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A Novel Computer Program to Improve Visual Field on Stroke Related Homonymous Hemianopia Patients

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Abstract

This article reports a novel treatment method for improving visual field deficits of Homonymous Hemianopia (HH) causing by stroke. The Computer Stimulated Visual Field Restorative Program (CSVFRP) is a home-based computer program intended to improve visual fields for patients with HH. It demonstrated increasing visual field in acute, subacute and chronic HH patients and improved patients' quality of life.

Keywords: Homonymous hemianopia; Stroke; Visual field loss; Visual rehabilitation; Neuroplasticity

Introduction

Homonymous Hemianopia (HH) is a common clinical condition in neuro-ophthalmic practice. Multiple neurological and systemic conditions may cause HH. Stroke, an important cause of morbidity and mortality worldwide, is the most common cause of HH in adults. Followed by traumatic brain injury and brain tumors [1-7].

HH refers to visual impairment due to a post-chiasmatic brain lesion [8]. Studies have shown that between 51.1% and 61.4% of HH are caused by occipital lobe lesions [1,4,9,10,11]. Damage to the occipital cortex causes loss of the contralateral half of the visual field of both eyes [9,12,13]. Performing Activities of Daily Living (ADL) rely heavily on visual functioning [14,15] and HH can significantly and negatively impact these functions including: (1) altered self-care; (2) inability to drive safely; (3) hemianopic reading deficit (hemianopic alexia); (4) problems with navigation, frequently bumping to objects and increasing fall risks during mobility activities; (5) inability to work; (6) decreasing visual searching during leisure activities. As a result of HH, patients demonstrate loss of independence and confidence, emotional and social implication, decreasing quality of life and increasing risk of accidents or injuries [1,12,14,16-20]. It also may affect patients' ability to participate in rehabilitation and recovery which ultimately may lead to institutionalization.

However, spontaneous recovery of HH happens only at acute or sub-acute stages of stroke. It is likely complete two months after onset of stroke [1,9,21].

In most hospitals, physical, occupational and speech therapy start stroke rehabilitation from as early as day one of hospitalization. Unlike motor, cognitive and language evaluation and intervention, there is currently no standardized visual intervention for patients with HH in stroke rehabilitation [9,22]. Three methods have been described for HH treatment: (1) optical aids, (2) substitution, and (3) visual field restoration [14,20]. However, the effectiveness of rehabilitation of HH is still limited [9]. To date, the main clinical interventions remain compensatory rather than restorative [20].

Thus, we developed the CSVFRP to restore visual fields for patients suffering from HH after stroke and other conditions. This article reports the clinical results of three case studies.

Method

Evaluation

Most patients had received interventions including prism glasses, compensatory therapy and some of them received visual therapy prior to be referred to our facility. Patients had perimetry testing to confirm complete or incomplete HH visual field defects at multiple neuro-ophthalmology clinics prior and following visual therapy. All patients received a comprehensive vision assessment including but not limited to the best corrected visual acuity in each eye and binocularly, near vision, visual filed, ocular motor function, contrast, color, and glare sensitivity, diplopia and scotoma,

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visual perception, orientation and mobility, eye fatigue level, visual hallucination and ADL function.

Main measure

All patients evaluated with confrontation visual field test using Brain injury Visual Assessment Battery for Adults (BiVABA) during baseline evaluation and after each clinical intervention.

Intervention

The CSVFRP is a computerized, home-based treatment aimed at reducing HH from stroke through repetitive stimulation to the blind fields. The CSVFRP is recommended to be done at least twice daily. There are two parts of the training: 1) Computer-led visual exercises and 2) eye relaxation exercises. For the computer-led exercises, patients are recommended to use desk top or big computer screen if available. Patients are instructed to sit 16 inches from the computer screen and maintain eye fixation on central red dot binocularly. There is a white circle moving towards right or left hemianopia area with duration of 10, 8, 6, and 4 sec. Patients are educated to be aware of the white circle eccentrical movement while fixing their eyes on the red dot. There is a grid at the background for measurement. Patients can perform self-screen measurements according to the grid. Its increased patient's satisfactory adherence. Between each computer program (about 5 min) or if increasing eye fatigue, patients are recommended to do acupressure eye relaxation exercises to acupoints around the eyes. Acupressure involves the counteraction among hypothalamic pituitary-adrenocortical axis that leads to overproduction of cortisol and cause a relaxation response [23]. The eye exercise is to induce relaxation [24]. Acupressure can increase relaxation response and break the stress-disease link [25]. Patients can tolerate more stimulation after eye relaxation exercises.

Patients were also treated with all other visual deficits like visual and visual perception dysfunction and neurological deficits such as neuromuscular deficits, cognitive deficits and psychological issues at the clinic.

Results

All the HH patients who referred to the clinic were received CSVFRP since 2014. In the majority of cases, patients had to do the home-based computer program longer than the duration of visual therapy at the clinic. Through patients' report and some retrospective chart review, CSVFRP demonstrated significant visual field improvement not only with acute and subacute HH patients, but also with chronic HH patients.

Patients reported significant improvement of their visual fields if they followed the CSVFRP. Their visual fields were checked by perimetry at ophthalmology clinic. Patients' success is based on self-understanding of the program and if actively following the program in daily basis. Patients demonstrated improved visual field. Furthermore, patients showed improved reading speed and accuracy; improved orientation and mobility; improved safety awareness in ADL function (no falling and not bumping to objects); and returned to drive safely.

All three cases started vision therapy later than two months which past spontaneous recovery period [3,20,22].

Case Presentation

Case 1

A 77-year-old male with a history of hypertension, hyperlipidemia, Charles Bonnet Syndrome, depression and anxiety was seen two years after onset ischemic stroke with right sided weakness and complete right HH. MRI showed left middle cerebral artery and posterior artery infarct. The patient reported that he kept bumping to bathroom doors when going to restroom, taking a shower, and while ambulating around his home. He relied on family or caregiver to go into community for errands and groceries due to fall risks. He experienced difficulties reading and writing. He experienced visual hallucinations including weird humans, umbrella, or ants at times which increased his anxiety. He had regular rehabilitation in the past two years and received a pair of prism glasses from a neurological optometrist.

On initial evaluation: Vision and visual perception: Best corrected distance visual acuity (BCDVA): OD: 20/50-1, OS: 20/50, OU: 20/50, Best Corrected Near Visual Acuity (BCNVA): OD: 20/30, OS: 20/30, OU: 20/30; visual field: Complete right HH; impaired contrast and glare sensitivities; reading and writing: impaired; visual perception: Intact except visual scanning (mild impaired); eye fatigue: 5/5. His ocular motor function, saccadic and pursuit function, and color discrimination were intact. He had no scotoma and diplopia. He had right sided weakness, more upper extremity (3+/5) then lower extremity (4+/5). There were no sensory and language deficits. His cognition was very mild impaired. His MoCA score was 25/30 (Normal level is >=26/30). He required minimum assistance for ADL and Instrumental ADL (IADL) functions.

The patient underwent visual rehabilitation 1 to 2 sessions per week for a total of 12 visits. He used CSVFRP at least 2 times a day with eye relaxation exercises in between the CSVFRP. He demonstrated improved visual field about 40 degrees during discharge assessment using BiVABA. The patient reported that he was no longer bumping into objects and able to read correctly at a slow pace. Intervention also focused on his Charles Bonnet syndrome and psychological conditions, and other visual issues and right sided weakness. He was modified independent with ADL and IADL function. His visual hallucination resolved. The patient instructed to continue home CSVFRP. He reported that he returned to completely normal visual field after seven months, later confirmed by his ophthalmologist.

Case 2

An 82-year-old male with history of hypertension, dyslipidemia, and benign prostatic hyperplasia presented after right cerebral infarction with left HH. The patient started vision therapy after one year of regular therapy. The patient was unable to read and bumped to objects often. His initial vision and visual field assessment were as following: Dominant eye: OD; BCDVA: OD: 20/25, OS: 20/25, OU: 20/25; BCNVA: 20/25, OS: 20/25, OU: 20/25; visual field: Complete left HH; visual perception: impaired visual form, visual memory, spatial relations and visual closure with score 17/39 by using modified Motor-Free Visual Perception Test 4 due to cognitive limitations and impaired visual scanning. He had prosopagnosia. His cognition was mild impaired with MoCA score of 24/30. He required supervision for ADL function. He had no motor deficits.

The patient underwent visual rehabilitation once a week for 24 visits. He used CSVFRP plus eye relaxation exercises daily. The treatment also emphasized on visual perception, facial blindness and reading training. After 6 months, he was modified independent with ADL function without bumping to objects and able to read simple books with normal speed. He had re-evaluation after 8 months with normal visual field and also approved with his ophthalmology clinic.

Case 3

A 47-year-old male with history of alcohol use disorder, hypertension, anxiety, panic disorder, and myofascial pain presented with left cerebral infarct, unspecified with right HH. The patient started vision therapy three months after stroke onset. The patient was unable to drive to work, kept bumping to objects and had frequent falls. He had severe anxiety, panic attacks, and headaches. His vision and visual perception at initial evaluation were as follows: Dominant eye: OS; BCDVA: OD: 20/20, OS: 20/20, OU: 20/20; BCNVA: 20/25, OS: 20/25, OU: 20/25; visual field: complete right HH; all other visual function and visual perception: Intact. There were no motor or other deficits.

The intervention first focused on psychological management. The patient was trained on CSVFRP with eye relaxation exercises. He completed the exercises at home for multiple times a day. He demonstrated significant improvement in only 9 visits. His visual field recovered 60 degrees from complete right HH. The patient was satisfied with the results. He reported no more panic episode and his headaches resolved. He also reported improvement in his anxiety and later returned to work.

Discussion

In the United States, the complete HH is about 10% out of approximately 700,000 stroke patients per year [26]. Goodwin [1] stated that about 8% to 10% of stroke patients have permanent HH. Human dependent on their vision as a main sense because half of the afferent neuronal fibers are from eyes [1,14]. Therefore, patients with HH showed significant decreased their quality of life and independence [20]. In patient with HH, spontaneous recovery is limited [22]. Visual field recovery happens within the first 10 days or the first few weeks after stroke [3,20]. Not like motor, language and cognitive rehabilitation, visual therapy is not the first line therapy and it may be implemented months to years after stroke, if at all [9]. The intervention for HH may be focused on compensatory strategies or optical aids, usually not visual field [9]. Although a variety of experimental rehabilitation techniques have been developed including visual field restoration, compensatory or substitution, and optical aids, these are rarely used in standard practice [14,22]. Optical aids like prisms, mirrors, telescopes and closed-circuit television and substitution strategies are not using neuroplasticity to enlarge the patient's true visual field and there is no significant improvement of quality of life [9,14]. Restorative rehabilitation programs address neuronal plasticity [27]. Vision Restoration Therapy (VRT) (Novavision Inc, Boca Raton, FL) enlarged 5-degree visual fields indicated by the conventional Humphrey perimetry [12,14,27]. Unfortunately, research is limited on HH intervention. There are no large, Randomized Controlled Trials (RCTs) for compensatory techniques and visual restoration therapy remains a controversial topic [3,9]. "Recent studies showing neuronal cortical plasticity in adulthood may promise future development in vision rehabilitation. At the present time the effect of visual restorative training is limited" [14]. Multiple researches were focused on Blindsight and Neuroplasticity [2,3,6,9,12,14,20,28]. HH patients concentrate their gaze towards the blind hemifield rather than the center of the pattern [3]. Deviating the eye fixation point into the blind field is the base theory of compensatory techniques. KUHN [29] revealed that patients with HH show their eye horizontal shift to the blind field. They suggested that it might be eccentric fixation, influenced by spatial attentional cueing and oculomotor compensation in the blind field. Plasticity is the basis of neurorehabilitation, especially vision rehabilitation [6]. Liu et al. [2] had a systematic review for rehabilitative interventions for hemianopia poststroke from 2006 to 2016. They found that visual neuroplasticity is the basis for restoring functional neural tissue in the visual field.

HH patients have significant difficulties to evaluate their environment due to less accurate and systematic saccades and slower searching pattern. The significant negative impacts are visual disorientation, having difficulties to find objects, and avoid hazards and obstacles, reading, driving and having visual hallucination [1,19,22]. Left-to-right readers must be able to see 3 to 4 letters to the left and 7 to 11 letters to the right of fixation. It is very difficult for right HH patients to read due to their inability to have appropriate systematic saccades [1]. Therefore, increasing visual field improves reading ability. Each state in the United States has different driving laws for visual field deficits. Twenty-seven states require at least 110° of binocular visual field and 12 states have no minimum visual field requirement. Goodwin [1] reported that HH drivers had trouble controlling the vehicle position, had problems adjusting their speed to traffic conditions, were unable to respond adequately to unexpected events, and had unusually bad driving maneuvers. It is important for visual therapists to be familiar with driving laws and HH drivers' behaviors [1].

Multidisciplinary approach has been used for HH management. Occupational therapy can treat HH for compensatory training, safety awareness, improve ADL function and possibly improve visual fields. Optometrists can provide prism glasses to expand the intact visual field. Ophthalmologists and neurologists can treat underlining conditions. Psychological rehabilitation and social support also play very important roles. A recurrent, complex visual hallucination is called Charles Bonnet Syndrome (CBS) [1,10]. 58% of HH patients had experienced visual hallucinations which cause severe anxiety [1]. It is important to treat this condition. Vision restoration therapy can be provided by specialists [30].

There are some computerized methods for visual training, but they were more towards substitutional methods, not visual field restoration [14,31]. Julkunena et al. [32], Kasten et al. [33] and Svaerke [31] found limited positive effect with computer-based programs for complementary visual training and partial visual restoration after stroke in small samples.

Given that relatively few therapeutic options exist to improve visual field in HH, developing novel programs is very important [9,12]. Most of visual rehabilitation programs are complex, labor intensive, costly, and require relatively specific facilities and equipment to provide treatments. The CSVFRP is a non-invasive, home based computer program. It is simple, easy, safe, user-friendly, and cost-effective with minimum effect on motor and other physical limitations. Patients are able to practice continuing treatment and repeated presentations of visual stimuli. Patients can also do self-assessment according to the measurement on the computer screen. There is no time limitation for the home-based computer program. The CSVFRP using computer repetitive visual stimuli to restore visual fields demonstrated clinical significance.

Limitations and Future Direction

The CSVFRP was able to increase visual field if patients followed the program. However, the visual therapy was not able to check patients closely due to home-based program. In the future, patients need to be following up periodically, for instance, every 3 months. Future studies should focus on a randomized clinical trial with a large sample.

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