



(CASE REPORT)



VISUAL AND BINOCULAR OUTCOMES OF MULTIMODAL THERAPY IN ADULT AMBLYOPIA: A CASE REPORT

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World Journal of Advanced Research and Reviews, 2026, 32(01), 1555–1563

Publication history: Received on 15 September 2026; revised on 21 October 2026; accepted on 23 October 2026

Article DOI: <https://doi.org/10.30574/wjarr.2026.32.1.2706>

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ABSTRACT

Background: Amblyopia is often considered resistant to treatment after the critical period, and adult intervention is uncommon. Vision therapy (VT) and syntonics phototherapy have each been reported to improve visual acuity, contrast sensitivity, and binocular function, but combined programs in adults remain sparsely documented, particularly with quantified suppression and stereopsis outcomes.

Case presentation: A 23-year-old male with long-standing right eye visual impairment, high anisometropia, suppression, and reduced stereopsis was diagnosed with right anisometropic amblyopia (baseline best-corrected visual acuity [BCVA] 6/15 in the right eye, 6/6 in the left eye). He completed 30 office-based sessions, progressing from monocular stimulation to dichoptic anti-suppression training, each followed by 20 minutes of Alpha Delta filter syntonics phototherapy, then 4 months of home-based therapy. By session 30, BCVA of the right eye improved to 6/6⁻², suppression resolved, 4 prism base-out testing became negative, stereopsis improved from 400" to 200", and right eye contrast sensitivity rose from 1.05 to 1.35 logCS (left eye) 1.50 throughout. At session 18, suppression and stereopsis were unchanged despite BCVA of 6/9. At 2 and 4 months, BCVA remained 6/6⁻¹, contrast sensitivity reached 1.50 logCS, and stereoacuity improved to 100" and then 80", possibly reflecting continued home practice, delayed learning, or measurement variability. No adverse events occurred.

Conclusion: Meaningful functional recovery is achievable in adult anisometropic amblyopia using vision therapy combined with syntonics phototherapy. As syntonics phototherapy was an adjunct, its independent effect cannot be determined. Controlled studies are warranted.

Keywords: Adult Amblyopia; Anisometropia; Vision Therapy; Dichoptic Training; Syntonics Phototherapy; Stereoacuity.

1 INTRODUCTION

Amblyopia is a neurodevelopmental condition defined by diminished visual acuity in one or both eyes despite normal ocular anatomy and sufficient refractive correction, and it remains the most prevalent cause of monocular visual impairment globally(1). Management has conventionally been emphasized throughout the crucial time of early infancy, on the belief that the adult visual system is mainly resistant to additional development after this window has closed(2).

This idea has been progressively challenged. Perceptual learning experiments in adults with naturally occurring amblyopia reveal demonstrable increases in visual performance with persistent, focused practice, demonstrating that the adult amblyopic visual cortex has a considerable capability for rearrangement(3). Broader neuroscience studies on the metamodal, experience-dependent architecture of the brain offer a possible basis for this residual plasticity, showing that correctly organized sensory input may still drive cortical change far beyond infancy(4). More recent pharmacologic work, in which an acetylcholinesterase inhibitor was used to lower the threshold for visual plasticity in older children and adults with residual amblyopia, reinforces the view that neuroplasticity in adult amblyopia is present but often under-recruited by conventional treatment alone(5).

Vision therapy (VT) alone has shown clinically relevant increases in people with anisometropic amblyopia specifically. In a pilot study of perceptual learning versus conventional patching, adults and children with anisometropic amblyopia experienced visual acuity and contrast sensitivity improvements with perceptual learning that were equivalent to, and in some areas preferred over, patching alone (6). Similarly, a case report of virtual reality-based dichoptic vision therapy in an adult with anisometropic amblyopia documented improvement in best-corrected visual acuity together with the emergence of stereopsis, with corresponding functional MRI changes supporting a genuine cortical basis for the recovery(7). Taken together, this evidence indicates that VT, utilized on its own, may substantially enhance vision in the particular demographic most relevant to our case: adults with anisometropic amblyopia.

Syntonic phototherapy, the therapeutic application of specific visible light frequencies via the eyes, has independently proven effective as a solo treatment for amblyopia. In a quasi-experimental study of children and adolescents with anisometropic and strabismic amblyopia, four weeks of syntonic phototherapy produced statistically significant improvement in visual acuity and contrast sensitivity, with anisometropic amblyopia responding better than strabismic amblyopia(8). In a prospective, randomized comparison against part-time occlusion for refractive amblyopia across a wide age range including adults, syntonic phototherapy produced significantly greater improvement in uncorrected and best-corrected visual acuity, accommodative facility, and functional visual field than occlusion alone(9). These results demonstrate that syntonic phototherapy, too, may independently enhance visual function in amblyopia.

VT and syntonic phototherapy act through different, plausibly complementary mechanisms: VT via repeated, task-driven binocular and monocular visual practice, and syntonic phototherapy via light-mediated modulation of visual and autonomic function. The latter has been reported to be applied clinically either as a stand-alone treatment or, more commonly, as an adjunct layered onto other vision therapies to accelerate and consolidate their effect (10). This rationale has been demonstrated clinically: a case report of an adult with form deprivation strabismic amblyopia and nystagmus who was treated with a combined program of vision therapy and syntonic phototherapy (including an Alpha Delta filter) achieved improvement in near visual acuity and fixation stability that neither modality had achieved on its own before the combined protocol began(11). However, combined VT syntonic protocols in adults remain reported almost exclusively as isolated case reports, and none to our knowledge has documented a full, quantified pre- to post-treatment binocular vision profile such as suppression testing, graded stereoacuity, and fusion status in an adult with anisometropic amblyopia specifically. This is precisely the gap this case is intended to address: it is not simply another demonstration that VT works, or that syntonics works, but a structured account of how the two used together, in an adult, with anisometropic amblyopia, produced resolution of suppression and doubling of stereoacuity that either therapy alone has only partially achieved in the existing literature.

This case report presents the management of unilateral anisometropic amblyopia in a 23-year-old male who underwent a structured, 30-session, three-phase multimodal program combining software-based vision therapy, dichoptic and anti-suppression training, and daily syntonic phototherapy, followed by four months of home-based binocular vision therapy, to illustrate a replicable protocol and clarify the specific contribution syntonic phototherapy may make when layered onto conventional vision therapy in adult amblyopia.

2 CASE PRESENTATION

2.1 Patient Information

A 23-year-old male was seen with long-standing, non-acute reduced vision in the right eye, with no relevant systemic, neurological, or prior ocular history and no history of trauma or intraocular illness; results are given below in Table 1.

He was originally issued spectacles at age 7 years and claimed consistent, practically full-time use subsequently, with no prior history of amblyopia treatment, patching, or vision therapy; family ocular history was non-contributing.

The case record showed severe bilateral myopia with anisometropia, right eye suppression, and reduced stereopsis, and the patient's major objective was to gain excellent unocular vision, binocular fusion, and enhanced stereoscopic depth perception.

2.2 Clinical Findings

Unaided visual acuity was 6/120 in the right eye and 6/48 in the left eye. Cycloplegic retinoscopy and subjective refraction showed refractive values consistent with manifest refraction OD $-18.00/-1.50 \times 40^\circ$ and OS $-9.00/-1.00 \times 130^\circ$; since cycloplegic and manifest powers were unchanged, no spectacle adaptation period was required prior to initiating therapy. Given the substantial myopic anisometropia, the patient was placed with soft toric contact lenses (base curve 8.6 mm, diameter 14.2 mm, powers matching the manifest refraction in each eye), with a two-week adaptation period provided before baseline testing and therapy started. Best corrected visual acuity with contact lens correction was 6/15 OD and 6/6 OS. The 4 prism base-out test was positive in the right eye and negative in the left eye.

The etiology of the considerable interocular refractive disparity was not established biometrically; axial length and keratometry were not collected as part of this study. The beginning of the anisometropia could not be determined since axial length and keratometry were not accessible. The patient indicated that spectacle correction had been administered at roughly 7 years of age, but the congenital or acquired etiology of the anisometropia could not be substantiated. The lack of amblyopia therapy throughout infancy despite constant spectacle usage is significant and may indicate under-detection of anisometropic amblyopia risk at the time of first refractive correction, rather than a late-onset refractive shift.

Cover tests revealed orthophoria at distance and near. Suppression was found in the right eye, and baseline Worth four-dot tests also demonstrated suppression of the right eye target. Titmus Fly stereopsis was 400 seconds of arc. Baseline contrast sensitivity (Pelli-Robson, logCS) was 1.05 in the right eye and 1.50 in the left eye. Confrontation visual fields were full to finger counting bilaterally, and dilated fundus examination (indirect ophthalmoscopy) was within normal limits in both eyes, without evidence of myopic retinal degeneration, staphyloma, or other posterior segment pathology that could account for the reduced right eye acuity.

2.3 Timeline

The patient's course extended roughly 6 months from first presentation to final follow-up. Following baseline diagnostic assessment and a two-week contact lens adaptation period, thirty in-office vision therapy sessions were delivered on consecutive days over one calendar month, structured as three ten-session phases (sessions 1–10, monocular stimulation; sessions 11–20, advanced monocular and early binocular training; sessions 21–30, dichoptic and anti-suppression training), with an interim assessment at session 18. Following completion of the 30-session in-office program, the patient began a four-month home-based maintenance phase of daily binocular exercises, with official outcome assessments at 2 and 4 months post-treatment (Table 2). The whole framework of the program, including the phase-specific equipment, the continual syntonics phototherapy component, and the transition to home-based maintenance, is presented in Figure 1.

2.4 Diagnostic Assessment

The diagnosis of right anisometropic amblyopia was based on the marked interocular refractive difference, reduced best-corrected visual acuity in the right eye despite optimal contact lens correction, and associated suppression and reduced stereopsis in the absence of an identified posterior segment abnormality. Other eye diseases and amblyogenic reasons were dismissed by the examining ophthalmologist. The diagnostic examination encompassed cycloplegic and manifest refraction, visual acuity, cover testing, 4 prism base out testing, Worth four-dot testing, stereopsis, confrontation visual fields, and anterior and posterior segment examination.

2.5 Therapeutic Intervention

The patient participated in thirty consecutive vision therapy sessions offered in the office. Each session lasted roughly 45 minutes and was separated into three discrete phases of therapy with increasing levels of complexity connected to the patient's growth.

- During Phase 1 (sessions 1 through 10), exercises were completed involving monocular visual stimulation on the amblyopic right eye utilizing items such as computerized perceptual treatment system (CPT) Medium, Amblyopia iNet 20/70, Sanet Vision Integrator, and Hart Chart.

- Phase 2 (sessions 11–20) expanded on the same exercises at greater difficulty, employing technologies such as computerized perceptual treatment system (CPT) Small, Amblyopia iNet 20/40, Sanet Vision Integrator, and Cheiroscope.
- During Phase 3 (sessions 21–30), the emphasis switched to binocular vision integration and suppression control, employing technology such as computerized perceptual treatment system (CPT) with red and blue glasses, Bar Reader, Split Vectogram, and Suppression Cards.

Along with the treatment provided in the office, the patient was also assigned an exercise program at home which involved Bar Reader training with red-green anaglyphic glasses performed daily for a period of 30 minutes with the purpose of developing binocular integration and enhancing stereoacuity in between visits to the clinic.

Syntonic phototherapy: Twenty minutes of syntonic phototherapy utilizing the Alpha Delta filter combination was provided at the conclusion of every session throughout all three stages. The Alpha-Delta filter set is specifically indicated for what is clinically termed 'lazy eye syndrome,' which includes amblyopia, an esophoric posture, and a poor accommodative response—the exact clinical profile exhibited by this patient at baseline(12), as summarized in Table 1. The filter was therefore selected to match the specific syntonic indication for amblyopia rather than applied as a generic light therapy adjunct, and its administration was kept constant across all three VT phases so that any incremental benefit could be attributed to the escalating VT protocol rather than to a changing photic stimulus. The alterations from the monocular treatment to binocular and dichoptic therapy were based on the clinical evaluation and increased significance of suppression control and binocular integration during the final stage of therapy. The patient handled both clinic and home treatment well and did not demonstrate any notable adverse effects.

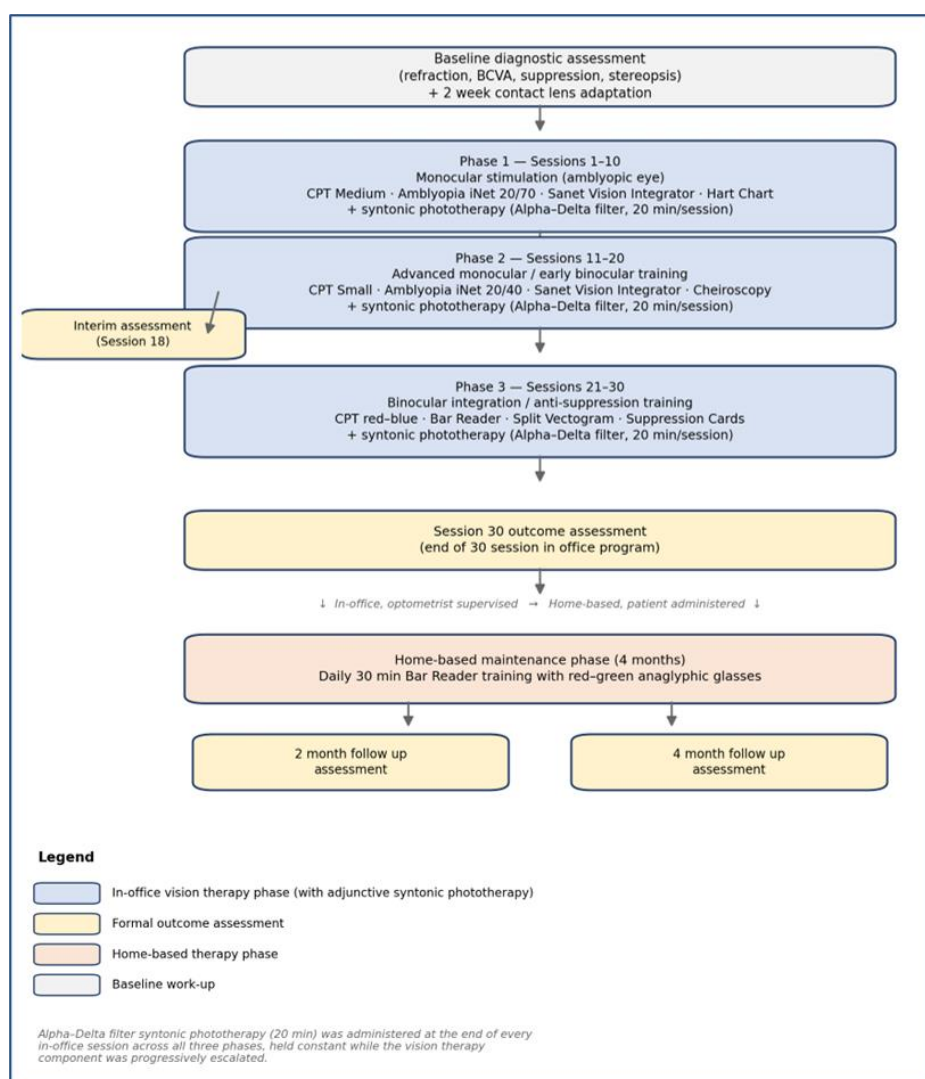


Figure 1: Structured multimodal treatment protocol, showing the three in-office vision therapy phases with their respective equipment, the constant adjunctive syntonic phototherapy component (Alpha-Delta filter, 20 minutes per session), the session 18 interim and session 30 outcome assessments, and the subsequent four month home based maintenance phase with 2 and 4-month follow-up assessments.

2.6 Administration

The program contained 30 sessions, each around 45 minutes in length, administered on 30 consecutive days. Each session finished with the 20 minute syntonics phototherapy component stated above. Therapy was delivered under direct optometrist observation throughout. This was followed by 4 months of home-based binocular vision treatment, consisting of daily 30-minute sessions utilizing a bar reader and red-green spectacles.

2.7 Outcome and Follow-up

Interim evaluation after 18 sessions indicated improvement in right eye BCVA from 6/15 to 6/9 and contrast sensitivity from 1.05 to 1.20 logCS, while suppression was maintained and stereopsis remained unaltered after 400 seconds of arc. By the conclusion of 30 sessions, right eye BCVA had increased further to 6/6⁻² and contrast sensitivity to 1.35 logCS; suppression was no longer observed, the 4 prism base out test had changed to negative, and stereopsis improved to 200 seconds of arc. Left eye contrast sensitivity remained stable at 1.50 logCS at every measurement. Worth four dot testing verified the existence of fusion, cover testing remained orthophoric at both distant and close fixation, and confrontation visual fields were within normal limits throughout. No adverse events were observed at any level of treatment.

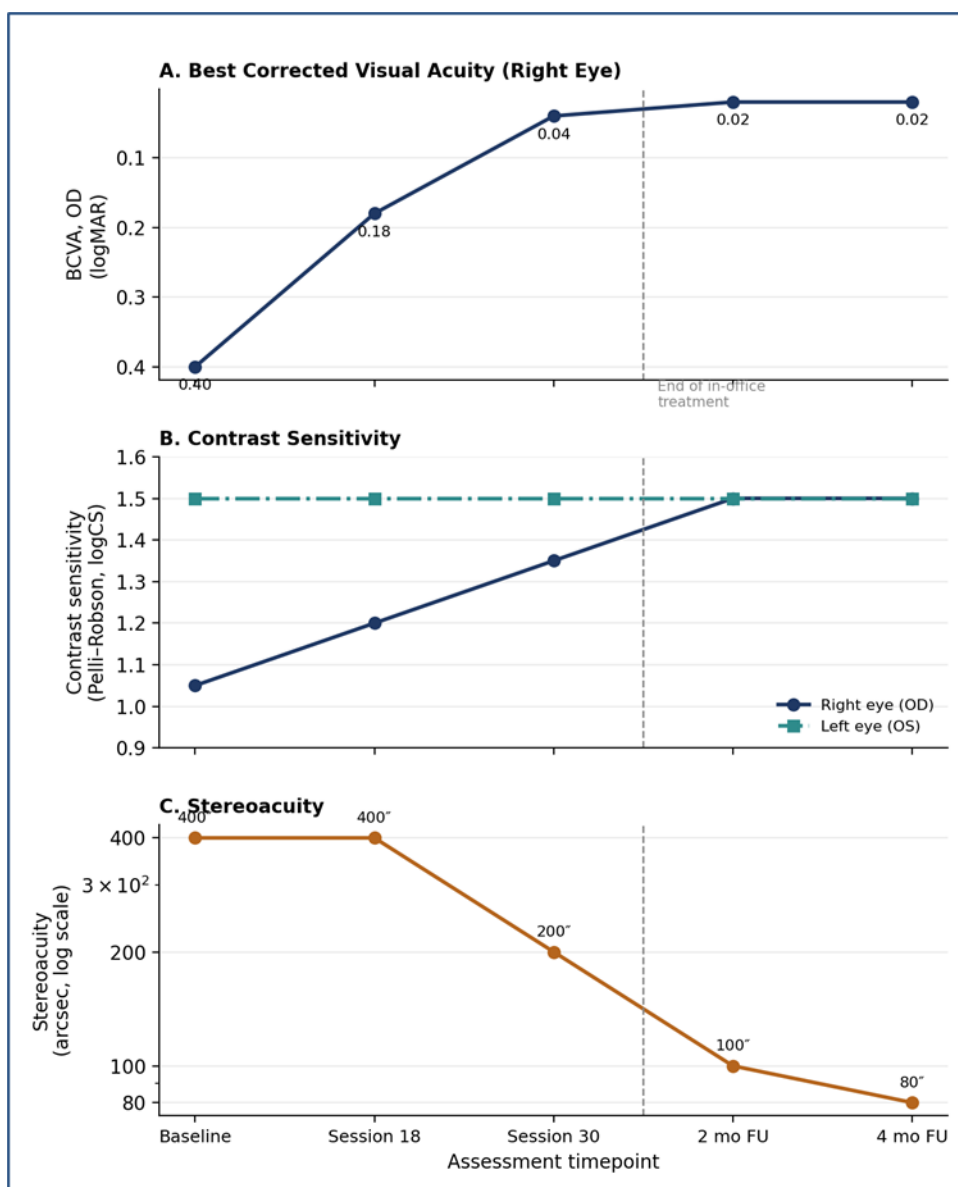


Figure 2: Longitudinal visual and binocular outcomes across assessment timepoints. (A) Best corrected visual acuity in the right eye (logMAR), (B) Pelli-Robson contrast sensitivity in both eyes, and (C) Titmus Fly stereoacuity (log scale, arcsec). The dashed vertical line marks the end of the 30-session in-office treatment program and the start of the four-month home-based maintenance phase. Visual acuity and contrast sensitivity plateaued near the fellow eye value by the end of in-office treatment, whereas stereoacuity continued to improve throughout the home-based maintenance phase.

On follow up evaluation at 2 months post-treatment, right eye BCVA was maintained at $6/6^{-1}$, contrast sensitivity had reached 1.50 logCS (matching the stable left eye value), and stereoacuity increased further to 100 seconds of arc. At 4-month follow-up, visual acuity and contrast sensitivity remained steady at $6/6^{-1}$ and 1.50 logCS, respectively, but stereopsis showed ongoing improvement to 80 seconds of arc, demonstrating prolonged and progressive consolidation of binocular improvements beyond the active treatment period. The entire longitudinal trajectory of visual acuity, contrast sensitivity, and stereoacuity across all testing timepoints is provided in Figure 2.

Table 1: Baseline Clinical Findings

Parameter	OD (Right)	OS (Left)
Unaided visual acuity	6/120	6/48
Manifest refraction	-18.00/-1.50 × 40°	-9.00/-1.00 × 130°
BCVA (contact lens corrected)	6/15	6/6
4 prism base out test	Positive	Negative
Cover test (distance/near)	Orthophoria	Orthophoria
Worth four dot	Suppression	
Titmus Fly stereoacuity	400" (binocular)	
Contrast sensitivity (Pelli–Robson, logCS)	1.05	1.50
Confrontation visual fields	Normal	Normal
Posterior segment exam	Normal	Normal

Table 2: Longitudinal Outcomes

Timepoint	BCVA OD	CS OD (logCS)	CS OS (logCS)	Suppression	4Δ BO test	Stereoacuity
Baseline	6/15	1.05	1.50	Present	Positive	400"
Session 18	6/9	1.20	1.50	Present	Positive	400"
Session 30	$6/6^{-2}$	1.35	1.50	Resolved	Negative	200"
2 month follow up	$6/6^{-1}$	1.50	1.50	Resolved	Negative	100"
4 month follow up	$6/6^{-1}$	1.50	1.50	Resolved	Negative	80"

4Δ BO = 4 prism base out test. Cover testing remained orthophoric and confrontation visual fields normal at every assessment point.

2.8 Patient Perspective

"Before starting therapy, I had resigned myself to poor vision in my right eye. The process was intensive, but I noticed steady improvements, first in clarity and later in how my eyes worked together. Achieving near normal vision and being able to use both eyes comfortably has been life changing. I am grateful for the support and encouragement throughout my treatment."

3 DISCUSSION

This case demonstrates substantial functional recovery in a 23 year old man with anisometropic amblyopia following a structured, 30-session multimodal program, with best corrected visual acuity improving from 6/15 to $6/6^{-2}$, right eye contrast sensitivity improving from 1.05 to 1.35 logCS, resolution of suppression, and stereopsis improving from 400 to 200 seconds of arc with fusion demonstrated at completion (Figure 2). These gains were not merely maintained but extended over four subsequent months of home-based binocular therapy: at 2-month follow-up, stereopsis had improved further to 100 seconds of arc with visual acuity stable at $6/6^{-1}$, and by 4 months stereopsis had reached 80 seconds of arc, indicating ongoing, progressive binocular consolidation well beyond the active, clinic-based treatment period. Because this recovery occurred long beyond the canonical critical period, it is compatible with, and adds a further clinical data point to, the idea that the adult visual system maintains substantial plasticity(3).

The phased structure of the program is instructive in distinguishing what each component likely contributed. Gains in visual acuity and contrast sensitivity emerged predominantly during Phases 1 and 2, the purely monocular and early binocular stages, which is consistent with prior reports that monocular perceptual learning type exercises alone can improve acuity and contrast sensitivity in adult anisometropic amblyopia (6, 7). By contrast, suppression and stereopsis did not alter at the 18 session intermediate evaluation despite acuity having already improved to 6/9, and only resolved when the dichoptic, anti-suppression-oriented Phase 3 was implemented (Figure 2A vs 2C). This dissociation supports the view, established in the binocular treatment literature, that acuity improvement and binocular re integration are separable processes that generally require different, targeted stimuli(7), in this case, dichoptic anti suppression work specifically, rather than continued monocular practice.

Following the 30 in-office sessions, the patient continued with a four-month home-based maintenance program consisting of daily 30-minute Bar Reader training using red-green anaglyphic glasses, undertaken specifically to consolidate binocular integration and further enhance stereoacuity outside the clinical setting. This unsupervised extension is notable both clinically and methodologically: stereopsis continued to improve after active clinic based therapy had ended, from 200 seconds of arc at the 30 session endpoint to 100 seconds of arc at 2 months and 80 seconds of arc at 4 months, while best corrected visual acuity and contrast sensitivity remained essentially stable ($6/6^{-2}$ to $6/6^{-1}$; 1.35 to 1.50 logCS, plateauing at the fellow eye value) and the resolution of suppression and fusion on Worth four dot testing persisted unchanged. This pattern of continued binocular gain in the absence of further monocular acuity or contrast sensitivity change suggests that once suppression had been broken and fusion established during Phase 3, sustained binocular practice at home was sufficient to drive further stereoacuity consolidation, consistent with the broader principle that perceptual and binocular learning benefit from consistent, repeated practice rather than office-based exposure alone. It also means, however, that the home program is itself a variable that must be considered when interpreting the durability of the in-office gains, since the 2 and 4-month follow-up findings reflect the combined effect of the completed clinic protocol and the subsequent home exercises rather than the clinic protocol in isolation.

The continuous addition of syntonics phototherapy with an Alpha Delta filter throughout all 30 sessions is the aspect that most separates this program from a typical VT only regimen, and it is the element this study is especially positioned to speak to. Because the filter was held constant while the VT component was escalated, the design cannot isolate a syntonics only effect size; however, the magnitude and consistency of gain achieved here, full suppression resolution and stereopsis doubling within 30 sessions, is at the favorable end of what has been reported for either modality in isolation. Syntonics phototherapy alone has been shown to significantly improve visual acuity and contrast sensitivity in amblyopia, with anisometropic cases responding particularly well(8), and, in a randomized comparison, to outperform part time occlusion for improving visual acuity and functional visual field across a wide age range that included adults(9). Mechanistically, syntonics phototherapy is understood to apply non coherent, wide spectrum light through the retina to stimulate the visual cortex directly; red dominant filters such as Alpha Delta preferentially stimulate foveal cone photoreceptors, which is one proposed pathway by which the therapy could support acuity and fixation gains in amblyopia(9). Syntonics is most often used clinically to support other therapies rather than replace them(10), which is precisely the role it appears to have played here, a consistent adjunct layered onto an escalating VT protocol, rather than the primary driver of any single phase's gains.

This example is not the first to combine VT with syntonics phototherapy in an adult. In a previously published case report, an adult with form deprivation strabismic amblyopia and nystagmus achieved improvement in near acuity and fixation stability using a combined VT and syntonics (Alpha Delta filter) protocol only after VT alone had produced a limited response(11), supporting the same adjunctive rationale applied here. The present case extends that literature in two respects: it involves anisometropic rather than strabismic amblyopia, and it reports a full quantified binocular vision profile, 4 prism base out suppression testing, graded Titmus stereoacuity, and Worth four dot fusion status, at baseline, interim, and final assessment, which the prior combined therapy case report did not include. This more detailed binocular data is what permits the acuity vs binocularity dissociation mentioned above to be discovered at all.

More broadly, this pattern of measurable adult visual cortical reorganization in response to targeted intervention is consistent with the concept of experience dependent, metamodal cortical organization(4), and with pharmacologic work showing that the threshold for eliciting such plasticity in older patients with residual amblyopia, while elevated relative to childhood, is not absent and can be lowered with the right intervention(5). Within that context, the combined VT syntonics procedure utilized here may be regarded as one behavioral method for mobilizing residual adult plasticity, rather than as proof of a distinct or unique mechanism. The constant results on confronting visual field testing and cover test throughout treatment imply that the observed gains were particularly attributed to the amblyopia and suppression strategy rather than to a fortuitous change in ocular alignment or peripheral field.

This report has the inherent limitations of a single case: there is no untreated or single modality control arm, so the relative contribution of syntonics phototherapy cannot be quantified, and the subsequent four month home based program was unsupervised and relied on the patient's self reported adherence rather than monitored sessions. Because

the home exercises followed directly after the clinic based regimen without an intermediate washout period, the ongoing stereoacuity increases shown at 2 and 4 months cannot be attributable to either component in isolation.

Nonetheless, given the consistency of this result with the combined therapy case literature and with each modality's independent evidence base, and given that the observed gains were sustained, and indeed extended, through 4 months of follow up rather than assessed only at the treatment endpoint, the findings support the design of a controlled trial directly comparing VT alone against VT with adjunctive syntonics phototherapy in adult anisometropic amblyopia, incorporating a structured and monitored home maintenance component and longer term follow up, and powered specifically to detect differences in suppression resolution and stereoacuity rather than visual acuity alone.

4 CONCLUSION

This case demonstrates that a structured, 30 session multimodal program combining escalating vision therapy with daily adjunctive syntonics phototherapy produced resolution of suppression, doubling of stereoacuity, and near normalization of visual acuity in an adult with anisometropic amblyopia, a magnitude and breadth of binocular recovery that neither vision therapy nor syntonics phototherapy has consistently achieved alone in the existing literature. The results encourage continuing clinical use and further controlled investigation of syntonics phototherapy as a supportive therapy alongside traditional vision treatment in adult amblyopia, and reaffirm the general message that adult amblyopia should not be rejected as untreatable.

STATEMENTS ON COMPLIANCE WITH ETHICAL STANDARDS

Disclosure of conflict of interest

The author(s) declare no financial, commercial, consulting, or other conflicts of interest with the manufacturers or distributors of any device, software, or filter system named in this manuscript, including but not limited to the computerized perceptual therapy system (CPT) software, Amblyopia iNet, Sanet Vision Integrator, and syntonics phototherapy equipment.

Statement of ethical approval

According to the policy of Narayana Nethralaya Eye Hospital, formal ethics committee approval was not required for this single-patient case report because it involved routine clinical evaluation and non-invasive treatment procedures and did not include any experimental, harmful, or investigational intervention.

Statement of informed consent

Written informed consent was obtained from the patient before submission of the manuscript. The patient consented to the publication of the clinical findings and relevant anonymized data. All personally identifiable information has been removed, and patient confidentiality has been maintained throughout the preparation of this report.

Author Contributions

Sk. Saief Ali contributed to patient examination, clinical management, data collection, and interpretation. Puja Sarbajna contributed to the therapeutic intervention. Mainak Motilal drafted the manuscript. All authors contributed to manuscript revision, approved the final version, and agree to be accountable for all aspects of the work.

AI Tool Usage Declaration

Perplexity was used only to assist with language editing, grammar correction, organization of manuscript sections, and improvement of readability. It was not used to interpret clinical results, develop the scientific discussion, generate citations or references, or make clinical conclusions. All AI-assisted content was reviewed and verified by the authors, who take full responsibility for the accuracy, originality, and integrity of the manuscript.

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