ARTICLE

Management of Anisometropic Amblyopia: A Case Report and Brief Review

Sung Hee (Kelly) Lee, OD, FAAO

Graham B. Erickson, OD, FAAO, FCOVD

ABSTRACT

Background

Unilateral functional amblyopia due to anisometropia is a common cause of vision loss in children. There has been a significant amount of research recently to determine the most effective management strategies for such cases, and it is important for clinicians to determine how to apply these findings clinically.

Case Report

A 6-year-old female presented for her first comprehensive eye exam after failing a school vision screening. She was diagnosed with significant anisometropia with anisometropic amblyopia in her left eye. She was treated with spectacle correction initially, and was eventually fit with soft contact lenses to achieve optimal vision and binocularity. Part-time occlusion therapy was also initiated, which was modified throughout the treatment period based on clinical findings. She was also treated with 19 sessions of office-based vision therapy in order to maximize the success of amblyopia treatment. At the completion of the treatment, this patient showed significant improvement in her visual acuity and other non-acuity factors, including contrast sensitivity and binocularity.

Conclusions

The successful treatment of this patient with anisometropic amblyopia was achieved by the combination of active vision therapy with evidence-based management strategies, consisting of optical correction and occlusion therapy.

Correspondence regarding this article should be emailed to Sung Hee (Kelly) Lee, OD, FAAO, at sh.kelly.lee@gmail.com. *VDR is indexed in the Directory of Open Access Journals. Online access is available at covd.org. https://doi.org/10.31707/VDR2019.5.2.p100*

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INTRODUCTION

Anisometropia is a common cause of functional amblyopia. It is often difficult to detect without an effective vision screening or a comprehensive eye examination, as there are typically no symptoms or obvious manifesting signs.

A generally accepted definition of anisometropia is at least 1D difference of sphere or cylinder power between each eye.[1,2,3,4] The potential amblyogenic amount of anisometropia is suggested to be 1D for hyperopia, 3D for myopia, and 1.5D for astigmatism.[5] The reported incidence of amblyopia is 100% with hyperopic anisometropia of 3.5D or higher, and in myopic anisometropia of 6.5D or higher.[1,2,6,7]

In anisometropic amblyopia, visual deprivation and the subsequent lack of adequate retinal stimulus are caused by optical defocus and abnormal binocular inhibition in the more ametropic eye.[1,3,6,8,9] In addition to acuity loss, these mechanisms also affect the normal development of other vision factors including contrast sensitivity, accommodation, oculomotor function, and eye-hand coordination.[1,2,3,6,10] Another considerable factor is the compromised binocularity in these patients. Even after improvement of vision and deficient vision skills in the amblyopic eye, aniseikonia and binocular inhibition patterns can remain as obstacles for obtaining sensory fusion without further intervention.

In addition to recognizing the risk factors and clinical findings described above, the appropriate evidence-based management strategies that should be considered for patients with anisometropic amblyopia include optical correction and occlusion. Further, active vision therapy (VT) should also be considered to potentially improve the efficacy and facilitate the efficiency of the treatment. This case report demonstrates an effective course of treatment for anisometropic amblyopia using all of these strategies.

CASE

AC, a 6-year-old female, presented for her first comprehensive eye exam after failing a school vision screening. This first grader was told that her left eye was not "focusing" as well as the right eye. Another optometrist at the clinic initiated the vision care of AC, before care was transferred to the authors. AC's mother reported no noticeable problems regarding her eyes or vision and AC never reported any complaints. AC's health history was unremarkable and the pregnancy and birth histories were normal. She was meeting normal developmental milestones and not experiencing any difficulties at school. She reported an allergy to penicillin that causes a rash, and was taking no medication other than a multivitamin supplement. There was no known family history of any ocular conditions.

Initial Exam

AC's uncorrected vision in the right eye was 20/20 (1.0MAR) at both distance and near; however, the left eye was 20/250^{-} (12.5^{-}MAR) at distance and 20/200^{-} (10.0^{-}MAR) at near. The pupils were equally reactive to light with no afferent pupillary defect in both eyes. The confrontation visual fields were grossly full, and extraocular muscle motilities were full and unrestricted in each eye. Cover testing revealed ortho alignment at distance and 6Δ exophoria at near. No stereo acuity was reported with the Lang I stereoacuity test. The following are the results of objective refraction:

Dry Retinoscopy:
- OD: +1.00D
- OS: +8.50-1.25x004

Wet Retinoscopy
(1gtt 1% cyclopentolate OU):
- OD: +2.00D
- OS: +9.00-1.00x175

Anterior and posterior segment ocular health were unremarkable.

Based on the findings, AC was diagnosed with refractive amblyopia in the left eye secondary to high hyperopic anisometropia of 6.5D (equivalent sphere). A spectacle correction was chosen over contact lenses since protection of the sound eye was one of the treatment goals due to the severe amblyopia. However, contact lenses to minimize aniseikonia were strongly recommended as a future option as the amblyopia resolves. A spectacle prescription of +1.00D OD and +8.00-1.00x175 OS was provided for full time wear. The importance of compliance with spectacle wear was emphasized and she was advised to return to the clinic in 6 weeks for a follow-up evaluation of her prescription and amblyopia.

Follow-Up Visit #1

AC's mother reported good compliance with spectacle wear. The corrected distance visual acuities were 20/20 (1.0MAR) OD and 20/125^{-} (6.3^{-}MAR) OS with isolated single line Snellen acuity. She demonstrated 400 arc seconds of local stereo acuity with Wirt-type circles on the Randot steroacuity test. The over-retinoscopy findings through the current spectacles revealed +1.25D OD and +0.25-0.25x180 OS. The prescription was not modified at this time, and it was decided to monitor. AC's optometrists at this visit initiated 2 hours of daily patching of the right eye with a Patchworks eye patch to expedite the recovery of visual acuity. AC was recommended to engage in eye-hand coordination activities at near while patching. A follow-up appointment was scheduled in 1 month.

Follow-Up Visit #2

AC still reported good compliance with spectacle wear. However, patching was reported to be extremely difficult, and it could only be done for about 30 minutes each day. The corrected distance visual acuity in the left eye improved to 20/80⁻ (4.0⁻MAR) with Snellen single line and 20/70 (3.5MAR) with Snellen isolated letter. Over-retinoscopy results were consistent with the first follow-up visit, so the right eye's prescription was updated to +2.00D from +1.00D. The left eye's prescription remained unchanged. She was recommended to try patching the right eye for 2 hours/day, 7 days/week, and was educated on the importance of compliance with occlusion therapy for maximum benefit. The next follow-up visit was scheduled in 1 month.

Follow-Up Visits #3-5

These follow-up visits were conducted in monthly intervals. AC had difficulty and poor compliance with the patching regimen of 2 hours per day that was prescribed. For follow-up visits #3 and #4, minimal improvement of the VA in the left eye was measured. The lack of further improvement was judged to be due to poor compliance with patching, and therefore the prescribed patching regimen remained the same.

Starting at follow-up visit #5, her care was transferred to the authors. By this point, she was able to increase patching to 1 hour per day for a few days a week. Corrected distance visual acuity in the left eye was 20/60⁻ (3.0- MAR) with the Snellen single line, 20/50 (2.0MAR) with single letter, and 20/60⁻ (3.0- MAR) with crowded Lea symbols. She reported no global stereo with the Randot butterfly stereoacuity test and 100 arc seconds of local stereo with the animals on the Randot test. The 3-Figure Worth test revealed suppression of the left eye at distances farther than 1 meter. Visuoscopy testing showed steady central fixation in the right eye and unsteady central fixation in the left eye. The clinical findings measured at this visit are summarized in Table 2. AC was recommended to attempt increasing patching to 2 hours a day while engaging in near eye-hand activities. The option of a contact lens correction was discussed again. AC's mother was informed about the option of active vision therapy to potentially increase the efficacy of occlusion therapy, decrease the treatment duration, train the vision skill deficits in the amblyopic eye, and maximize binocularity. After the discussion, it was decided to pursue a contact lens correction and initiate a weekly vision therapy program.

Active Vision Therapy Program (28 weeks)

Active Vision Therapy

Weekly 45-minute in-office vision therapy sessions were conducted, and AC's visual acuity in her left eye was measured at each visit. In addition to daily patching, approximately 35 minutes of home therapy was prescribed for 5 days each week. The compliance with in-office visits was good, with moderate compliance with the prescribed home therapy activities. Progress evaluations were conducted every 4 to 5 visits to measure non-acuity factors. AC followed the general therapy sequence of monocular, bi-ocular, and then binocular procedures. The monocular phase activities included both accommodation and oculomotor activities. Although these skills were not evaluated pre-vision therapy, they were assumed to be reduced due to the significant visual acuity reduction in the left eye. Monocular phase was combined with the bi-ocular activities, also known as monocular fixation in binocular field (MFBF), to minimize the suppression of the amblyopic eye. When AC's visual acuity in the amblyopic eye reached about 20/40 (2.0MAR) to 20/50 (2.5MAR), the binocular therapy activities were initiated. An emphasis was made on divergence activities as AC was showing relative difficulty compared to convergence. The in-office and home activities included in her therapy program are listed below:

1. Monocular Phase: Majority of activities at the beginning of VT
    a. Accommodation: Monocular Accommodative Rock
    b. Oculomotor: Hart chart saccades, rotating pegboard, symbol tracking (modification of Michigan Letter Tracking)

2. Bi-ocular Phase: Activities done with red/green anaglyphic glasses
    a. Sherman playing cards
    b. Red mazes
    c. Red symbol tracking

3. Binocular Phase: Initiated when VA of amblyopic eye reached 20/40-20/50
    a. Accommodation: Binocular Accommodative Rock
    b. Vergence: Brewster-type Stereoscope, Vectograms, VTS-3 (multiple choice vergence with random dot stereo targets)

After completion of the office-based vision therapy program, maintenance therapy with the Home Therapy System (HTS) was prescribed for fusional vergence activities.

Modification of Refractive Correction and Patching Regimen During Active Vision Therapy Program

By the second vision therapy session, AC was fit with daily modality contact lenses based on her most recent spectacle prescription. She was given the spherical equivalent prescription in the amblyopic eye rather than a toric lens, since the benefit of minimizing the fitting complications was determined to be more beneficial than the optical improvement obtained by correcting 1D of with-the-rule astigmatism. The contact lens prescription of +2.00D OD and +8.00D OS was finalized. Throughout AC's follow-up visits and active vision therapy sessions, her prescription was closely monitored for any need of modification. Cycloplegic refractions were repeated when indicated, and her contact lens prescription was modified twice. The first modification was made shortly after AC's initial contact lens fit. A cycloplegic refraction result of +4.25-0.25x090 OD and +9.50-1.00x180 OS confirmed the consistent over-refraction results of +2.50D through the current prescription in the right eye. While the prescription in the left (amblyopic) eye remained the same, the right eye's prescription was changed to +3.00D in both spectacles and contact lenses. This modified prescription achieved symmetrical under-correction of hyperopia of approximately 1.25D in both eyes. The second modification was made based on a repeatedly measured excessive lag of accommodation on MEM retinoscopy in both eyes. The amount of hyperopia compensation was increased in both eyes to normalize the accommodative response at near. At this visit, the contact lens prescription was adjusted to +3.75 in the right eye and +9.50 in the left eye, which resulted in +0.50D of uncorrected hyperopia in each eye through the prescription. Due to the left eye's higher prescription and the limited availability in the initial daily contact lens design chosen, the modality was changed to a monthly lens, and an appropriate cleaning regimen was recommended. Since AC was primarily wearing her contact lenses, the spectacle prescription was not changed at this time; however, a copy of the updated prescription was released for future use. The history of prescription changes are summarized in table 1.

Table 1. Prescription (Rx) change history

		OD	OS
Initial Assessment	Wet Refraction	OD: +2.00DS	OS: +9.00-1.00x175
	Rx (spectacles)	OD: +1.00D	OS: +8.00-1.00x175
Rx change #1	Rx (spectacles)	OD: +2.00D	OS: +8.00-1.00x175
Contact Lens (CL) fitting	Rx (CL)	OD: +2.00D	OS: +8.00DS
Rx change #2	Wet Refraction	OD: +4.25-0.25x090	OS: +9.50-1.00x180
	Rx (spectacles)	OD: +3.00D	OS: +8.00-1.00x175
	Rx (CL)	OD: +3.00D	OS: +8.00D
Rx change #3	Rx (CL)	OD: +3.75D	OS: +9.50D

Since the initiation of active vision therapy, AC's compliance with patching improved and she was able to tolerate a 2 hours/day regimen for an average of 4 days each week. By the 12th VT session, AC's visual acuity in the amblyopic eye stabilized at 20/40 for approximately 2 months. After discussing the option of tapering or increasing the patching regimen, AC's mother agreed to increase it to a 6 hours/day regimen. To maximize compliance, the Patch-works patch was replaced with an adhesive patch; the parents were informed of possible adverse effects of skin irritation from the adhesive. With this new type of patch, AC showed excellent compliance for the 6 hours/day patching regimen.

Progress Evaluation Results and Further Treatment Plan

After the completion of 19 sessions of office-based vision therapy with occlusion therapy, a progress evaluation was conducted to obtain detailed measurements. AC's corrected visual acuity in the right eye was 20/15 at distance and 0.32M at 40 cm. In the left eye, it was measured 20/30+1 (1.5+1MAR) with Snellen single line, 20/30+ (1.5+MAR) with Snellen isolated letter, and 20/35 (1.8MAR) with Wesson Psychometic acuity cards at distance. Near VA in the same eye was 0.63M^{+} at 40cm. AC was no longer reporting suppression OS

Table 2. Comparison of clinical measurements between initial visit, pre-VT visit, and post-VT visit.

Test	Initial (sc)	Pre-VT (spectacle)	Post-VT (contact lens)
Distance VA (Snellen)	OD: 20/20	OD: 20/20	OD: 20/15
	OS: 20/250- (single line)	OS: 20/60 (single line) 20/50 (single letter)	OS: 20/30 (single line) 20/30 (single letter)
Near VA (Lea)	OD: 20/20		OD: 20/16
	OS: <20/200		OS: 20/30-
Psychometric VA (Wesson VA card)			OS: 20/35
Stereoacuity*	None reported	(-) Global, 100" local OS suppression >3ft	(+) Global, 50" local
Cover Test	Distance: Ortho	Distance: Ortho	Distance: Ortho
	Near: 6 Exophoria	Near: Ortho	Near: Ortho
Contrast Sensitivity (threshold)		OD: 8% (@ 20/20)	OD: 3.2% (@ 20/20)
		OS: 20% (@ 20/50)	OS: 6.3% (@ 20/40)
MEM		OD: Variable large lag	OD: +0.50D
		OS: Variable large lag	OS: +0.50 D
Near Vergence Range		PFV: Unreliable	PFV: X/8/X**
		NFV: Unreliable	NFV: X/6/X **

* Lang I stereo test used at initial visit. Randot Butterfly and Wirt Circles stereo test used at subsequent visits. Child Worth test used for suppression test.
** Suppression at the break point.

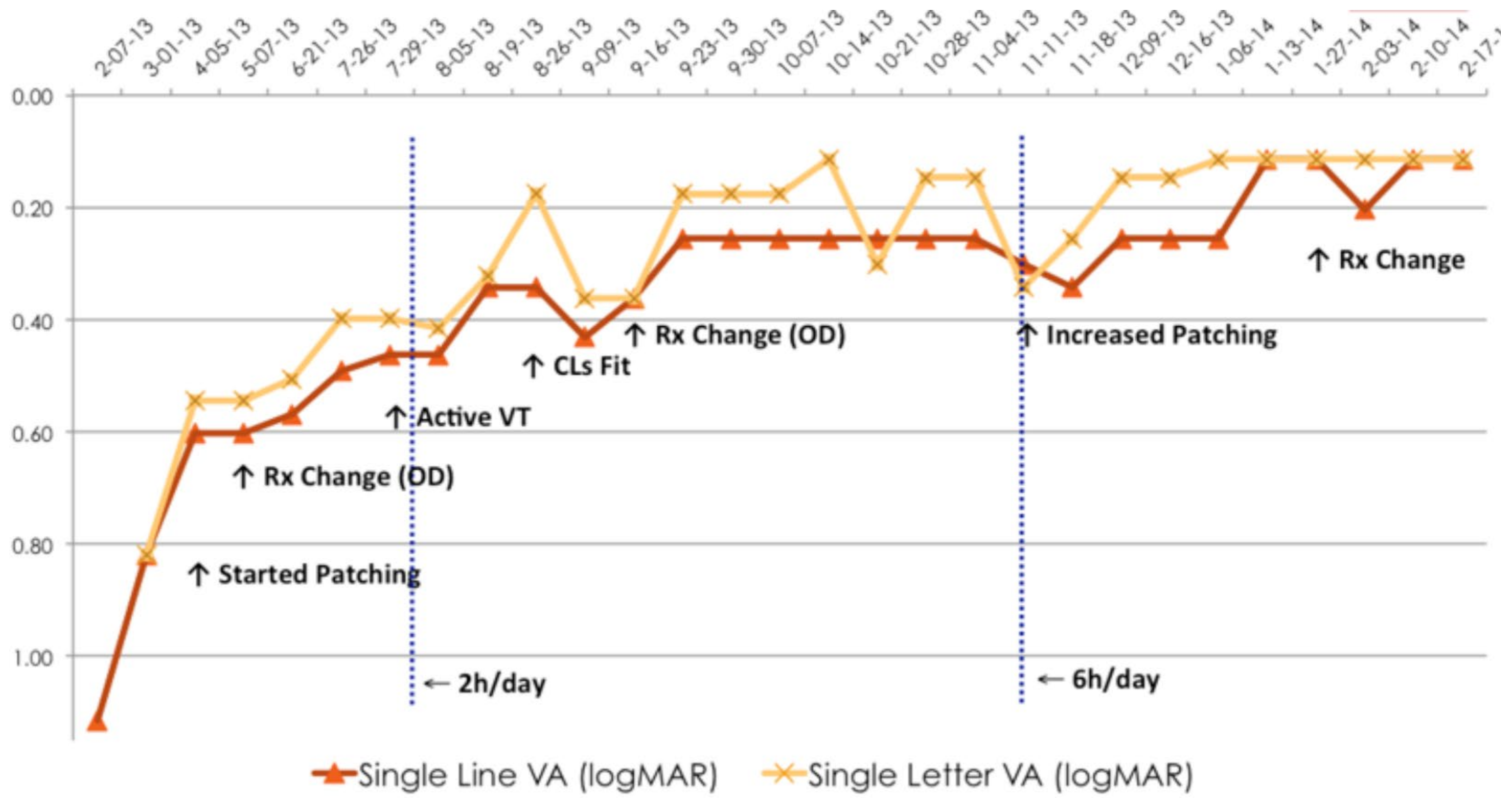

Figure 2: Change of visual acuity (logMAR) in amblyopic eye throughout treatment

and was able to see global stereo with the Randot butterfly and improved local stereo was measured with Wirt circles. Contrast sensitivity measured with each eye's threshold VA also improved in both eyes and MEM retinoscopy normalized. The suppression point for positive fusional vergence (PFV) and negative fusional vergence (NFV) were both reduced compared to expected values. However, a discrepancy was noted on AC's performance on the VTS-3 multiple choice vergence activity with random dot stereo targets, which showed a maximum of 27Δ for PFV and 12Δ for NFV. A comparison of the clinical measurements is shown in Table 2, and the changes in visual acuity are shown in Figure 2.

After this evaluation, the results were discussed with AC and her mother. As her visual acuity in the amblyopic eye stabilized at 20/30 (1.5MAR) for approximately 2 months and her binocularity improved significantly, the patching regimen was tapered down to 2 hours a day. Also, the weekly vision therapy was discontinued and a maintenance home therapy program with monthly follow-up visits was initiated. For the home therapy, the Computerized Home Therapy System (HTS) was dispensed, and specific vergence activities were prescribed. AC's performance was monitored weekly using the software's monitoring system and the prescribed activities were modified accordingly. For accommodation therapy, Binocular Accommodative Rock with +/-2.50 lens flipper was prescribed.

During her first 5 monthly follow-up visits, AC showed no regression in any clinical measurement and her local stereoacuity further improved to 40 seconds of arc. Her PFV performance on the VTS-3 system also improved; however, NFV remained unchanged. The patching regimen was tapered further down to 1 hour a day for 3 days a week, then to 1 day a week, and was eventually stopped as her findings, including VA, were stable. The Binocular Accommodative Rock and HTS program with emphasis on divergence were continued for maintenance therapy. The activities were eventually tapered down to 1 day a week based on her stable performance. She was followed periodically at the clinic even

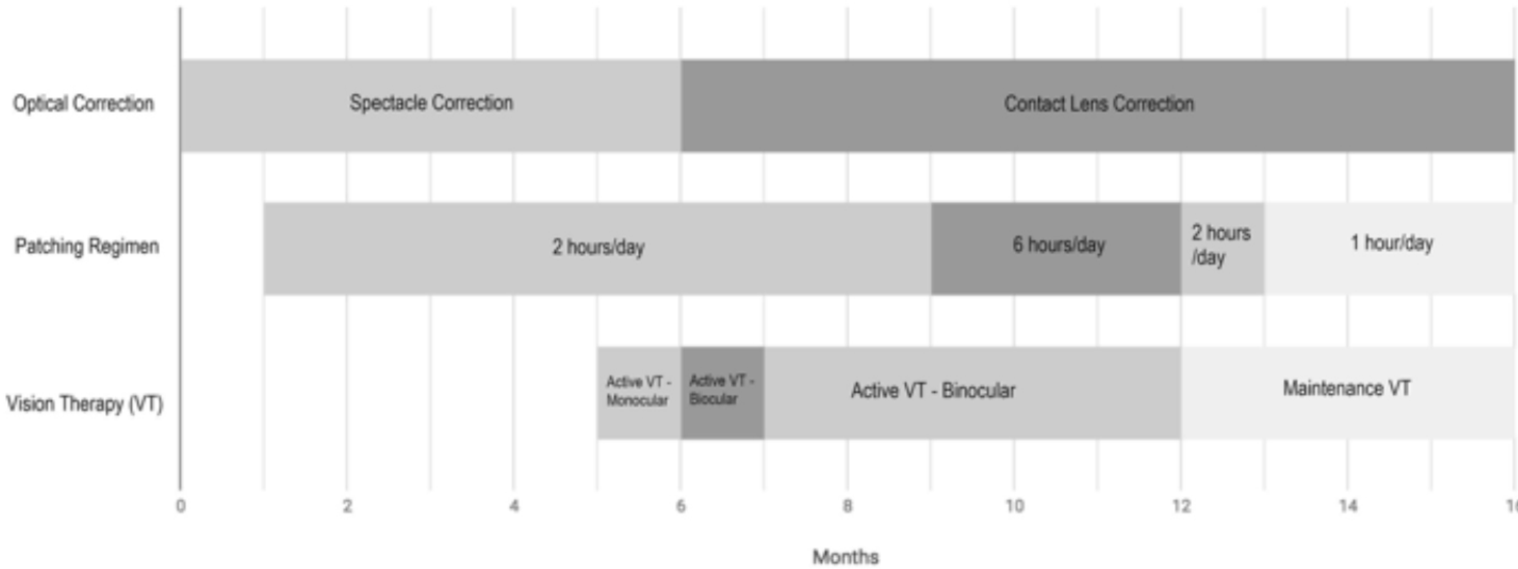

Figure 1: Treatment timeline

after the author moved to another location. She was eventually switched to a soft toric lens in the left eye, which maintained 20/30+ to 20/30-visual acuity. The most recent record, which was 4 years following discontinuation of patching and active vision therapy, showed that her vision stabilized at 20/40.

DISCUSSION

There has been a significant amount of research conducted to determine the most effective treatment options for anisometropic amblyopia since it is a common cause of vision reduction in children. Recent research provides useful clinical guidance regarding vision assessment, refractive error correction, and patching regimens to assist eye care providers in managing this condition most effectively. In the case presented, patching, contact lens wear, and active vision therapy were prescribed simultaneously in an attempt to achieve the maximum treatment results. Therefore, it should be noted that it is difficult to determine how much each treatment alone contributed to AC's visual acuity improvement. AC's treatment timeline is illustrated in Figure 1, and her change of visual acuity over the course of treatment is shown in Figure 2.

Refractive Error

The potential amblyogenic amount varies depending on the type of refractive error. When assessing refractive error, objective measurement with retinoscopy is extremely valuable since the central visual acuity in an amblyopic eye is unreliable for performing a subjective refraction.[1,2,11] It is recommended to fully correct the amount of anisometropia, and a cycloplegic refraction should be completed to determine accurate values.[1,12] When prescribing for patients with hyperopia the Pediatric Eye Disease Investigator Group (PEDIG) guidelines require symmetrical under correction of hyperopia up to 1.5D.[12] When prescribing for anisometropia, aniseikonia and its related symptoms must be considered.[1,2,13-6] A clinical rule-of-thumb is that 1D of anisometropia causes about 1% aniseikonia when correcting with traditional spectacle lenses. Patients with 2 to 3% of aniseikonia often become symptomatic, experiencing symptoms such as reduction of stereoacuity, headache, asthenopia, and/or reading difficulties.[17] However, when aniseikonia is greater than 5 to 6%, no symptoms may be noticed due to suppression of an eye.[18,19,20] For symptomatic and potentially symptomatic patients, correction with contact lenses is a good option because it reduces aniseikonia and can improve stereopsis. Conventionally, it was believed that aniseikonia is reduced most effectively by contact lenses in refractive anisometropia, and by spectacles in axial anisometropia. However, more recent studies have found that contact lenses are more effective in reducing aniseikonia than spectacles even in axial anisometropia.[15,16] Therefore, contact lens correction is recommended in anisometropia greater than 2.5D-3D.[1,2,6,8,15] In addition, contact lens correction does not cause prismatic imbalance between each eye in different gaze positions that occurs in spectacle correction of anisometropia.[14,20,21] Further, contact lenses improve cosmesis, convenience for prescription modification, and compliance with prescription wear, especially when the sound eye requires a minimal correction.[1] Given all these advantages, contact lens wear was recommended in this particular case with a large anisometropia of 6.5D and suspected aniseikonia. However, in any case where contact lenses are prescribed for amblyopic patients, the patient should be counseled on the potential for contact lenses complications in the sound eye, since the risk of vision loss is higher in this patient group.22 In severe amblyopia, spectacles with impact resistant lenses are a prudent option to provide protection for the sound eye; this can also be combined with contact lens wear.

Occlusion Therapy

Occlusion of the sound eye has been the treatment of choice for amblyopia, and recent research, including PEDIG Amblyopia Treatment Studies (ATS), has provided useful information regarding effectiveness of various amblyopia treatment options. Since occlusion treatment can be a significant burden for both patient and caregiver,[4,23] it is important to consider how to achieve the maximum effect with the minimal amount of treatment time. For this purpose, the following questions should be considered before initiating occlusion therapy: 1) When to initiate occlusion; 2) How to prescribe an appropriate regimen; and 3) Which occlusion method is best for this individual.

Studies have shown that optical correction alone can achieve significant improvement in amblyopia without any other intervention. According to PEDIG study results, more than a quarter of ATS patients with anisometropic amblyopia showed resolution of amblyopia with refractive compensation alone (greater than 20/30 in amblyopic eye, or less than 1 line of interocular difference). Furthermore, the subjects experienced stabilized acuity with an average of 3-lines improvement with approximately 3 to 4 months of optical correction wear alone.[12] Based on this evidence, the full time use of optical correction may be initiated without occlusion, and progression can be monitored for the first 4 months. This clinical application may allow avoidance of unnecessary occlusion therapy or minimize the amount of occlusion time when it is indicated.[8,12] For the patient discussed in this case, occlusion was initiated at the same time when the glasses were prescribed. We speculate that the visual acuity improvement noted in the early phase of the treatment is mainly a result of the refractive error correction alone since her occlusion therapy compliance was very limited. The overall period of occlusion therapy would likely have been reduced if it was initiated after the visual acuity stabilized with full time wear of the optical correction first, which can be a significant benefit for both the patient and her parents.

When occlusion therapy is necessary to obtain further acuity improvement in amblyopia, an effective patching regimen depends on the baseline acuity in the amblyopic eye. An ATS study found that, when combined with near activities, daily patching of 2 hours/day is as effective as 6 hours of patching for moderate amblyopia with acuity between 20/40 and 20/10024, and 6 hours/day is as effective as full time patching for severe amblyopia with acuity worse than 20/100.25

Furthermore, a recent study suggested that it is reasonable to initiate a 2 hours/day regimen even with severe amblyopes, and increase it to 6 hours/day if improvement plateaus.[26] As seen in AC's case, some patients experience difficulty complying with patching despite a variety of methods available, including adhesive, pirate, or a spectacle frame-attached patch. For these patients, partial occlusion options can be considered as alternatives to patching. A graded Bangerter foil, a film that is applied to the lens of spectacles to achieve reduced acuity in the sound eye, was also found to be an effective treatment choice for moderate amblyopia.[27] Although the study could not conclude its treatment effectiveness relative to patching, Bangerter foil use was found to have less treatment burden.[27] Another option for partial occlusion therapy is atropine penalization. According to a randomized clinical trial, 1% atropine therapy was found to be as effective as patching in moderate amblyopia.[23] Further study also showed that weekend and daily atropine led to similar visual acuity outcomes.[28] Studies that compared patching with an adhesive patch to atropine penalization showed better compliance, easier administration, and better cost effectiveness with atropine.[23] However, atropine can cause photosensitivity, allergic reaction (rarely), and poor cosmesis in light colored irides.[23] More importantly, atropine penalization interferes with binocularity since it impairs accommodation in the penalized eye.

Once the specific occlusion method for the individual patient has been selected, the amblyopic eye should be closely monitored. When there is no improvement of visual acuity for about 2-3 months, a clinical judgment has to be made to either modify the current regimen or to cease the treatment. When the patient is motivated and compliant, increasing the occlusion regimen should be considered since it was found to be effective in achieving additional improvement when there is residual amblyopia.[29] However, the evidence supporting this strategy only applies to total occlusion with an adhesive patch.

According to a long term follow-up study, the majority of patients with moderate amblyopia who were treated with either patching or atropine at 7 years of age or younger maintained their acuity improvement at 15 years of age.[30] Despite this finding, cessation of patching therapy should still be administered with caution to further minimize the recurrence of amblyopia once the maximum improvement is achieved. The definition PEDIG used for recurrence is "2 or more logMAR levels reduction in 2 consecutive measures."[31] The risk of recurrence in children who have undergone occlusion therapy before the age of 12 was found to be low (7%) to moderate (24%), depending on the type and duration of treatment.[31,32] This recurrence rate was determined to be minimized by tapering rather than abruptly stopping occlusion for patients treated with 6 or more hours of daily patching.[33] Therefore, patients with associated risk factors, such as good visual acuity (≥ 20/32) at cessation, larger improvement of acuity during the treatment, or previous history of recurrence should be monitored with extra caution.[31,33]

There has been recent interest in determining the effectiveness of using binocular computer/tablet games alone as a new treatment option for amblyopia. Some studies showed that a binocular game alone was not as effective as part-time patching in improvement of visual acuity and stereoacuity,[34-36] whereas others showed promising results with clinically significant improvement in visual acuity and/or stereoacuity, as well as the compliance of the treatment.[37-44] The PEDIG randomized clinical trials with 5- to 12-year-olds and 13- to 16-year olds comparing binocular iPad games to part time patching found fairly poor compliance with the binocular iPad games; only 22.2% and 13% completed more than 75% of the prescribed treatment, respectively.[34,35] Use of flicker glasses that provide rapid alternating occlusion is another new approach to treat amblyopia.[45] This device provides rapid square-wave alternation of visual stimuli to help break suppression.[45] These encouraging new treatment options should be studied with further research, as they may be beneficial particularly in cases where occlusion therapy may not be practical. However, until their effectiveness is clearly proven, occlusion therapy should remain an integral part of amblyopia treatment.

Non-Acuity Factors of Amblyopia

While many clinicians use visual acuity as the sole outcome measurement when treating amblyopia, it must be recognized that the amblyopic eye has additional visual deficits. The crowding effect is a well-known and characteristic deficit of amblyopia. Therefore, the current evidence-based methods of acuity assessment, including ATS-HOTV and Early Treatment Diabetic Retinopathy Study (ETDRS) protocol with single-surrounded ototype, are recommended to obtain the most accurate and consistent measurements. When these methods are unavailable, the psychometric visual acuity method can be used as it has the least variability, which is helpful since fluctuations in measurements are often evident in amblyopia.[1,2,11,46] Contrast sensitivity can be another measure to monitor with amblyopia, as its improvement can achieve visual function gain without change in visual acuity.[1,2,17,46] Those with anisometropic amblyopia typically have reduced contrast sensitivity in all spatial frequencies compared to strabismic amblyopia where there is often only a reduction at high spatial frequencies.[46-7] In addition, there are often deficits in accommodative and saccadic function in the amblyopic eye, as it has not received the same level of visual stimulation as the sound eye.[18,46] Eye-hand coordination deficits are another consideration due to diminished spatial judgment from reduced binocularity.[1,2,6,17,18,46] Abnormal binocularity is an important deficit in anisometropic amblyopia. Due to the relative optical defocus in one eye, binocular inhibition can cause suppression or reduction in stereoacuity as a result.[1-3,6-9,48] Despite having equal visual acuity, it was found that patients with a history of successful occlusion treatment for anisometropic amblyopia can still show reduced stereoacuity when compared to an age-matched population without the condition.49 According to many studies, reduction in stereoacuity is associated more with the amount of anisometropia rather than the interocular difference in visual acuity.[7,8,13,16,49] Also, it was found that patients with hyperopic anisometropia are more affected by the amount of anisometropia, and likely to have greater reduction in stereopsis compared to those with myopic anisometropia.[16] As mentioned previously, contact lenses are often the best method for correcting anisometropia to improve binocularity.[1,2,8,16,20]

Vision Therapy

Although there has yet to be a large-scale randomized clinical trial supporting vision therapy for amblyopia treatment, vision therapy is often recommended concurrently with occlusion therapy to improve treatment efficacy and reduce treatment time.[50-54] Further, it is typically designed to address the non-acuity deficits in the amblyopic eye, thereby maximizing visual function and binocularity.[1,2,3,17,46] The vision therapy activities can be categorized into three phases: monocular, bi-ocular, and binocular.[2,8,17,46] Monocular activities can be prescribed to enhance accommodation, pursuit and saccadic eye movements, and eye-hand coordination with the amblyopic eye, and can be done while patching or with atropine penalization. Bi-ocular, also known as monocular fixation in binocular field (MFBF), activities allow only the amblyopic eye to see stimulus details while both eyes receive peripheral stimuli using anaglyphic filters.[1,6,48] The amblyopic eye typically sees red colored central targets through the green filter while the sound eye only gets peripheral information through the red filter due to filter cancellation. The activities with red targets, such as mazes, symbol tracking, and playing cards, can be used during this phase. It is a good transition from the monocular to binocular phase as it minimizes the inhibitory effects that occur in anisometropic amblyopia.[1,2,6,48] When visual acuity of the amblyopic eye improves to approximately 20/40 (2.0MAR) and suppression is reasonably controlled with MFBF, binocular activities can be initiated to achieve maximum sensory and motor fusion ability. Treatment with atropine penalization interferes with this phase, as accommodation in both eyes is required for successful binocular therapy. Commonly used activities include tranaglyphs, vectograms, stereoscopes, and binocular accommodation procedures. In addition, there are numerous computer software programs that allow for binocular training with anaglyphic or LCD shutters. In addition to improvement of stereopsis, the sensorimotor fusion training may also improve the efficacy of treatment for mild residual acuity loss that is often harder to obtain.1[,2]

Prognosis of Anisometropic Amblyopia Treatment

Generally, a successful outcome of amblyopia treatment is considered to be visual acuity better than 20/30 (1.5MAR) in the amblyopic eye, or less than 1 line of intraocular difference.[12,23-5,27-29,31,46,49,55-57] Good compliance with optical correction use and occlusion are the most important prognostic factors for amblyopia therapy.[1,3,23,58] The use of optical correction is particularly important in anisometropic amblyopia since it is critical for the amblyopic eye to receive the clearest retinal image for improvement. Another positive prognostic factor is commencing treatment with better initial visual acuity. Since there is a correlation with amount of anisometropia, patients with less anisometropia can be predicted to have a better acuity outcome.[1,8,20,49] In addition, some studies found the presence and degree of pre-treatment stereoacuity are associated with better post-treatment stereoacuity, as well as visual acuity in the amblyopic eye.[8,49] Historically, there has been some controversy over age-related limitation to treatment success for amblyopia.[59-61] However, it was shown that older children (ages 13 to 17 years) could also obtain a significant improvement from compliant occlusion therapy, especially if they had not been treated previously.[57,62] A possible contributing factor in older children was that their treatment compliance is often worse when compared to younger children.[20]

CONCLUSION

This case report demonstrates how anisometropic amblyopia was effectively managed by the discussed treatment strategies, consisting of optical correction and occlusion therapy, supported by recent research. A program of vision therapy was incorporated into the treatment to address specific visual deficits and potentially increase the efficacy of the treatment. Additional improvement was achieved by increasing the patching regimen when visual acuity stabilized at a sub-par level; the regimen was then tapered to minimize the chance of recurrence of amblyopia. The non-acuity vision deficits related to amblyopia were addressed and improved by active vision therapy, and the patient's binocularity was further maximized with contact lens wear. The combination of these treatments was used as the best attempt to maximize results in managing this case.

REFERENCES

1. Caloroso EE, Rouse MW. Clinical Management of Strabismus. Santa Ana: Optometric Extension Program Foundation, 2007:17-22, 113-125, 175-199. https://doi.org/10.1177/026461969301100310
2. Griffin JR, and Borsting, EJ. Binocular Anomalies: Therapy, Testing & Therapy. Volume 2. 5th Edition. Santa Ana: Optometric Extension Program Foundation, 2010:126-146.

3. Rouse MW. Optometric clinical practice guideline: care of the patient with amblyopia. American Optometric Association, 1994. Web. 26 Jan. 2014.
4. Summers CG., et al. Preferred Practice Pattern: Amblyopia. American Academy of Ophthalmology 2012. Web. 10 Feb. 2014.
5. Varma R., et al. The multi-ethnic pediatric eye disease study: design and methods. Ophthalmic Epidemiol. 13 (2006):253-62. https://doi.org/10.1080/09286580600719055
6. Ciuffreda KJ, Levi DM, Selenow A. Amblyopia: Basic Clinical Aspects. Stoneham: Betterworth-Heinemann, 1991.
7. Weakley DR. The association between nonstrabismic anisometropia, amblyopia, and subnormal binocularity. Ophthalmology 108 (2001):163-171. https://doi.org/10.1016/s0161-6420(00)00425-5
8. Caputo R., et al. Factors influencing severity of and recovery from anisometropic amblyopia. Strabismus 15 (2007):209-14. https://doi.org/10.1080/09273970701669983
9. Von Noorden GK. Amblyopia: a multidisciplinary approach. Invest Ophthalmol Vis Sci 26 (1985):1704-16.
10. Von Noorden GK. Factors involved in the production of amblyopia. Brit J Ophth 58 (1974):158-164. https://doi.org/10.1136/bjo.58.3.158
11. Davidson DW, Eskridge JB. Reliability of visual acuity measures of amblyopic eyes. Am J Optom Physiol Optics 54 (1977):756-66. https://doi.org/10.1097/00006324-197711000-00003
12. Pediatric Eye Disease Investigator Group. Treatment of anisometropic amblyopia in children with refractive correction. Ophthalmology 113 (2006):895-903. https://doi.org/10.1016/j.ophtha.2006.01.068
13. Dobson V, et al. Associations between anisometropia, amblyopia, and reduced stereoacuity in a school-aged population with a high prevalence of astigmatism. Invest Ophthalmol Vis Sci 49 (2008):4427–36. https://doi.org/10.1167/iovs.08-1985
14. Edwards KH. The management of ametropic and anisometropic amblyopia with contact lenses. Ophthal Optician 19 (1979):925-929.
15. Rose L, Levinson A. Anisometropia and aniseikonia. Am J Optom Physio Opt 49 (1972):480-4. https://doi.org/10.1097/00006324-197206000-00003
16. Winn B., et al. The superiority of contact lenses in the correction of all anisometropia. Journal of British Contact Lens Association 9 (1986):95-100. https://doi.org/10.1016/s0141-7037(86)80034-9
17. Scheiman M, Wick, B. Clinical Management of Binocular Vision: Heterophoria, Accommodative, and Eye movement Disorders. 3rd Edition. Philadelphia: Lippincott Williams & Wilkins, 2008. 478-495, 525-554.
18. Greenwald IB. A binocular approach to amblyopia therapy. J Optom Vis Dev 26 (1995):62-67.
19. Kutschke PJ, Scott WE, and Keech RV. Anisometropic amblyopia. Ophthalmology 98 (1991):258-63. https://doi.org/10.1016/s0161-6420(91)32307-8
20. Sen DK. Results of treatment of anisohypermetropic amblyopia without strabismus. Br J Ophthalmol 66 (1982):680-684. https://doi.org/10.1136/bjo.66.10.680
21. Oguchi, Y, Mashima, Y. The influence of aniseikonia on the VEP by random-dot stereogram. Acta Ophthalmol 67 (1989):127–130.
22. Tommila V, Takkanen A. Incidence of loss of vision in the health eye in amblyopia. Br J Ophthalmol 65 (1981)575-7. https://doi.org/10.1136/bjo.65.8.575
23. Pediatric Eye Disease Investigator Group. A randomized trial of atropine vs. patching for treatment of moderate amblyopia in children. Arch Ophthalmol 120 (2002):268-278. https://doi.org/10.1001/archopht.120.3.268
24. Pediatric Eye Disease Investigator Group. A randomized trial of patching regimens for treatment of moderate amblyopia in children. Arch Ophthalmol 121 (2003):603-611. https://doi.org/10.1001/archopht.121.5.603
25. Pediatric Eye Disease Investigator Group. A randomized trial of prescribed patching regimens for treatment of severe amblyopia in children. Ophthalmology 110 (2003):2075-2087. https://doi.org/10.1016/j.ophtha.2003.08.001
26. Wallace DK, et al. Time course and predictors of amblyopia improvement with 2 hours of daily patching. JAMA Ophthalmol 133 (2015):606-9. https://doi.org/10.1001/jamaophthalmol.2015.6
27. Pediatric Eye Disease Investigator Group. A randomized trial comparing Bangerter filters and patching for the treatment of moderate amblyopia in children. Ophthalmology 117 (2010):998-1004. https://doi.org/10.1016/j.ophtha.2009.10.014
28. Pediatric Eye Disease Investigator Group. A randomized trial of atropine regimens for treatment of moderate amblyopia in children. Ophthalmology 11 (2004):2076-2085. https://doi.org/10.1016/j.ophtha.2004.04.032
29. Pediatric Eye Disease Investigator Group. A randomized trial of increasing patching for amblyopia. Ophthalmology. 120 (2013):2270-2277.
30. Repka MX, et al. Atropine vs patching for treatment of moderate amblyopia follow-up at 15 years of age of a randomized clinical trial. JAMA Ophthalmol 132 (2014):799-805. https://doi.org/10.1001/jamaophthalmol.2014.392
31. Pediatric Eye Disease Investigator Group. Risk of amblyopia recurrence after cessation of treatment. J AAPOS 8 (2004):420-428. https://doi.org/10.1016/s1091-8531(04)00161-2
32. Pediatric Eye Disease Investigator Group. Stability of visual acuity improvement following discontinuation of amblyopia treatment in children 7 to 12 years old. Arch Opthalmol 125(2007):655-9. https://doi.org/10.1001/archopht.125.5.655
33. Holmes JM, et al. Factors associated with recurrence of amblyopia on cessation of patching. Ophthalmology 114 (2007):1427-1432. https://doi.org/10.1016/j.ophtha.2006.11.023
34. Pediatric Eye Disease Investigator Group. Effect of a binocular iPad game versus part-time patching in children aged 5 to 12 with amblyopia: a randomized clinical trial. JAMA Ophthalmol 136 (2018):1391-1400.

35. Pediatric Eye Disease Investigator Group. Pediatric Eye Disease Investigator Group. A Randomized Trial Of A Binocular iPad Game Versus Part-Time Patching In Children 13 To 16 Years Of Age With Amblyopia. Am J Ophthalmol 186 (2018):104-15. https://doi.org/10.1016/j.ajo.2017.11.017

36. Gao TY, et al. Effectiveness of a binocular video game vs placebo video game for improving visual functions in older children, teenagers, and adults with amblyopia. JAMA Ophthalmol 133 (2015):172-81.

37. Hess RF, Mansouri B, and Thompson B. A new binocular approach to the treatment of amblyopia in adults well beyond the critical period of visual development. Restor Neurol Neurosci 28 (2010):793-802.

38. Knox PJ, et al. An exploratory study: prolonged periods of binocular stimulation can provide an effective treatment for childhood amblyopia. Invest Ophthalmol Vis Sci 53 (2012):817-24. https://doi.org/10.1167/iovs.11-8219

39. Li J, et al. Dichoptic training enables the adult amblyopic brain to learn. Curr Biol 23 (2013):R308-9. https://doi.org/10.1016/j.cub.2013.01.059

40. Li SL, et al. A binocular iPad treatment for amblyopic children. Eye (Lond) 28 (2014):1246-53. https://doi.org/10.1038/eye.2014.165

41. Birch EE, et al. Binocular iPad treatment for amblyopia in preschool children. J AAPOS 19 (2015):6-11. https://doi.org/10.1016/j.jaapos.2014.09.009

42. Herbison N, et al. Randomised controlled trial of video clips and interactive games to improve vision in children with amblyopia using the I-BiT system. Br J Ophthalmol 100 (2016):1511-16. https://doi.org/10.1136/bjophthalmol-2015-307798

43. Bossi M., et al. Binocular therapy for childhood amblyopia improves vision without breaking interocular suppression. Invest Ophthalmol Vis Sci 58 (2017):3031-43. https://doi.org/10.1167/iovs.16-20913

44. Portela-Camino JA., et al. A random dot computer video game improves stereopsis Optom Vis Sci 95 (2018):523-5. https://doi.org/10.1097/opx.0000000000001222

45. Vera-Diaz FA., et al. A flicker therapy for the treatment of amblyopia Vis Dev Rehab 2 (2016):105-14.

46. London R, Silver, JL. Diagnosis Amblyopia: Emphasis on Nonacuity Factors. Problems in Optometry: Amblyopia. Rutstein, RP. Philadelphia: J.B. Lippincott Company, 1991.

47. Abrahamsson M, Sjostrand J. Contrast sensitivity and acuity relationship in strabismic and anisometropic amblyopia. Br J Ophthalmol 72 (1988):44-9. https://doi.org/10.1136/bjo.72.1.44

48. Cohen AH. Monocular fixation in a binocular field. J Am Optom Assoc 52 (1981):801-6.

49. Pediatric Eye Disease Investigator Group. Stereoacuity in children with anisometropic amblyopia. J AAPOS 15 (2011):455-461.

50. Wick, B., et al. Anisometropic amblyopia: Is the patient ever too old to treat? Optom Vis Sci 69 (1992):866-78. https://doi.org/10.1097/00006324-199211000-00006

51. Garzia RP. Efficacy of vision therapy in amblyopia: a literature review. Am J Optom Physiol Optics 64 (1987):393-404. https://doi.org/10.1097/00006324-198706000-00003

52. Leyman IR. A comparative study in the treatment of amblyopia. Am Orthop J. 28 (1978):95-9. https://doi.org/10.1080/0065955x.1978.11982464

53. Callahan WP, Berry D. The value of visual stimulation during contact and direct occlusion. Am Orthopt J 18 (1968):73-4.

54. Von Noorden GK., et al. Home therapy for amblyopia. Am Orthopt J 20 (1970):46-50. https://doi.org/10.1080/0065955x.1970.11982261

55. Pediatric Eye Disease Investigator Group. A randomized trial to evaluate 2 hours of daily patching for strabismic and anisometropic amblyopia in children. Ophthalmology 113 (2006):904-912. https://doi.org/10.1016/j.ophtha.2006.01.069

56. Pediatric Eye Disease Investigator Group. Feasibility of a clinical trial of vision therapy for treatment of amblyopia. Optom Vis Sci 90 (2013):475-481. https://doi.org/10.1097/opx.0b013e31828def04

57. Pediatric Eye Disease Investigator Group. Randomized trial of treatment of amblyopia in children aged 7 to 17 years. Arch Opthalmol 123 (2005):437-447. https://doi.org/10.1001/archopht.123.4.437

58. Lithander J, Sjostrand, J. Anisometropic and strabismic amblyopia in the age group 2 years and above: a prospective study of the results of treatment. Br J Ophthalmol 75 (1991):111-6. https://doi.org/10.1136/bjo.75.2.111

59. Wick B., et al. Anisometropic amblyopia: is the patient ever too old to treat? Optom Vis Sci 69 (1992):566-78. https://doi.org/10.1097/00006324-199211000-00006

60. Kivlin J, Flynn J. Therapy of Anisometropic Amblyopia. J Pediatr Ophthalmol Strabismus 18 (1981):47-56

61. Birnbaum MH., et al. Success in amblyopia therapy as a function of age: a literature survey. Am J Optom Physiol Opt 54 (1977):269-75. https://doi.org/10.1097/00006324-197705000-00001

62. Younger age associated with greater treatment response in children with amblyopia. ScienceDaily. JAMA and Archives Journals, 12 July 2001. Web. 20 Feb. 2014.

CORRESPONDING AUTHOR BIOGRAPHY: Sung Hee (Kelly) Lee, OD, FAAO

Dr. Kelly Lee earned both her BSc degree in science and Doctor of Optometry degree from the University of Waterloo in Canada. She completed her residency in Vision Therapy, Rehabilitation, and Pediatrics at Pacific University College of Optometry.

Dr. Lee is a Fellow of the American Academy of Optometry (FAAO). She was previously an adjunct faculty member at the School of Optometry and Vision Science, University of Waterloo, and is now fully committed to a private vision therapy clinic in the Toronto area.