

# Dichoptic Rescue for Spectacle-Flip Sabotage of Anisometropic Amblyopia Therapy

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**Background:** To be successful, amblyopia therapeutic techniques must respond when ingenious (shrewd) amblyopic children sabotage treatment effect by discovering ways(1) to alter those therapy aspects they find frustrating.

**Methods:** Her guardian consented to IRB-approved study outside typical FDA enrollment guidelines for CureSight dichoptic therapy. Acuity (EVA) and stereopsis was by PEDIG protocols.

**Results:** A 6-year-old rural Alaska native girl in foster care had previously been diagnosed with anisometropic amblyopia and treated with spectacles and patching but had poor compliance with BCVA 0.9–1.0 logMAR. She demonstrated exceptional creativity and hyperactivity but had no other medical issues. Atropine was prescribed in addition to her spectacles +5.50+1.00x90 and +0.50+1.00x90, but the patient discovered the rare “Spectacle Flip” method that sabotaged therapeutic impact. She had EVA enrollment acuities of logMAR 0.9 right and –0.1 left with stereo 400 seconds of arc. After just one month dichoptic therapy 1.5 hours 6 days per week, acuity improved to logMAR 0.7 and –0.1 left with stereo up to 140 second of arc. Four months later acuity was 0.6 right and –0.2 left. Stereoacuity improved from 400 to 200 arc seconds.

**Conclusion:** Even when conventional compliance methods fail, dichoptic therapy with eye-tracking has the novel and unique potential to improve amblyopia treatment compliance with real-time monitored fixation compliance and confirmation of correct spectacle wear.

**Clinical Trial Registration:** NCT06165705.

**Plain Language Summary:** Dichoptic therapy with eye-tracking improved compliance and achieved de novo acuity and stereo gains in a girl with severe refractory anisometropic amblyopia compounded by the rare complication of topical atropine therapy called “spectacle-flip sabotage”

**Keywords:** anisometropic amblyopia, compliance, eye tracking, anaglyph

## Introduction

Successful amblyopia therapy is at the mercy of compliance.<sup>1</sup>

The Pediatric Eye Disease Investigator Group (PEDIG) amblyopia treatment studies (ATS) have demonstrated that successful amblyopia therapy for patients younger than 10 years of age with strabismic and/or refractive etiologies involves correction of refractive error, and then consistent part-time occlusion and/or atropine penalization of a non-myopic sound eye.<sup>2</sup> Dichoptic therapy, especially the recently approved Curesight (Novasight, Airport City, Israel) can improve amblyopic visual acuity and stereopsis.<sup>3</sup> Part of the advantage of Curesight with eye tracking is virtual, real-time monitoring of treatment compliance.

Hyperopic anisometropia is a common cause of profound amblyopia. If spectacles are not prescribed early enough, then anti-suppression therapy such as part-time patching is usually added to the spectacles. If patching compliance is not satisfactory, then atropine 1% is often prescribed for the sound eye. The only way an atropinized, hyperopic sound eye could resolve near images would be to have a high plus lens over it.

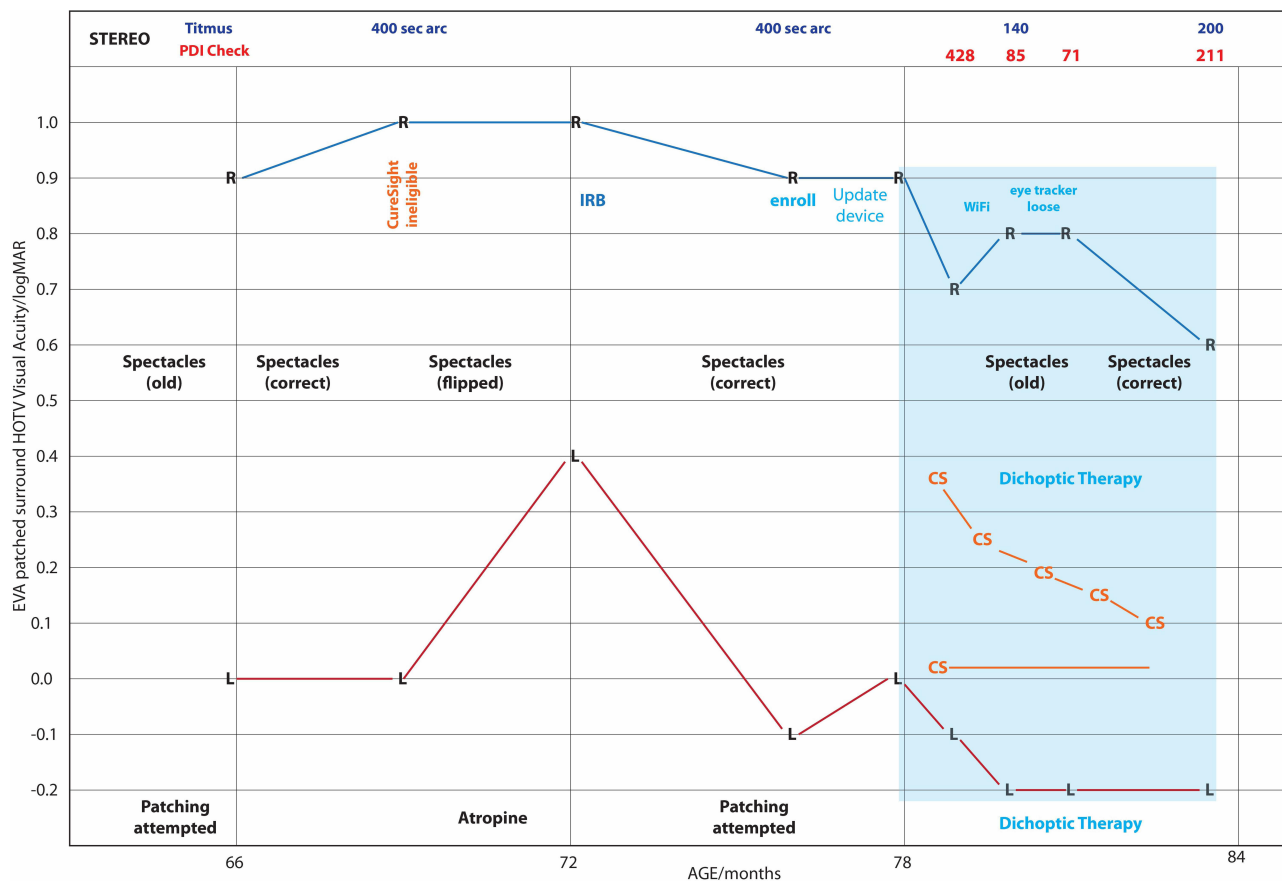
A novel treatment is described for a young patient who discovered that Spectacle-flip allowed her to enjoy near video games during amblyopia therapy. The spectacle-flip effectively sabotaged or incapacitated the beneficial value of anisometropic hyperopic glasses plus atropine penalization.

## Case Report

A bright 5-year-old Alaska Native girl with severe anisometropic refractive amblyopia had been referred to our pediatric ophthalmology specialty clinic. One year earlier, her optometrist diagnosed her with amblyopia, gave her spectacles and offered part-time patch therapy over her left, sound eye. Unfortunately, in her foster living situation, she peeled off her occlusion patches so the therapy produced family frustration but not better visual acuity.

A confirmatory exam revealed cycloplegic refraction right eye of  $+6.00 +0.50 \times 88$  and left eye of  $+1.00 +0.50 \times 92$ . Her patched HOTV acuities were logMAR 0.9 right eye and logMAR 0.0 left eye. She had stereo acuity 400 seconds of arc and alignment of 5 PD micro-esotropia without nystagmus. Her optic nerves and maculae appeared normal. She was prescribed new spectacles and informed of various additional amblyopia treatment options. The time course of her best corrected visual acuity and stereo acuity are shown in Figure 1. Details (metric and USA) of her clinical course are shown in Table 1.

She returned to be considered for the multi-center, USA randomized clinical trial of CureSight dichoptic therapy. Patched, calibrated M&S Clinical Trials Suite EVA surround HOTV acuities were logMAR 0.9 right eye and left eye logMAR  $-0.1$ . She had 5 prism diopter distance esodeviation and 400 seconds of arc stereo. Unfortunately, the poor amblyopic visual acuity disqualified her for the Curesight clinical trial, therefore atropine 1% drop daily on weekends was prescribed for the sound, left eye.



**Figure 1** Time course of prior and dichoptic amblyopia therapy including spectacle-flip sabotage while on atropine for anisometropia therapy.

**Notes:** Best corrected visual acuity (logMAR) is plotted versus age in months with the amblyopic right [R] eye in blue and the sound left [L] eye in dark red. Stereo acuity in arc seconds shown at the top with details in the text. Comparative mean visual acuity and age for the Israel multicenter CureSight study are superimposed in orange, data from Wygnanski-Jaffe et al.<sup>3</sup>

**Table 1** Characteristics of Anisometropic Amblyopia Patient

Characteristic	Right eye	Left eye	Stereo (sec arc)
Cycloplegic refraction	+6.00+0.50x88	+1.00+0.50x92	
Age 5 Vision	20/160 (logMAR 0.9)	20/20 (logMAR 0.0)	400
Attempt Curesight	20/160 (logMAR 0.9)	20/16 (logMAR -0.1)	400
On atropine 1%	20/200 (logMAR 1.0)	20/50 (logMAR 0.4)	
New Spectacles	+5.50+1.00x90	+0.50+1.00x90	
Age 6 enroll vision	20/160 (logMAR 0.9)	20/20 (logMAR 0.0)	400
PDI Check enroll	20/800	20/30	1070
1-month Curesight	20/100 (logMAR 0.7)	20/16 (logMAR -0.1)	428
5-month Curesight	20/80 (logMAR 0.6)	20/12 (logMAR -0.2)	200/
PDI Check 5-month	20/800	20/20	211

**Abbreviations:** ATS, Amblyopia Treatment Studies (of PEDIG); Arc sec, seconds of arc; BCVA, best corrected visual acuity; EVA, Electronic Visual Acuity (PEDIG Visual Acuity paradigm with surround HOTV optotypes); FDA, Food and Drug Administration (USA); IRB, institutional review board; logMAR, logarithm of the minimum angle of resolution; PEDIG, Pediatric Eye Disease Investigator Group; PDI Check: Pediatric Eye Check autostereoscopic near vision game; Tobii, brand of eye tracking appliance; WCG, Western Institutional Review Board-Copernicus Group in Puyallup, Washington.

Over the next three months, she observed that her dominant left eye was blurry for screen viewing with the atropine drop however she discovered she could flip her spectacles placing the higher plus lens in front of her cyclopleged, sound left eye making near work more enjoyable. She either slid her glasses sideways or flipped them upside down. Her spectacles measured +4.50+1.00x90 right amblyopic eye and +0.50+1.00x90 sound left eye. Her guardian was favorably impressed with her new-found interest in near activities. On examination, patched HOTV was logMAR 1.0 right eye and the left atropinized eye diminished to logMAR 0.4. Her guardian was warned about the adverse impact of the flipped-spectacles method of viewing near detail. Atropine was stopped and she was instructed to desist from flipping her spectacles. A special IRB was sought to allow her an option at dichoptic therapy.

The legal guardian provided signed, informed consent to a modification of the CureSight clinical trial that allowed enrollment with worse levels of amblyopia in children over a wider range of entry ages (WCG IRB study number 1349156, Protocol #20230623, Clinical Trials registration NCT06165705). Her enrollment visual acuity was logMAR 0.9 right eye and logMAR 0.0 left eye.

A CureSight table top computer console left over from the USA FDA clinical trial was retro-fit with a new Tobii eye tracking device that was held with magnets below the monitor screen. The patient and guardian were oriented to the device and commenced therapy prescribed as 90 minutes per day, six days per week using home internet delivered content (YouTube videos) that CureSight real-time split into a blue channel for the right amblyopic eye and a red channel that presented eye-tracking aimed central blur when viewed through specifically prescribed anaglyph goggles over her existing spectacles.

After one month of prescribed CureSight, right eye acuity was 0.7 logMAR while the left eye was -0.1 with 140 sec arc Titmus stereo. PDI Check dynamic autostereoscopic stereo was 428 sec arc.<sup>4</sup>

One month later, WiFi had been less reliable in different home and she was wearing an old pair of spectacles. However she was enjoying 90 minutes per day viewing YouTube on the CureSight. Visual acuity right eye was 0.8 logMAR and left eye -0.2 logMAR however she required being held from creeping up to lean too close to the M&S screen for patched acuity testing. The PDI Check dynamic stereo was 85 seconds of arc stereo.

One month later her compliance for home therapy remained a challenge even though she enjoyed watching the YouTube videos. She tried to view with her spectacles off but the CureSight would remind her not play until correct spectacles were on. She would also dislodge the Tobii eye tracker from its magnetic position, and again the CureSight would not play video until

the eye-tracker was in position. Visual acuity right while she tried to peak with sweaty eye patches was logMAR 0.8 in her old glasses and acuity left was logMAR -0.2. PDI Check stereo was 71 seconds of arc. New spectacles were provided.

Two months later with the new spectacles compliance on her CureSight online monitor was a consistent 90 minutes per day and she was enjoying Kindergarten. Visual acuity right eye improved to logMAR 0.6 and left eye logMAR -0.2. Titmus stereo was 200 seconds of arc while PDI Check was 211. Her ocular alignment and refraction remained stable. At the conclusion of this intervention, both patient and guardian continued to enjoy the CureSight dichoptic therapy especially compared to their prior experience with patching or atropine.

## Discussion

When amblyopia therapy requires compliance several methods have been devised to enhance, monitor and follow patients.<sup>5, 6</sup> Occlusion therapy can have compliance improved with elbow splint arm restraints,<sup>7</sup> shutter goggles,<sup>8</sup> taping over the patch,<sup>9</sup> glue on the patch,<sup>10</sup> sewn-on occlusion shields<sup>11</sup> or opaque contact lenses.<sup>12</sup> Blurring the sound eye with a cycloplegic drop like atropine may have better compliance than patching<sup>13</sup> and compliance with blur can be enhanced by modifying the lens on the sound eye,<sup>14</sup> using Bangerter foils<sup>15</sup> and dichoptically blurring part or all of the sound eye image.<sup>16</sup> The motivation to comply with therapy can be improved by child-preferred patches,<sup>17</sup> more interesting content,<sup>18</sup> parent education<sup>19</sup> and reward systems.<sup>1</sup> The duration of wearing an eye patch or drops for amblyopia therapy can be monitored with a calendar,<sup>20</sup> a temperature-under-patch device,<sup>21</sup> supervision,<sup>22</sup> and eye tracking behavior.<sup>3</sup> Clinicians should adapt some of these techniques especially for patients with compliance challenges. The Curesight therapy offers several of these (Central monitoring center calendar and education, interesting content, supervision and eye-tracking) and improves stereo in addition to visual acuity in contrast to the consistent, month-long occlusion of the intra-operative sew-on shield.

Supervision may be the key to superior vision recovery in amblyopia therapy.<sup>22</sup> The eye-tracking component of CureSight not only directs the region of sound-eye blur real-time in dichoptic content delivery, but can also monitor level of alertness with fixation losses and blinking, and also whether the spectacles are over the correct eye. Spectacles remain a critical component of amblyopia therapy.<sup>23, 24</sup>

Spectacle-flip is a rare but feared complication. Our patient loved watching videos, and discovered ways to improve her view. Though not by her deliberate intent, the spectacle-flip effectively sabotaged her conventional atropine/hyperopic anisometropic spectacle therapy. In my experience as a PEDIG investigator since 2000, this patient is my first to suffer from spectacle-flip sabotage of therapeutic efficacy. CureSight for our patient achieved 3 logMAR lines de-novo improvement from her severe amblyopia with a consistent increase in stereopsis. The patient and guardian were still motivated to continue even more dichoptic therapy with child-friendly content. The maximum residual amblyopia acuity retrieval – perhaps even rivalling the sound eye – for a 7-year-old, treated amblyopic child is not yet known.

In conclusion, the orientation and location of sturdy spectacles is a critical aspect of successful amblyopia therapy and must be monitored in some reliable way. Eye tracking, as a component of some types of dichoptic therapy, is a practical real-time tool for precise monitoring of the amblyopia treatment process and duration.

## Ethics and Consent

The parent and legal guardian provided signed informed consent for the study. The legal guardian provided signed consent for sharing and publishing of patient images/video for educational purposes. Approval for this study was given by the Alaska Blind Child Discovery department of the Alaska Children's EYE & Strabismus institution.

## Disclosure

Dr. Arnold coordinates the Alaska Blind Child Discovery which has received discounted vision screening technology from several vendors. He was an investigator for the USA Curesight multi-center clinical trial and received Curesight dichoptic devices one of which was modified and used free-of-charge in this separate study. He is a board member for PDI check; In addition, Dr Robert Arnold has a patent Systems and Methods for Eye Evaluation and Treatment issued to Robert W. Arnold and Alex Damarjian.

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