Case Series

Vision Restoration Therapy: New Hope for Stroke Patients with Visual Field Loss

Kong-Yong Goh,[1,2,3]

Abstract

Introduction: Patients suffering from visual field defects caused by optic nerve or post-chiasmatic injury commonly experience many limitations in their daily activities. The generally accepted paradigm that nothing can be done leaves little hope for such patients as restoration was once considered impossible. In recent years, however, a paradigm shift has taken place. Through high-resolution perimetry (HRP), areas of residual vision can now be identified where training visual functions help to restore some of the lost vision and there is now a growing body of evidence that the visual system possesses a high degree of plasticity. Clinical Picture: A retrospective case review of 3 patients who suffered post-chiasmatic visual field loss and underwent 6 modules of vision restoration therapy (VRT). Their HRP results were compared before and after therapy. Treatment: All 3 patients underwent 6 modules of VRT. Each module consisted of twice daily 30 minutes of visual stimulation consisting of 500 randomly placed supra-threshold visual stimuli in a central 54^0 by 43^0 dark monitor screen. Outcome: All 3 patients experienced an improvement in their confidence in mobility as well as bumping less into objects in their peripheral fields. In Case 1, pre-VRT HRP showed a stimulus detection accuracy of 55.34%. After 6 modules of VRT there was an impressive increase to 90.23%. In Case 2, pre-VRT HRP showed a left incomplete homonymous hemianopia with a stimulus detection accuracy of 70.32% that improved to 98.10%. In Case 3, pre-VRT HRP revealed a left superior quadrantanopia with a stimulus detection accuracy of 57.03% that increased to 73.42%. Conclusions: Although VRT is in its early stages in Singapore, the results from these 3 patients are promising and this can become one of the new modalities in the provision of an all-rounded neuro-rehabilitation programme for our patients with post-chiasmatic visual field loss.

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Key words: High-resolution perimetry, Post-chiasmatic visual field loss, Residual vision

Introduction

Patients suffering from visual field defects caused by optic nerve or post-chiasmatic injury commonly experience many limitations in their daily activities. The generally accepted paradigm that nothing can be done leaves little hope for such patients as restoration was once considered impossible.

This arose from Hubel and Wiesel's[1-3] discovery that neurons in the visual cortex are highly specialised. Consequently, much of vision research has focused on further characterising the specialised neuronal organisation.

In recent years, however, a paradigm shift has taken place. Through high-resolution perimetry (HRP), areas of residual vision can now be identified where training visual functions help to restore some of the lost vision. The area of residual vision is identified after 3 consecutive diagnostic tests on the HRP reveals detection of light stimuli in at least 2 out of 3 tests. It occurs at the junction between the seeing and non-seeing parts of the visual fields. There is now a growing body of evidence that the visual system possesses a high degree of plasticity. Plasticity[4] is the ability of the brain to adapt to various experiential and structural changes as seen in the following:

1. After lesions of the central nervous system, animals and humans can recover visual functions even without therapeutic interventions.[5]
2. Visual receptive fields can shift their location and increase in size following deafferentation[5-7] and under

[1] Department of Ophthalmology, Tan Tock Seng Hospital, Singapore
[2] The Eye Institute, National Healthcare Group, Singapore
[3] Department of Ophthalmology, Yong Loo Lin School of Medicine, Singapore
Address for Correspondence: A/Prof Goh Kong Yong, Department of Ophthalmology, TanTock Seng Hospital, 11 Jalan Tan Tock Seng Hospital, Singapore 308433.

different conditions of alertness.[8]

3. Cells surviving an area of partial injury undergo massive molecular and cellular changes that help to overcome the loss of vision.[9]
4. Practising visual tasks in normal monkeys and humans significantly improve discrimination performance in normal eye.[10]
5. Through a complex neuronal network of lateral interactions and feedback connections, visual information can reach many areas of the brain through alternative routes, thus providing a structural basis for re-organisation and plasticity.[11]

Diagnosis of Residual Vision

Areas of residual vision are those sectors of the visual field that do not function normally but in which some visual capacities have survived the injury. These areas are also called transition zones[12] because they are usually located at the border between the blind and seeing area. It is likely that the degree of residual vision correlates directly with the relative number of cells surviving the injury. Because of their relatively lower resolution, standard perimeters used in ophthalmology are not precise enough to demonstrate residual vision.

A HRP procedure using computer screens is needed to perform high-resolution qualitative perimetry of the central visual field.[13] As a result, a detailed analysis of the residual vision can be performed. HRP is a suprathreshold perimetry compared to the Humphrey perimetry, which is a projection perimetry that utilises threshold strategies to plot the visual field defects. As a result, it is difficult to compare both forms of perimetries and although changes could be detected in the HRP's they could not be detected on the Humphrey perimetries.

Restoration of Visual Field Defects

The restoration of visual field defects can be seen in the following:

1. Spontaneous Recovery

Both animals[9] and humans[14-17] recover some lost visual functions spontaneously even without any intervention. As early as 1917, Poppelreuter observed spontaneous recovery from visual dysfunction in soldiers with gunshot wounds.

2. Training-induced Enlargements of Visual Field Defects

Animal studies since the 1940s[9] revealed that systemic training or experience can improve visual functions. Such studies were extended to human subjects in the 1980s.

The first by Zihl et al in 1980[18] found that repeated testing of the visual field border significantly increased the visual field size in patients with post-chiasmatic lesions.

The group of neuro-psychologists led by Professor Bernhard Sabel at the University of Magdeburg, Germany had been active in this field of vision restoration therapy (VRT); conducting and publishing their results from an initial open pilot study (1995) and then 2 prospective randomised, placebo-controlled clinical trials (1997 and 1998).

In the initial pilot study,[19] 14 patients with post-chiasmatic visual loss trained with VRT for approximately 1 year. Although 3 untreated patients experienced a slight decrease of visual field size, most patients in the treatment group showed a significant visual field enlargement.

In a subsequent randomised, double-blind, placebo-controlled trial,[20] 19 patients with post-chiasmatic visual loss were assigned randomly to either the experimental or control group. After a period of 6 months, the experimental group showed a significant increase of visual field size amounting to 29.4% above baseline (baseline = 100%). Interestingly, the training which was done only with white or gray stimuli, also improved their colour and form recognition.

In a second clinical trial with 19 patients[20] with optic nerve injury, the effect of training was even more pronounced. In the experimental group, visual field size increased by 73.6% over baseline. Unlike the post-chiasmatic group, patients with pre-chiasmatic visual loss showed improvements primarily in the early stage (within 4 to 6 weeks) after the commencement of training. It is also interesting to note that optic nerve patients also showed an improvement in visual acuity.

Mechanism of Action

The visual system is not as hard-wired as previously assumed. There is a considerable overlap of receptive fields in the visual system and an astonishing degree of plasticity[21] is maintained in life. Receptive fields may change their location and size following injury and through the process of perceptual learning, both the uninjured and the lesioned brain can improve visual performance. Because visual field enlargements in patients usually occur at the transition zones, it has been proposed that partially surviving neurons and their axons within the zone of damage provide the structural basis for this plasticity. Whatever the cellular mechanisms may be, transition zones are the functional representation of partially damaged regions of the visual system. By repetitive visual stimulation of these surviving neurons, these cells may become more efficient by reducing their threshold of firing.

Case Reports

Three patients with post-chiasmatic lesions underwent 6 modules of VRT at Tan Tock Seng Hospital between

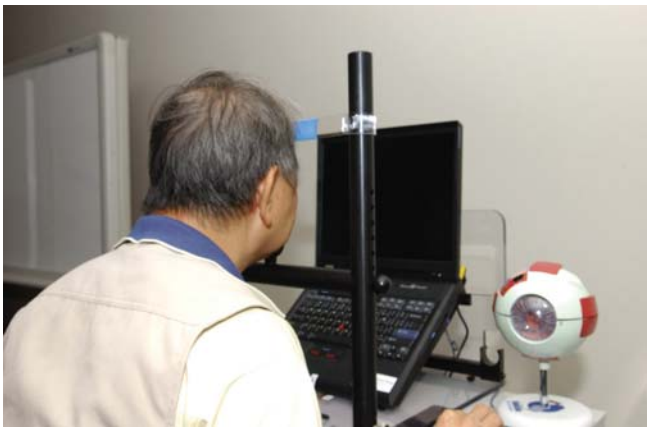

Fig. 1. A patient doing a diagnostic test at a VRT device.

October 2005 and March 2006. Each initially underwent a diagnostic test to identify the area of transition vision in each patient (Fig. 1). The therapy is then customised to each patient with modifications after each module. At each session supra-threshold visual stimuli are presented in the central 54^0 by 43^0 monitor screen. Small stationary white dots are presented at 500 different loci on a dark monitor screen and the patient is required to hit a key when a target stimulus is perceived. The stimulus presentation is at random positions with random variations in the inter-stimulus interval. Fixation control is assessed by the patient identifying a change in colour of the central 0.5^0 fixation point from bright green to right yellow. Data analysis is made by counting the number of correct responses expressed as a percentage value (stimulus detection accuracy).

Case 1

Mr AKG, a 50-year-old Chinese male, suffered a right posterior cerebral artery infarct in August 2004. Magnetic resonance imaging (MRI) revealed an acute right medial occipital lobe infarct that caused a left homonymous hemianopia which remained unchanged since the initial insult. He started VRT in October 2005. Pre-VRT HRP showed a stimulus detection accuracy of 55.34%. After 6 modules of VRT there was an impressive increase to 90.23% in May 2006 (Figs. 2a and 2b). He has also returned to driving a motor vehicle.

Case 2

Mr CKC, a 66-year-old Chinese male, who had a left temporal lobe arterio-venous malformation that bled in 1998 resulting in a right incomplete homonymous hemianopia. He started VRT 98 months after this initial insult to the brain. Pre-VRT HRP showed a left incomplete homonymous hemianopia with a stimulus detection accuracy of 70.32% that improved to 98.10% after 6 months of VRT (Figs. 3a and 3b). He also noticed that he has stopped bumping into objects and people.

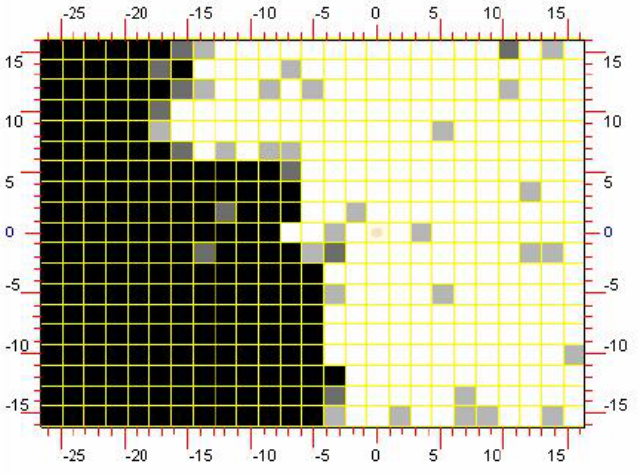

Fig. 2a. Pre-VRT HRP (Case 1) (1.10.2005) showing a left homonymous hemianopia.

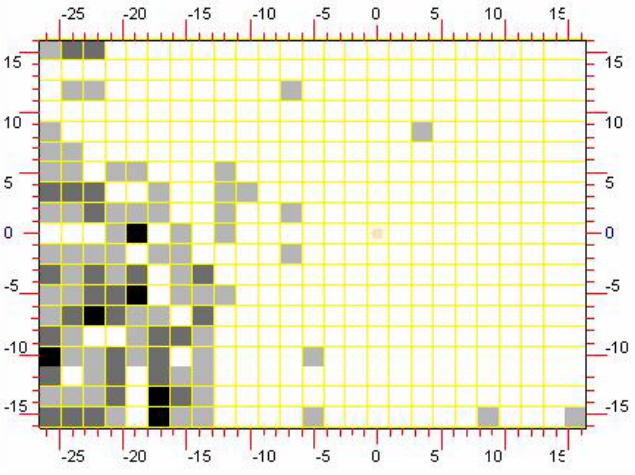

Fig. 2b. Post-VRT HRP (Case 1) (11.5.2006) showing a reduction in the hemianopia.

Case 3

Ms NHL, a 27-year-old Chinese female, had a right posterior cerebral artery dissection in August 2005 which resulted in a right occipital infarct. This caused a left superior quadrantanopia. She started VRT 7 months after the initial insult to the brain. Pre-VRT HRP revealed a left superior quadrantanopia with a stimulus detection accuracy of 57.03%. This increased to 73.42% after 6 months of therapy (Figs. 4a and 4b). She also noticed that she is more aware of objects coming from her left temporal field and bumps less into them after the therapy.

Conclusion

Although there has been significant improvements in the HRPs in these patients, their Humphrey visual fields (HVFs) did not show much change before and after VRT. This is because of the different strategies utilised to plot the field loss, namely, suprathreshold light stimuli in HRP and threshold stimuli in HVF. This was also in spite of subjective

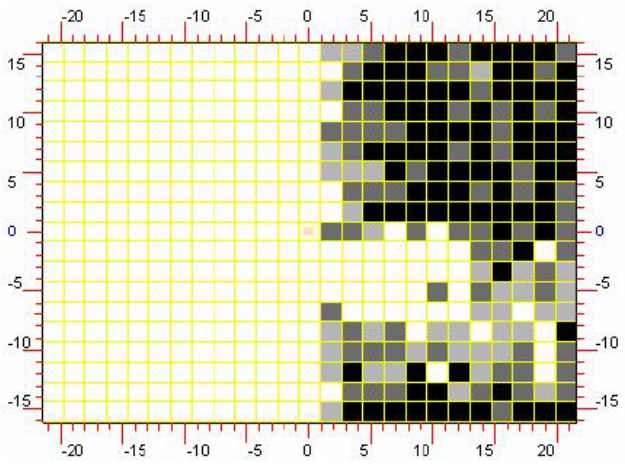

Fig. 3a. Pre-VRT HRP (Case 2) (19.2.2006) showing a right incomplete homonymous hemianopia.

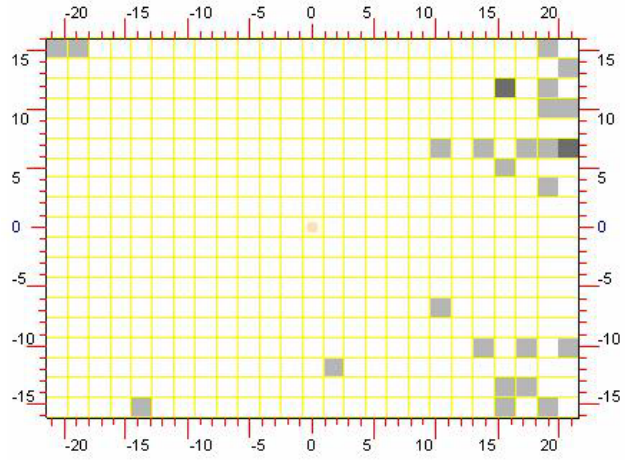

Fig. 3b. Post-VRT (Case 2) (12.9.2006) showing near complete resolution of the hemianopia.

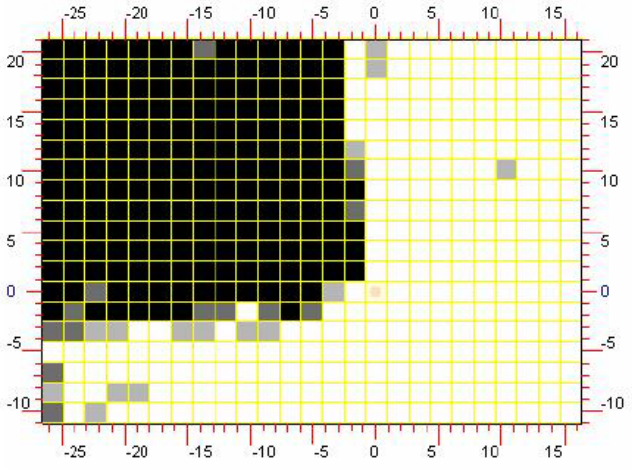

Fig. 4a. Pre-VRT HRP (Case 3) (14.3.2006) showing a left superior quadrantanopia.

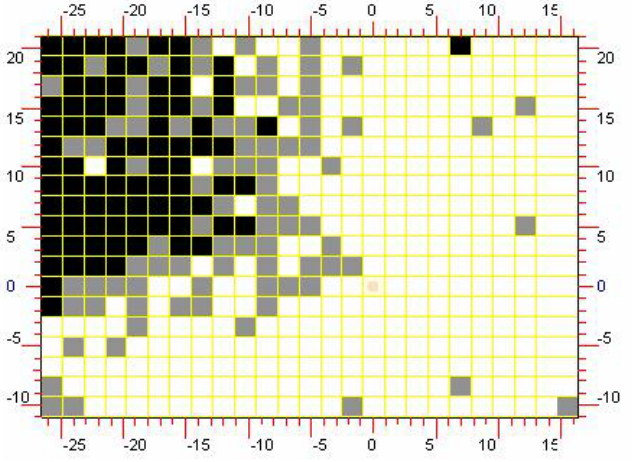

Fig. 4b. Post-VRT HRP (Case 3) (12.10.2006) showing central resolution of the quadrantanopia.

improvement in visual fields described by the above patients.

VRT is still in its early stages in Singapore and its efficacy needs to be evaluated further. As it is safe and non-invasive in nature, it can become one of the new modalities in the provision of an all-rounded neuro-rehabilitation programme for our patients with strokes in future.

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