attempted fusion of such visually disparate images. In longstanding cases, suppression may play a relieving role. Headaches and asthenopia are much more common than distorted space perception. Note that manifest diplopia does not appear on this list, created over seventy years ago (Table 1).

Table 1. Symptoms of Aniseikonia Patients by Bannon and Triller (1944)¹

Characteristic Symptoms of Aniseikonia Patients	
Headaches	67%
Asthenopia	67%
Photophobia	27%
Reading Difficulty	23%
Nausea	15%
Motility	11%
Nervousness	11%
Vertigo and Dizziness	7%
General Fatigue	7%
Distorted Space Perception	6%



Figure 4. Space eikonometer (left), with controls for neutralizing X-, Y-, and Z-axis aniseikonia (middle and right)

More recently, in 2012, Rutstein found a similar list of symptoms, including asthenopia, general fatigue, headaches, impaired fusion and stereopsis, reading difficulties, rivalry, diplopia, and distorted space perception.²

Common Causes of Aniseikonia

Optically induced aniseikonia is universally caused by anisometropia. Often, the anisometropia is sudden. An example would be unilateral aphakia, as when a traumatic cataract is extracted and the posterior capsule is not intact to hold an intraocular lens (IOL).

Other times, the sudden absence of longstanding anisometropia can cause neurologic aniseikonia. This can occur in refractive surgery, most commonly LASIK, or cataract surgery, particularly when a former anisometrope becomes more isometric for the first time. In these cases, a well-adapted infantile anisometrope may have corrected the optical aniseikonia neurologically in the visual cortex and cannot adjust to optical isometropia.

Cataract surgery remains arguably the most common cause of acute aniseikonia. When a patient with significant ametropia has very asymmetric cataracts, there is a danger of cataract extraction creating significant anisometropia and aniseikonia. With this in mind, many cataract surgeons will only create a maximum of 2D of post-surgical anisometropia, even if this means that emmetropic IOL correction is not possible after the second cataract is removed and the second IOL is implanted.

In a 2015 study, Rutstein³ measured aniseikonia in seventeen patients before cataract surgery (visit 1), as well as after surgery on one eye (visit 2) and both eyes (visit 3). Patients were left anisometric after the first eye was operated on to create emmetropia with a posterior-chamber IOL. Patients showed significant anisometropia and complained of increased

reading difficulty, distorted space perception, and nervousness after surgery.

It is worth noting that in this study, the amount of post-surgical anisometropia at visit #2 did not necessarily predict the amount of aniseikonia. Rutstein³ reports that three participants with between about 2-4 D of anisometropia experienced 11-12% aniseikonia, while one who temporarily had 11 D of post-surgical anisometropia before the second eye was operated on only had about 2%. Aniseikonia was generally diminished when the second eye was operated on and received an IOL a short time later.

With the emergence of optical coherence tomography used to diagnose macular holes and epiretinal membranes (ERMs), as well as refinement of the “macular peel” procedure to treat these, retinal aniseikonia is an increasingly common cause of symptoms, even in the absence of current or past anisometropia. These symptoms certainly accompany ERM but can also persist after treatment of both ERM and retinal detachment (RD) when visual acuity is improved.

Because they are concave, macular holes and central retinal detachments usually cause micropsia. In a 2012 study, Rutstein found that six out of seven retinal detachment patients experienced micropsia, or a smaller image, in the affected eye.² In a study by Okamoto of 56 patients with monocular macular hole, 55% experienced micropsia of about -3% on average but as high as -15%. About 40% of the remainder had no aniseikonia, leaving only 7% with macropsia.⁴

It is perhaps unsurprising that central retinal detachments create the same kind of micropsic aniseikonia as macular holes. In a 2014 study, Lee et al.⁵ studied 30 patients who had undergone RD surgery. Seventeen of these RDs were macula-off, with the remaining 13 patients having macula-on RD. About 90% of macula-off RD patients had micropsia. In the macula-on RD group, the ratio was reversed: almost 80% were unaffected by

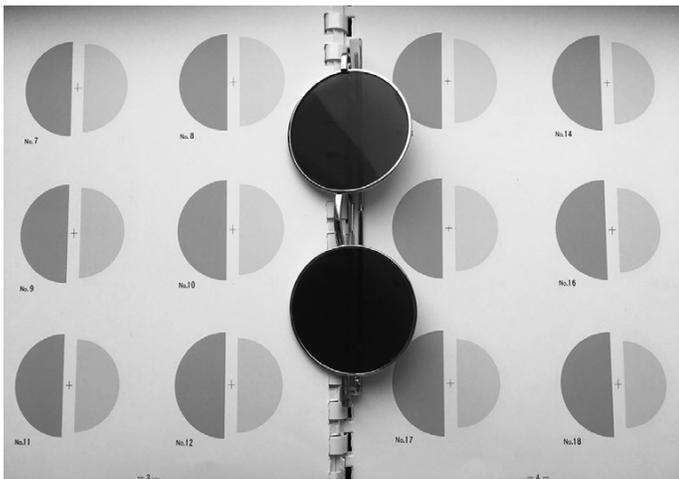


Figure 5. Awaya Aniseikonia Test

aniseikonia. Overall, 60% developed micropsic aniseikonia, all but three of whom were in the macula-off RD group.

Conversely, because they are convex, epiretinal membranes usually cause macropsia (larger retinal image). In a case series, Rutstein² reported that three out of four cases of ERM and one case of AMD resulted in macropsia, or an enlarged image in the affected eye. In 2014, Okamoto's group found that 89% of ERM patients had macropsia proportional to inner nuclear layer thickness, but this aniseikonia was not reduced by surgery.⁶

In a much larger study of ERM, Chung et al.⁷ found that among 65 participants with idiopathic ERM, over 80% experienced macropsia. Using Photoshop to measure the thickness of the inner nuclear layer on macular OCT in both the horizontal and vertical meridia, Chung's team was able to correlate the subjective aniseikonia measured on the Awaya test with structural changes in the retina.⁷

Measurement of Aniseikonia

Clinical measurement of aniseikonia is perceived as difficult by many clinicians. This is in part due to gold standard obsolete instrumentation (i.e., the space eikonometer), inaccurate analog methods (i.e., the Awaya plate test) and accurate but rarely available (and now discontinued) software, like The Aniseikonia Inspector (Optical Diagnostics). Yet for aniseikonic patients, there are readily available alternatives.

Many clinicians, as well as optometric educators, were taught that the gold standard device for measuring aniseikonia is the space eikonometer. This unique instrument has long been out of production and requires a savvy binocular patient to respond subjectively. Unfortunately, even the best subjective responder with aniseikonia may not be binocular enough to respond to this test, even if a working eikonometer can still be found (Figure 4).

In 1985, the Awaya Aniseikonia Test was introduced. This simple book test was designed to be as straightforward and easy to administer as pseudoisochromatic plate tests for color blindness (Figure 5).

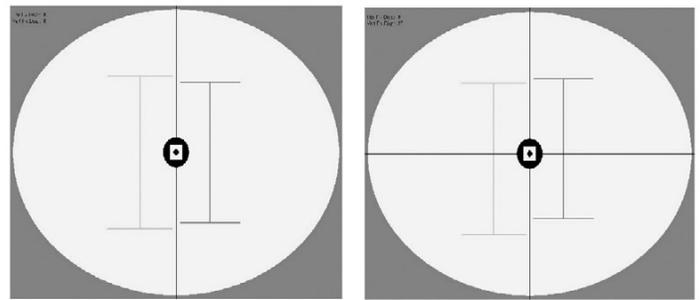


Figure 6. Aniseikonia Inspector showing two targets with Vernier lines for vertical aniseikonia. The patient makes forced-choice comparisons of the lines as to which appears larger while wearing anaglyphic filters.

Credit and permission from: Gerard de Witt, PhD, Optical Diagnostics

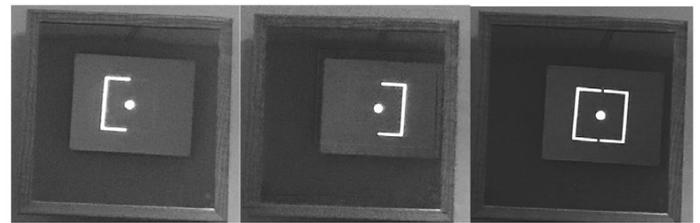


Figure 7. Polarized aniseikonia targets as seen OD, OS, and OU, with central fusion lock.

There have been digital developments in aniseikonia testing since. Notably, the Aniseikonia Inspector (AI) software, when still in production, was the dominant and precise quantification method for image size difference for over a decade. In the three versions commercially available from Optical Diagnostics, this software picked up where the Awaya test left off and refined the semicircular presentation to include four meridia and eventually to use Vernier lines for more precise comparison. Like the Awaya test, early versions of the AI software were potentially affected by size-color illusions, as shown by Garcia-Pérez and Peli.⁸

Although responses are subjective, version 3 of the AI software has been shown to be accurate, even for younger patients. Kehler⁹ found that eighteen asymptomatic children, ages 5-13, measured only about 0.6% background aniseikonia, and mean vertical-meridian aniseikonia was about 3.8-4.3% when a 4% size lens was introduced. However, at least one author has found that both the Awaya and AI software still slightly underestimate the true amount of aniseikonia.³ See Figure 6 for an example of the forced-choice AI targets.

In 2017, Sasaki et al. developed an iPad software alternative to eikonometry. In thirty young subjects with simulated aniseikonia, they showed that there was approximately a 40% underestimation in known aniseikonia.¹⁰ Note that these participants had normal binocularity and stereopsis, which is something that naturally occurring aniseikonics lack.

Perhaps most promising in diagnosing and measuring aniseikonia are 3D video displays, which exhibit high-contrast images that can be filtered using the same type of circularly polarized filters used in movie theaters. Unlike the linearly polarized filters routinely used in optometric practice for stereopsis testing, circularly polarized filters are not dependent on the angle at which the patient's head is held. However, like

size lenses, this type of filter is not found in manual or digital phoropters, and so testing must be done in free space.

Aniseikonia can be quantified by using iseikonic (size) lenses to equalize the size of two targets, such as a pair of square brackets, one seen by each eye. An example of the type of aniseikonia target used on polarized digital displays is shown in Figure 7. Note that this type of high-contrast target avoids size-color illusions that can affect anaglyphic targets.

When a patient views this target through circularly polarized filters, one square bracket is seen by each eye, with the circle seen by both eyes to serve as a fusion lock. The brackets make a square shape in the absence of aniseikonia. If size lenses are used to equalize the images, this suggests one possible treatment.

Treatments for Aniseikonia

Contact lenses are often one of the first treatment options for refractive aniseikonia. In this case, contact lenses were primarily prescribed to correct the patient's irregular astigmatism secondary to keratoconus and a subsequent corneal transplant. However, corneal ectasia is not necessary to make a contact lens recommendation for aniseikonia.

Knapp's Law mathematically predicts when contact lens correction of aniseikonia is indicated. Its obscurity may be due to the original definition:

"When a correcting lens is so placed before the eye that its second principal plane coincides with the anterior focal point of an axially ametropic eye, the size of the retinal image will be the same as though the eye were emmetropic."¹¹

Knapp's Law predicts that contact lenses are ideal for the correction of refractive aniseikonia, while spectacles would be the ideal correction for axial aniseikonia. However, Knapp's Law neglects retinal and cortical aniseikonia. In addition, many older patients cannot or will not attempt contact lens correction. Even when contact lenses are necessary and effective, sometimes they are not sufficient to eliminate symptoms, as the above case demonstrates.

When a spectacle correction is used to treat aniseikonia, manipulation of the base curve, center thickness, vertex distance, and/or index of refraction can all be used to modify the retinal image size. Complicated nomograms (as seen in Appendix A) and calculations are not always necessary, however, because the front base curve is the largest single modifiable factor. In general, flatter base curves minify, and steeper base curves magnify the retinal image.

Following this rule, if a patient with aniseikonia chooses a stock base curve as flat as available in the most-plus eye and a base curve as steep as possible on the least-plus eye, the vertex distance alone will reduce aniseikonia by 2-3%.³ While specific spectacle base curves can be prescribed from standard nomograms, surfacing the lenses to create them can be expensive and works by making the lenses thicker. Patients are often better off using stock base curves with high-index lenses rather than paying for custom surfacing.

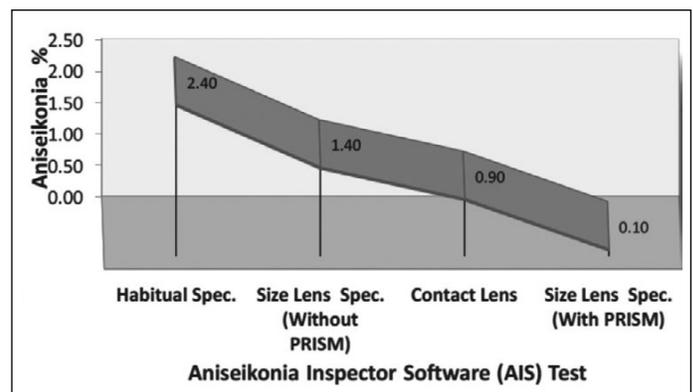


Figure 8. Mean aniseikonia of different lenses as found with the Aniseikonia Inspector software. Source: <http://bit.ly/2Mq4jlt>

In a case series from 2012, Rutstein³ discusses a dozen cases of confirmed aniseikonia, all among presbyopes. Most had experienced retinal complications in the form of epiretinal membrane, retinal detachment, or AMD. Only six demonstrated stereopsis, and only one had better than 100 arc sec stereopsis. This is a bit surprising considering Bannon and Triller's 1944 study showing that distorted space perception only accounted for 6% of aniseikonia symptoms.¹ In all three cases detailed in this publication, size lenses were unsuccessful, and attenuation (Bangerter) foils were instead applied. Two of the cases were unsuccessful with the filter treatment modality, perhaps because they had already undergone retinal surgeries to improve visual acuity, making suppression more difficult.

Ophthalmic prism also seems to have a role for most aniseikonic patients.³ It has long been established that base-in prism slightly enlarges size perception OU, while base-out prism diminishes size perception through the SILO effect. However, since aniseikonia is by definition an asymmetric condition, it is not clear why the symmetric effects of horizontal prism should reduce aniseikonic symptoms. The presumption is that when this occurs, it is due to diminishment, rather than elimination, of perceived size differences, as shown below.

In a 2016 study of aniseikonic young women (n=10), Al Habdan determined that the rule-of-thumb ratio of 1.00 D of anisometropia causing 1% aniseikonia was a bit inflated. Instead, she found 0.80% aniseikonia per diopter of anisometropia. She also found that in the majority of her aniseikonic participants, there was a subjective prism correction. Moreover, the image size difference was diminished with this prism as measured by either Brecher testing or Aniseikonia Inspector software. This diminishment was even greater than that provided by either iseikonic lenses alone or with contact lenses (Figure 8).¹²

In order to produce inexpensive iseikonic lenses without surfacing fees, Al Habdan followed the clinical principle that when all other factors are equal, flatter base curves minify images and steeper base curves magnify. To diminish aniseikonia with stock lens blank base curve manipulation, the most-plus-lens base curve should be flattened as much as possible, while the most-minus-lens base curve should be steepened as much as

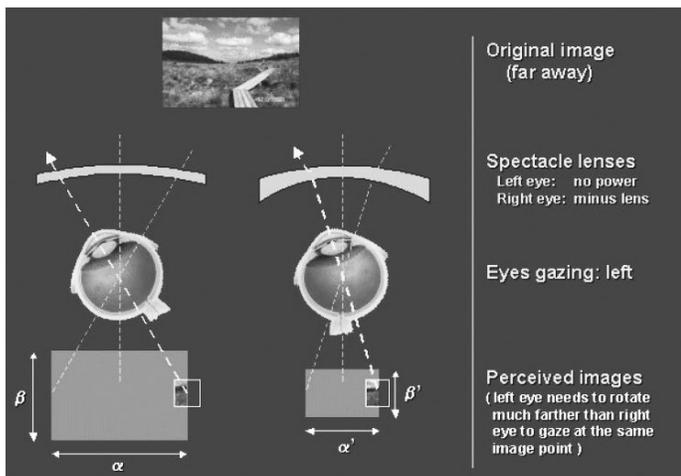


Figure 9. Optically-induced anisophoria
 Source: <http://bit.ly/2Mi91Sx>
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possible.¹² This does thicken both lenses, and thus should be combined with high-index lens materials whenever possible.

Contact lens and spectacle combinations can be used to treat aniseikonia. Of particular interest is the Galilean contact lens telescope. This uncommon treatment is necessary to eliminate symptomatic but large (>7%) amounts of aniseikonia. A contact lens telescope is created with an over-minused contact lens eyepiece and a sufficient-power-plus spectacle lens objective as found by over-refraction. The vertex distance between these two lenses creates magnification. As a rule, each diopter of overcorrecting minus in the contact lens will create slightly more than 1% aniseikonic correction. Fortunately, this treatment is rarely needed, as patients with double-digit aniseikonia often can ignore one retinal image, generally the smaller one.

Similar to prescribing low vision telescopes, contact lens telescopes can cause optically induced anisophoria. This is when “the amount of the aniseikonia varies as a function of visual field angle.” Fortunately, high angles typically result in less aniseikonia³ (Figure 9).

Since many cases of the macropsic variety of aniseikonia are caused by epiretinal membrane (ERM), it stands to reason that macular peel to treat ERM would affect retinal image size difference. In a 2016 study, Han et al. found a greater than 40% reduction in both horizontal and vertical aniseikonia after macular peel procedures in 24 presbyopic participants. Greater improvement in aniseikonia was seen in participants with better best-corrected visual acuity preoperatively, shorter symptom duration, and early vitrectomy.¹³

Future Directions in Aniseikonia Diagnosis

The presence of acute aniseikonia has been known at least as long as there have been patients with unilateral aphakia. With continuing refinement of optical coherence tomography and microsurgery for the retinal problems that can so elegantly be imaged with it, some acquired aniseikonia can be treated better than at any previous time in history. However, the increased

Figure 10. Online iseikonic lens calculator
 Source: <http://bit.ly/2JDIExS>

best-corrected visual acuity after epiretinal membrane peel or macular hole repair leads patients to experience increased awareness of aniseikonia.

To diagnose aniseikonia, many digital targets have joined the legacy of analog tests to aid in quantification of different visual image sizes. Since anaglyphic tests may be contaminated by size-color illusions, digital polarized measurement is preferable.⁸

Difficult calculations are no longer necessary to treat aniseikonia optically. While analog shape magnification nomographs are still in occasional use to produce iseikonic lenses (Appendix A), digital calculators are available, such as the one offered since 2005 by The Optician’s Friend website (Figure 10).¹⁴

Conclusions

Aniseikonia can present with symptoms of headache, asthenopia, and other non-specific concerns, but rarely diplopia or symptomatic depth perception issues. Consideration should be made for symptoms of aniseikonia once adequate binocular acuity is achieved in a previously monocular patient. The Brecher test, combined with a size lens set, lens clock, and specialty contact lenses, can be used to diminish or to eliminate aniseikonia without requiring additional equipment or mathematical calculation of spectacle base curve or center thickness. Aniseikonia should be ruled out even in contact lens wearers, as contact lenses can only eliminate a moderate (~5%) size difference. Prism correction or, rarely, a contact lens telescope may be needed to correct larger amounts of aniseikonia, especially in post-surgical cases with residual symptoms.

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Correspondence regarding this article should be emailed to James Kundart, OD, MEd, kundart@pacificu.edu. All statements are the author's personal opinions and may not reflect the opinions of the representative organizations, ACBO or OEPF, Optometry & Visual Performance, or any institution or organization with which the author may be affiliated. Permission to use reprints of this article must be obtained from the editor. Copyright 2018 Optometric Extension Program Foundation. Online access is available at www.acbo.org.au, www.oepf.org, and www.ovpjournal.org.

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