Case Report

Artificial Intelligence-Driven Vision Therapy for Cerebral Visual Impairment in Remote Settings: A Three-Year Follow-Up Case Report

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ABSTRACT

Cerebral visual impairment (CVI) is a neurodevelopmental disorder that affects the brain's visual processing centres. It is typically associated with perinatal hypoxia, traumatic brain injury, infections, and genetic disorders. Artificial Intelligence in vision therapy can revolutionize optometric treatment. We describe a case of AI-powered vision treatment of a patient diagnosed with CVI in a remote region. AI powered remote vision therapy was provided to a 4-year-old male with CVI in the Indian state of Himachal Pradesh. The 14-week therapy was monitored and altered using AI findings. The patient was followed up with continued home therapy. The findings were monitored on a quarterly basis.After 14 weeks of distant vision therapy, visual acuity, contrast sensitivity, and oculomotor function improved significantly, and a consistent improvement was noticed. Artificial Intelligence powered vision treatment technologies have the potential to enhance optometry care equity.

Keywords: Artificial Intelligence, Vision Therapy, Cerebral Visual Impairment.

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INTRODUCTION

AI is the theory and development of computer systems that can perform human functions including visual perception, speech recognition, and decision-making.[1] It shows promise in different medical fields including optometry. A complex neurodevelopmental disorder is cerebral visual impairment (CVI) which is considered untreatable.[2] In the previous two decades, treatable or preventable illnesses including cataracts and Retinopathy of Prematurity (ROP) have been successfully treated. However, preterm babies that survive have increased CVI rates.[3,4] CVI is caused by retro-geniculate deformities. Neonatal hypoglycemia and hypoxic-ischemic encephalopathy (HIE) produce cerebral ischemia (CII).[5] Neonatal hypoglycemia damages the Parieto Occipital lobe while HIE causes periventricular leukomalacia. Evidence shows that structural damage to visual cortex areas and visual processing pathways in cases of neonatal hypoglycaemia and HIE can yield persistent visual acuity deficits and other visual dysfunctions.CVI is common in neonates who have birth hypoxia.[6,7]The aim of presenting this case was to describe improvement in Vision in a patient of Cortical Visual impairment using AI.

Case Report

In November 2021, a 4-year-old child with a birth history of hypoglycemic encephalopathy was referred to Tenzin Eye Centre, Tenzin Hospital, NH-22, Bypass Road, Panthaghati, Kasumpti, Shimla, Himachal Pradesh 171009, India, for ocular investigation.Written parental consent was obtained before investigation,and ethical approval was taken by

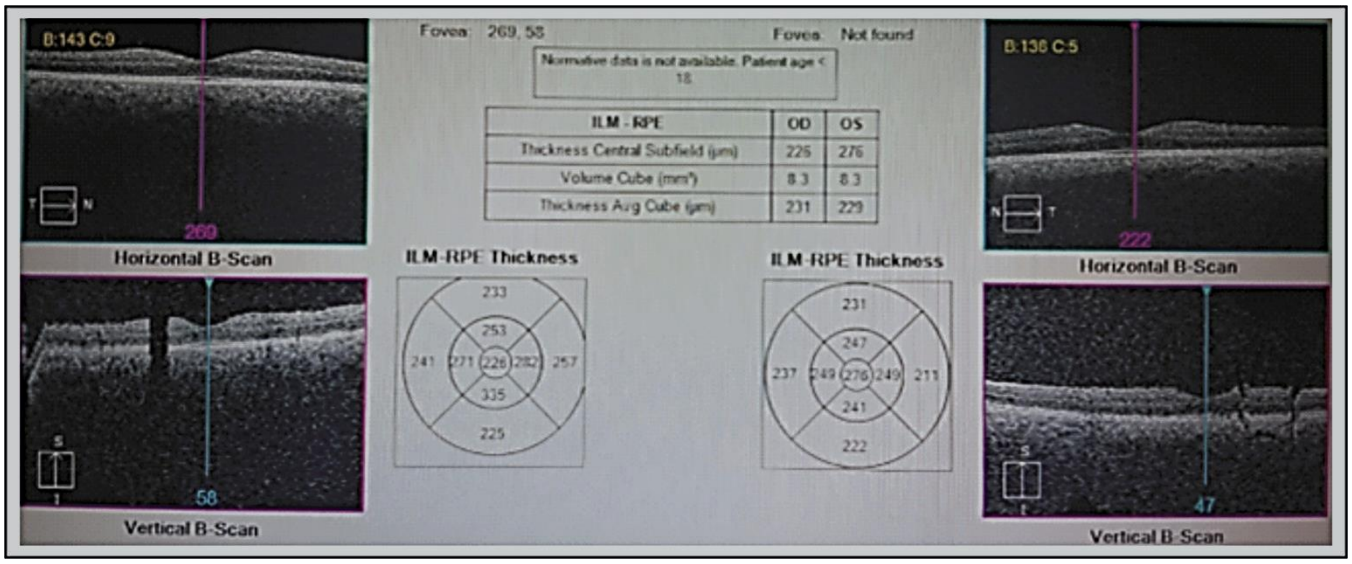

Figure 1: Illustrate Cirrus HD- OCT 500 macula report of the patient; Left top indicates right eye macula thinning with Right top indicates left eye macula thinning, left bottom show right eye Retinal pigment epithelium thinning with right bottom indicates RPE thinning and poor centration.

Table 1: *Vision therapy In-Office and Home Therapy.*

Monocular Therapy	Vergence Therapy	Anti-Suppression Therapy	Home Therapy
Hart chart for Distance (alternate patch)	Brock string with red-green glasses	Red-green glasses with brock string	HART chart with brock string Balancing board White board for perceptual exercise
Saccades and pursuits with wide Hart Chart Letter tracking	Tranaglyph was used only for 4 visits	Neuro visual trainer software with EYEBAB software	Wide saccades with HART Chart
Saccades with Hart chart	Marsden ball	Pegboard rotator	Red/blue flipper with pen torch light therapy for centric fixation

the hospital. The procedures adhered to the ethical norms of the committee on human experimentation (institutional or regional) and the Helsinki Declaration of 1975, amended in 2000. Subjective refraction was not possible due to the child's speaking problems.

The comprehensive investigation for vision, stereopsis, cover test, slit lamp examination and posterior segment examination were normal. OCT was done as shown in Figure 1. Extra ocular motility was evaluated prior to vision therapy and post vision therapy, as mentioned in Table 2. His first treatments included Hart chart (large letters) and physiotherapy. First 14 visits included Hart chart for distance, brock string, and pegboard rotator. Alternate patching was done for 20 minutes while colouring or watching TV from a distance. Patients could walk independently after one year of therapy. The balancing board with loose prism goggles improved his up gaze, attention, and balancing. The patient visited the hospital once a month but received most of his treatment at home. The patient was doing therapy with HART chart, Marsden ball, brock string, walking rail, balancing board with white board exercise every 5 days in a week. Physical assessment was done after every 4months. After three years, the speech, writing, and understanding have improved. Continued in-office and home Vision Therapy was given for 6 months and followed up for 3 years. Details are shown in Table 1.

The first two months of vision treatment enhanced fixation, saccades, and pursuits. Object and video tracking, Marsden ball, pegboard, floor rotator, balancing board, and walking rail increased eye-hand coordination. EYEBAB, neural vision trainer software (Figure 2) and Neuro Visual Trainer by Ocu-Digital (https://neurovisualtrainercom.) was used with total 60 sessions on Zoom meeting. Artificial intelligence in vision therapy enhanced CVI treatment programs by studying each patient's unique visual processing patterns and progress. AI-driven treatments adjust therapeutic activities, enhancing CVI recovery.

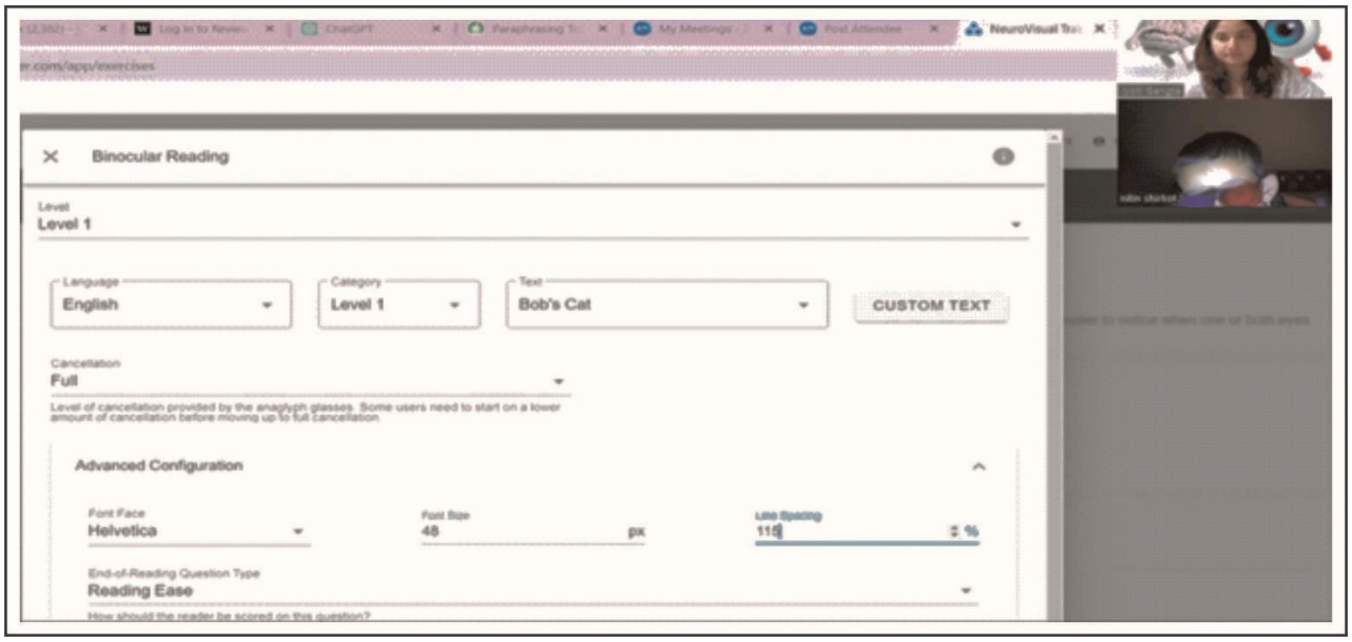

Figure 2: Illustrate Remote Vision Therapy with AI- tool [Neurovisual trainer software] The workout alternatives with different categories are indicated at the right top, the level selected for the patient's case is indicated at the right bottom, and the picture of the patient and therapist via the Zoom app is indicated at the left top.

Table 2: *Examination Pre & Post Vision Therapy.*

Tests	Initial Evaluation	Post Vision Therapy (6 Months)	Post Vision Therapy (12 Months)	Post Vision Therapy (24 Months)	Post Vision Therapy (36 Months)
BCVA	OD:-1.00/0.75X40° 6/60 OS: -1.00 DS- 6/60	OD:-1.00/0.75X40° 6/60 OS:-1.00 DS- 6/36p	OD: -1.00/0.75X40°- 6/36p OS: -1.00 DS- 6/36p	OD:-1.00/0.75X40° 6/36 OS: -1.00 DS- 6/36p	OD: -1.00/0.75X40° 6/24p OS: -1.00DS- 6/24p
EOM	Full range of motion, mild restriction to up gaze due to head movement	Full range of motion, better movement in up gaze direction	Full range of motion, better movement in up gaze direction	Full range of motion in all gazes	Full range of motion in all gazes
Cover test	Nystagmus (Horizontal); Mild Exotropia about 4-6 PBO	Exotropia 3-4 PBO, Reduced Mild Horizontal movement.	Exotropia 3-4 PBO, Reduced Mild Horizontal movement	Exotropia 3-4 PBO, Mild Horizontal movement	Exotropia 2-4 PBO,
Stereopsis	Poor 400 sec of arc	400 sec of arc	200sec of arc	200sec of arc	140sec of arc

Stereopsis and accommodation improved over the following four months using software-based treatments, minus lens sorting, and hart charts. Left-right ideas, bilateral integration, and visual perceptual skills were treated over four months.

DISCUSSION

Prenatal insults cause CVI, which affects the dorsal and ventral brain.[8] Clinical vision assessments are difficult in most CVI cases; however visual acuity may indicate vision improvement. The treatment of CVI does not have a defined clinical procedure. As a result, the treatment strategy emphasizes symptom control and scientific research. Expectable visual prognoses can inspire caretakers or parents to interact with the child. Early active vision therapy accelerates visual development. In a case study reported by Atillio Sica et.al, a 5 year old kid with CVI secondary to hypoxic-ischemic injury demonstrated that even in the absence of co-existing amblyopia, treating even small refractive errors and starting amblyopia therapy can greatly improve vision in kids with CVI, but they did only patching and atropine penalization.[9] Additionally, it also emphasized the value of interdisciplinary therapy and early intervention for kids with CVI, with

an emphasis on motor and cognitive skills. There was also a significant variation in motor skills before and after vision training in the child with low vision resembling findings with the present study.

The therapy should convert residual vision to functional vision by magnifying objects, increasing background-to-target contrast, using the bright ball, and eliminating clutter. Sometimes sensory and motor elements of vision alter the visual field and visual activities. Child and parent/caregiver's effort is the most essential factor in improving the condition. More longitudinal studies can be useful in proving the effect of this therapy.

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Conflict of Interest: Authors declared no conflict of interest.

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Authors Designation and Contribution

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Jyoti Gangta; Senior Optometrist: *Literature search, Data analysis, Statistical analysis, Manuscript review.*