Article • Relearning to Fixate as an Adult with Strabismic Amblyopia: Supportive Evidence of Neuroplasticity

Yutaka Maki, OD, MS • UIW Rosenberg School of Optometry • San Antonio, Texas
Russell S. Coates, OD • UIW Rosenberg School of Optometry • San Antonio, Texas

ABSTRACT

Background: Neuroplasticity is the basis for accepting adult strabismic/amblyopic patients into vision therapy. Although the patient's age has a large impact on the prognosis, it is only one of the deciding factors. Patient goals/motivation, fixation, correspondence, magnitude and frequency of strabismus, suppression, degree of fusion, etc. also have a significant impact on the patient's prognosis.

Case Report: A 34-year-old Caucasian female with long-standing strabismus and amblyopia presented with a goal to improve her vision OS. Best-corrected visual acuities (BCVA) were 20/20 OD, $20/100^{-2}$ OS at distance and 20/20 OD, $20/80^{-2}$ OS at near. Other pertinent findings included: 4-6 PD constant left esotropia, anomalous correspondence at near, steady central fixation OD, steady 1.5 PD nasal eccentric fixation OS, central suppression OS, flat fusion at 40 cm and 1 m, simultaneous perception (eso) at 2 m with partial suppression OS, and suppression OS at 3m. The patient was informed of a guarded prognosis, and a ten-session, trial-basis course of vision therapy was initiated. The patient's degree of eccentric fixation changed to unsteady 0.5 PD nasal eccentric fixation OS after ten weeks. The patient self-discontinued the therapy program after 18 sessions (due to job constraints) with a final BCVA of $20/50^{-1}$ OS without visual symptoms.

Conclusion: The significant improvement achieved in the patient's visual acuity OS was evidence of neuroplasticity in adult patients. The most probable reason for the improvement in visual acuity was the improvement of monocular fixation OS. In addition, strong motivation and compliance with vision therapy homework led to success.

Keywords: amblyopia, eccentric fixation, optometric vision therapy, strabismus

Introduction

Neuroplasticity is the basis for accepting adult strabismic/amblyopic patients into vision therapy.[1-3] Multiple studies have shown visual improvement in adults with amblyopia (strabismic, refractive, and deprivational).[4-16] Although the patient's age has a significant impact on their prognosis, it is only one of the deciding factors. Fixation,[17] correspondence,[18] magnitude and frequency of strabismus,[19] suppression,[10] and binocular status[17] also have a significant impact on the patient's prognosis. The case presented in this paper contributes to the evidence of the effectiveness of the rehabilitation of visual dysfunctions in adults through the application of neuroplasticity principles.[20-22] Vision therapy uses the same principles (motivation, feedback, repetition, loading, and multi-sensory integration)[23] as other rehabilitation disciplines to achieve recovery of impaired function through the initiation of neuroplasticity.

While the presence of eccentric fixation in an amblyopic patient is certainly relevant to the prognosis, it should not prevent the practitioner from initiating therapy. Monocular fixation techniques were stressed throughout the ensuing patient case, thereby applying the

Table 1. Summary of Initial Evaluation

Test	Results
Current Rx and entrance VA (full-line)	DVA NVA OD -0.75-0.25x005 20/20 20/20 OS -0.75 sph 20/100-2 20/80-2
Refraction and VA (full line)	DVA NVA OD -0.75-0.25x008 20/20 20/20 OS -0.75-0.25x180 20/100-2 20/80-2
2.2x telescope	OD 20/10-2 OS 20/60+2
Cover test	Dist & Near cc: 4-6Δ CLET
NPC cc	11/13 cm (+) OS turn out
EOM	Full OU, comitant; (-) diplopia, pain
Pursuits	Smooth movement OD, OS, OU
Saccades	Quick and accurate in all gazes OD, OS, OU
Stereo	(-) Random dot stereogram
DBI (prism bar)	x/14/12 (unreliable due to patient's poor response)
DBO (prism bar)	x/16/12 (unreliable due to patient's poor response)
NBI (prism bar)	x/18/10 (unreliable due to patient's poor response)
NBO (prism bar)	x/16/12 (unreliable due to patient's poor response)
Visuoscopy	OD steady central fixation OS steady 1.5Δ nasal eccentric fixation
Amplitude of accommodation	OD 6.50 D OS unable to obtain due to her poor vision
MEM	OD +0.25 OS +0.25
Bagolini lens	Central suppression OS. Patient reported seeing a faint line in the periphery only through her left eye.
Clown vectograms	BI: x/B/A, BO: x/4/1, (-) localization, (-) appreciation of float, unable to assess SILO or parallax
Keystone visual skills*	The patient met all the expected responses except for lateral posture at distance (card #3 and 4). Slight over-convergence was seen at distance.

DVA = distance visual acuity; NVA = near visual acuity; CLET= constant left esotropia; NPC = near point of convergence; EOM = extraocular motility; DBI = distance base-in; DBO = distance base-out; NBI = near base-in; NBO = near base-out; MEM = monocular estimation method. *Keystone View 5100 Visual Skills Test Set.

principle and importance of attention to the visual task. Research shows that attention has an essential role in bringing about change in visual function.[24] The importance of stressing and monitoring patient motivation throughout the therapy program is key to maintaining attentional behavior if cortical plasticity is to be generated.[20] In order to facilitate the brain's attention, the therapy techniques should be varied and the level of difficulty increased appropriately. This approach was followed in the management of the case below.

Case Report

R.G., a 34-year-old Caucasian female with strabismus and amblyopia, was referred for an evaluation. She was told in the past that her vision was decreased in her left eye due to an eye turn. She did not report any other visual complaints, including diplopia. There was no history of strabismus surgery, patching, or vision therapy. She had been wearing glasses since she was a child. She reported no change in her vision with her current glasses, which she received a year prior. At a comprehensive eye exam six months prior, she was informed that she was at high risk for glaucoma due to her elevated intraocular pressures (20-22 mmHg OD, 19-22 mmHg OS), large cupping of her optic nerves (0.6v/0.6h OD/OS), and a positive family history of glaucoma (maternal grandmother). An optical coherence tomography of her optic nerves and visual field tests were negative for glaucoma, but she had been closely monitored

by her ophthalmologist for the past six months. With a positive family history of near blindness due to glaucoma, R.G. had a legitimate concern for her vision. Consequently, she wanted to see whether vision therapy could improve the vision in her left eye.

Developmentally, R.G. was three months premature, with a birth weight of four pounds. She reached each developmental milestone at the expected ages. R.G.'s medical history was unremarkable except for high blood pressure and osteoarthritis, for which she took Metoprolol and Mobic, respectively. She had a history of meniscus arthroscopic surgery for her left knee two years prior to the evaluation. She reported no known allergies.

At the end of the evaluation (Table 1), R.G. was diagnosed with constant left esotropia with eccentric fixation and mild central suppression OS, moderate strabismic amblyopia OS, and compound myopic astigmatism OU.

The patient's goal was to improve the visual acuity in her left eye as much as possible. The prognosis for her success in vision therapy was guarded due to the limited improvement of her left eye's visual acuity through the 2.2x telescope,[25] no history of amblyopia treatment, and her age being beyond the sensitive period. Her history of early-onset strabismus suggested the adaptations of OS eccentric fixation and mild central suppression, resulting in visual comfort and lack of symptoms. The nasal eccentric fixation OS most likely developed as an adaptation to the constant left esotropia, since the direction of the eccentric fixation followed the expected pattern. Esotropia and exotropia with strabismic amblyopes have a high prevalence of nasal and temporal eccentric fixation, respectively.[26]

Although it was challenging to predict improvement in R.G.'s vision, our goal of vision therapy was to improve her visual acuity OS without causing intractable diplopia or horror fusionalis.[27] Reducing the eccentric fixation OS was to be emphasized in the vision therapy techniques selected to improve her visual acuity OS. The determination of anomalous or normal correspondence was inconclusive from the evaluation; however, based on her history (e.g., long-standing small-angle CLET and no symptoms of diplopia) and the exam findings (e.g., W4D findings: flat fusion at 40 cm and 1 m; Keystone Visual Skills findings: flat fusion with fusion cards #4 and #11), harmonious anomalous correspondence (at near subjective angle = ortho from W4D and objective angle = 4-6 ET with unilateral cover test) was suspected. Retrospectively, the amblyoscope, Hering-Bielschowsky after-image test, or macular integrity test (MIT) with after-image transfer could have been conducted to investigate her correspondence further. If vision therapy was to be extended after improvement in her OS visual acuity was accomplished, then the new goals would be to decrease the angle of the strabismus and to improve her binocularity using her anomalous correspondence point at near. The approach would be to prioritize improving her binocularity at near initially, extending it to greater working distances as therapy progressed. Once her visual acuity OS improved and her central suppression decreased, there would be a possibility for intractable diplopia and horror fusionalis to develop. Consequently, R.G. was clearly instructed to discontinue her vision therapy homework if diplopia was experienced at any point. Considering that the patient was a responsible adult who would carefully follow therapy instructions, and the exam findings strongly suggested anomalous correspondence, the decision was made to proceed with therapy.

Although it was clearly communicated that her prognosis was guarded, R.G. was determined to proceed with vision therapy. The decision was made to begin with ten sessions of vision therapy on a trial basis. The patient understood that vision therapy would continue beyond ten sessions only if there was greater than a one-line acuity improvement OS.

During the early therapy sessions, R.G. worked on improving central fixation using the macular integrity tester (MIT). It was initially difficult for her to appreciate the Haidinger brush and to control her ability to fixate more centrally. During her first therapy session, she was only able to fixate on the central target twice and for only a split second over a ten-minute interval. She also worked on accommodation OS using the near-far Hart chart (NFHC) and monocular accommodative rock (MAR) techniques. The NFHC target had to be enlarged by 200% due to her reduced acuity. In addition, she was assigned Michigan tracking with three paragraphs per page (OS only) for a home activity, and she was prescribed two hours of patching OD per day.

By week five, R.G.'s visual acuity had improved to $20/60^{-1}$ OS. The magnification of the near Hart chart target was reduced from 200% enlargement to 125%. By week eight, her performance on the MIT showed some improvement. She could successfully fixate centrally for a duration of three seconds. She reported that the Haidinger brush had a tendency to shift nasally but that she could exert control to bring it closer to the fixation point. In addition, maze templates specifically designed for use with the MIT were added, in which she would navigate the Haidinger brush through the mazes.

A re-evaluation was conducted at week ten. Her visual acuity OS had improved to $20/50^{-1}$. Cover test results remained the same at $4\text{-}6^{\Delta}$ CLET at distance and near. Visuoscopy was measured at 0.5^{Δ} unsteady nasal eccentric fixation OS (with the patient fixating centrally 30% of the time). The amplitude of accommodation OS was now measurable and recorded at 4.25 D. The patient reported that she noticed the improvement in her visual acuity OS. She did not experience diplopia or other visual discomfort. At the end of the evaluation, continuation of vision therapy was recommended. R.G. was extremely pleased with her progress so far and was excited about the possibility of further improvement.

During week 11, the Brock string, vectograms, and mirror transfer therapy techniques were incorporated to begin working on her vergence abilities. Using the Brock string, she could successfully fuse with some accuracy from 8 cm to 15 cm; however, R.G. intermittently suppressed OS. She completely suppressed OS when attempting to fuse a bead target at working distances greater than 15 cm. A Quoit vectogram was selected since she appreciated float on the Quoit vectogram better than on the Clown vectogram. The difficulty she experienced using the Clown vectogram was most likely due to the central suppression OS. She had an easier time using the Quoit vectogram because it allowed her to use her peripheral fusion; however, occasional suppression OS was experienced. The mirror transfer technique was selected to improve her binocularity by decreasing the frequency of suppression. This technique also provided feedback on the degree of her tendency to suppress targets centrally. During mirror transfer using two dissimilar images (cartoon pictures of a house and a chick), R.G. was not able to fuse the images. She often reported seeing either two unfused images or one image (due to suppression OS). At times, when she almost fused the images, she reported partial suppression of the target corresponding to OS. In addition, monocular fixation in a binocular field (MFBF) techniques using Michigan tracking and Groffman tracing targets were incorporated as part of the amblyopia treatment. R.G. experienced no difficulty with these tasks, and no suppression was reported.

After week 12, R.G. was absent from her vision therapy sessions for almost three months due to a conflict related to her job. Upon resuming in-office therapy, she reported that there was no noticeable reduction in her vision, although she was concerned about the potential regression of her visual acuity

Table 2. Comparison of Initial and Post-Vision Therapy Evaluations

	Initial Evaluation	Post-Vision Therapy
Cover test	Dist & Near cc: 4-6$^{\Delta}$ CLET	Dist & Near cc: 4-6$^{\Delta}$ CLET
Refraction and VA (full-line)	OD -0.75-0.25x008 20/20 OS -0.75-0.25x180 20/100-2	OD -0.75-0.25x008 20/20 OS -0.75-0.25x180 20/50-1
Visuoscopy	OD steady central fixation OS steady 1.5$^{\Delta}$ nasal eccentric fixation	OD steady central fixation OS unsteady 0.5$^{\Delta}$ nasal eccentric fixation (centrally fixated 30% of the time)
Amplitude of accommodation	OD 6.50 D OS unable to obtain due to her poor vision	OD 6.50 D OS 4.25 D

OS. She had continued her home therapy activities (MAR with Michigan tracking, Brock string, and direct patching two hours per day) while she had been absent. Her corrected visual acuity OS remained at 20/50^{-1}. Her performance on the Brock string showed improvement. She was able accurately to appreciate physiological diplopia without suppression from 5 cm to 40 cm. She intermittently suppressed OS beyond 40 cm. Using the MIT, she was able to fixate centrally for 15 seconds at a time using OS.

By week 18, R.G. reported that she would not be able to return for in-office therapy for the next six months due to job commitments. Her visual acuity OS measured 20/50^{-1}, which was better than predicted by the 2.2x telescope at the initial evaluation. The cover test with habitual correction at distance and near remained 4-6$^{\Delta}$ CLET. The unchanged angle of strabismus suggested that her anomalous correspondence was deeply embedded, and maintaining the small esotropia was functionally positive for this patient. Visuoscopy measured 0.5$^{\Delta}$ unsteady nasal eccentric fixation OS. R.G. reported visual comfort without diplopia at all working distances (Table 2). The decision was made to discontinue in-office vision therapy, to continue home therapy activities, and to schedule a follow-up appointment in six months.

Discussion

It was satisfying to see how R.G.'s acuity and monocular fixation OS improved over time considering her age and guarded prognosis. One study showed a mean improvement in visual acuity of 0.17 logMAR, with 68% participants with amblyopia achieving gains less than 0.2 logMAR;[11] whereas, our patient's visual acuity improvement was 0.32 logMAR. The most probable reason for the significant improvement in her visual acuity OS was the improvement of her monocular fixation OS. Eccentric fixation is considered a factor contributing to a poor prognosis of remediation of amblyopia.[17] However, the results that we achieved with our patient suggest that amblyopia can be treated by reducing the degree of eccentric fixation. In addition, her strong motivation and compliance with her vision therapy homework contributed to her successful post-therapy results. The most effective treatment for her was the MIT, direct patching, and monocular near vision therapy activities. After only five weeks of therapy, her visual acuity improved from 20/100^{-2} to 20/60^{-1}. Upon discontinuance of the therapy, her visual acuity had improved to 20/50^{-1}. Although not incorporated into this patient's therapy program, indirect patching could have been attempted, with the intent of disrupting the eccentric fixation.[17] The effectiveness of this technique is in question for this patient considering how R.G. had adapted to her esotropia, correspondence, and eccentric fixation for the past 34 years. Indirect patching might be more effective for a child whose eccentric fixation is less embedded.[17] Other possible therapeutic techniques to reduce the magnitude of eccentric fixation include pleoptics, biofeedback, and audio feedback.[28,29] One study conducted

biofeedback rehabilitation of eccentric fixation on patients with Stargardt disease.[29] The authors used an MP-1 microperimeter, which combined computerized perimetry, digital fundus photography, and fixation analysis (location and stability), and included an auditory biofeedback system that can help patients stabilize their preferred retinal locus. The study demonstrated that MP-1 auditory biofeedback rehabilitation improves residual visual function in patients with Stargardt disease through a stabilization of the eccentric fixation. Another study analyzed eccentric fixation in strabismic amblyopic patients by using a scanning laser ophthalmoscope to image and to present stimuli (black discs and Landolt Cs) simultaneously. The majority of the patients studied displayed very clear and consistent fixational strategies. Initially, the patients' fixation remained eccentric when looking at the black discs and larger Landolt rings. However, the patients were able to switch their fixation to the fovea as soon as recognitional effort was required (smaller Landolt C gaps).[30]

Conclusion

In this case report, a combination of vision therapy and direct patching was used to improve the visual performance of the amblyopic eye. The therapy program concentrated on improving the patient's monocular fixation using traditional vision therapy techniques, resulting in a reduction in the degree of eccentric fixation and thereby, visual acuity improvement in the amblyopic eye. Several factors contributed to the patient's success: a high motivation level, good compliance with the prescribed therapy, the presence of (probable) anomalous correspondence, some degree of binocularity, and moderately decreased initial BCVA (i.e., not severe amblyopia). This case illustrates that with strong determination, the improvements made to patients' visual function may be substantial. Further improvements (decreased degree of eccentric fixation and increased VAs) may have resulted if other non-traditional methods had been incorporated into the patient's therapy program and the course of therapy had been allowed to finish to its natural endpoint.

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Correspondence regarding this article should be emailed to Yutaka Maki, OD, MS, at maki@uiwtx.edu.

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