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Case Report

Assessment of Visual Dysfunction in a Patient with Right Occipital Infarct

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Purpose: This study describes a patient with multiple visual impairments following right occipital infarction in the posterior cerebral artery (PCA) territory. The earliest stage of cortical processing of visual information occurs in the occipital lobe, so damage to this lobe causes not only visual field deficits but also other forms of visual problems. However, few cases of this sort have previously been reported in the literature.

Case report: A 54-year-old female suffered from a progressive throbbing headache over the right occipital area for 2 weeks. Blurred vision and left hemianopia were found, and brain magnetic resonance imaging revealed cerebral infarction over the right posterior cerebral artery territory, mainly over the right occipital lobe. Advanced assessment in basic and high levels of visual function was arranged to confirm her visual complaints. Several types of assessment of visual function revealed not only visual field defects but also impairments in visual acuity, color vision, contrast sensitivity function, and stereo vision. In addition, deficits in visual attention test were also observed, mainly in divided and selective attention, which cannot only be explained by impaired visual deficits.

Conclusion: In this case, defining visual impairment by visual fields did not present the whole impact of occipital stroke on the visual function and functional vision. Deficits in visual acuity, color vision, contrast sensitivity, stereo acuity, and visual attention were associated with visual cortex lesion. In terms of visual rehabilitation, there is a need for comprehensive visual assessment of patients with occipital stroke.
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Key Words: ischemic stroke, occipital lobe, visual function, visual impairment, visual rehabilitation

INTRODUCTION

Vision is a very important sensory modality. Nearly half of the afferent fibres projecting to the brain are from the eyes for visual information processing, and the visual

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and vision-associated cortices comprise around one quarter of the total human cortex.[1] Also, visual activities are quite complicated, involving different visual components, and are closely linked with other non-visual activities, such as motor control or cognition.[2] For example, good visual search and eye motility are necessary for space perception, object recognition and reading.[2,3] Stereo vision provides major cues for depth perception, which is required for accurate and smooth performance of motor activities such as grasping, manipulating, and locomotion.[4] Visual attention also facilitates both basic and higher-level visual activities, such as visual search, object recognition, driving, and reading.[5,6] Due to these complex relationships and interactions, disorders of visual function can easily cause difficulty in maintaining normal activities of daily living.

A high percentage of brain injuries, such as stroke or trauma, results in visual impairment of varying forms and degrees.[2] Although defects of visual acuity and visual field are frequently reported in the literature,[2,7] few stroke patients and clinicians are aware of these vision problems,[8] not to mention other forms of visual impairment. The majority of studies to date, which have focused on the visual field, indicate that more than half of visual field defects do not recover after six months of initial brain injury.[9] A recent study recommended routine visual field testing for every stroke patient in order to increase early awareness of the visual disability and inform referrals for visual rehabilitation.[8] But other forms of visual impairment, including color vision, stereo vision, and visual attention, have generally been ignored.

It has long been believed that any recovery in the impaired adult visual cortex due to brain injury will be limited.[10] However, this idea has been challenged by recent evidence of plasticity and the repair of the visual cortex in molecular and cellular studies of the visual cortex,[11] and also by results from functional magnetic resonance imaging studies in patients with cerebral blindness after visual training.[12] Indeed, visual rehabilitation with optical aids, eye movement training, and visual field restitution offers a possible insight to improving visual function after stroke.[13,14] However, visual function in various domains should be comprehensively evaluated before and after visual training to develop an appropriate program of visual rehabilitation.

In this paper, we report a patient who experienced right occipital infarction. The occipital lobe is the earliest stage of cortical processing of visual information, so damage to this lobe will cause different forms of visual problems. However, few cases of this sort have previously been reported in the literature. This case report aimed not only to clarify the visual symptoms by basic and higher visual function assessment, but also to highlight the interest in the visual problems after occipital stroke for health professionals in the departments of neurology and physical medicine and rehabilitation in Taiwan.

CASE REPORT

All procedures of data collection were reviewed and approved by the Institutional Review Board of Taipei Tzu Chi Hospital, Buddhist Tzu Chi Medical Foundation, and all tests were conducted in accordance with the tenets of the Declaration of Helsinki. Participants (patient and control) were informed of all measurement before obtaining written consent. Healthy control (S1: male, 58 years old; S2: female, 51 years old) with normal or corrected to normal vision and without congenital color impairment, amblyopia, high refractive errors, cataract, diabetes and histories in any kinds of retina diseases, photorefractive keratectomy, and high intraocular pressure were included.

1. The patient: case history, neurological and neuroradiologic examinations

A 54-year-old female diagnosed with diabetes mellitus and hypertension had been treated with regular medical control for 1 year after a recurrent right hemisphere subcortical lacunar infarction. She received regular medical treatments with sequela of some left limb weakness, but she could walk with some unsteadiness using a cane after rehabilitation programs. She did not have any visual complaints, though similar gait problems persisted, until 2 weeks before this admission.

For 2 weeks prior to admission, she had a progressive throbbing headache over the right occipital area and some dizziness. Blurred vision and some left limb numbness occurred several days later, without significant warning. When the headache became unbearable, she visited our emergency room, where she presented with left homonymous hemianopia and decreased touch sensation over the left trunk and limbs. Brain imaging revealed cerebral infarction over the right posterior cerebral artery territory, mainly in the right occipital lobe (Figure 1). Further digital subtraction angiography revealed bilateral moyamoya syndrome with total occlusion of the right posterior cerebral artery.

The left limb numbness and unsteady gait recovered slowly after postural training and the headache subsided several days later after admission. However, she complained that she could not see objects on her left and that her vision on her right had become more blurred. She felt the color of objects was faded or clouded, and reading had become more difficult. She could correctly recognize and name familiar characters and figures (score of the National Institutes of Health Stroke Scale/NIHSS Category 9-Best Language=0 point), but spent more time in characters or figures with complex structures. She also showed some difficulty in finding words from newspaper or magazine. She was able to write and copying figures (scores of the Minimal Mental Status Examination/MMSE= 26 points, item of writing a sentence=1 point, pentagon copying=1 point). In addition, she did not have symptoms of visual hallucinations.

2. Ophthalmological survey

A general ophthalmology survey, including the general appearance of the eyes, intraocular pressure, and corneal clearance, was normal. No significant cataract or diabetic retinopathy was found. Visual acuity and visual field examinations were performed. The visual acuities of both eyes were around 0.1 of decimal visual acuity, and best corrected visual acuities (BCVA) were around 0.5 of decimal visual acuity. Her visual field exhibited left homonymous hemianopia (Figure 2). Although impaired visual acuity and visual field could affect the performance of reading and searching, the results of general ophthalmological examinations could not completely explain the patient's current visual complains. Therefore, we arrange other basic level and higher level assessment of visual function to identify her other visual problems.

3. Visual function assessment

3.1. Color vision

The Hardy-Rand-Rittler (HRR) pseudoisochromatic test, composed of 24 plates and designed to screen (blue-yellow (B-Y) defect, red-green (R-G) defect, or normal) and diagnose the severity of color impairment,[15] was used to measure her monocular color perception. In color vision, the patient stated that she had normal color vision on the Ishihara color test before the stroke. In addition, there was no significant cataract or diabetic retinopathy in this patient. However, in our assessment, the results indicated mild R-G deficit and B-Y defect in the right eye, and mild R-G defect in the left eye, so the occipital lesions this time had impaired her color perception.

3.2. Stereo acuity

Near stereo acuity was tested with the Butterfly Stereo Acuity Test which can simutaneously measure gross stereopsis through identifying images of a butterfly and fine stereopsis by recognizing a circle in each testing box while wearing polarized viewers.[16] In gross stereopsis measurement, she was able to recognize the lower wings but not the abdomen, which corresponded to 1,000 seconds of arc (sec of arc). In fine stereopsis assessment, her stereo acuity threshold (200 sec of arc) was much higher than those of two normal controls (50 sec of arc for S1 and 40 sec of arc for S2).

3.3. Contrast sensitivity function

Contrast is the difference in luminance between objects or between an object and its background. Contrast sensitivity defines the ability to discriminate the details of low contrast pattern stimuli, or contrast threshold.[17] This is different from visual acuity, which is a measure of the minimal size threshold at a high contrast level. Contrast sensitivity function (CSF) describes the relationship between the degree of detail of a visual pattern (e.g., coarse or fine) and the necessary ability, contrast threshold, to just discriminate the visual pattern.

The visual stimulus used to measure CSF in this study was a sinusoidal grating (black and white bars) specified in units of spatial frequency (the number of cycles falling within one degree of visual angle). Three types of spatial frequencies (1, 3, and 9 cycles per degree (cpd), representing low, median, and high spatial frequency, respectively) (Figure 3A) were used to measure

the CSF. Contrast is defined by the Michelson contrast formula as
$(I_{max} - I_{min}) / (I_{max} + I_{min})$ with I_{max} and I_{min} representing the highest and lowest luminance (I: luminance)

The stimuli were generated by the Psykinematix software[18] running on a Mac mini computer (Intel Core i5) and displayed on a CTX EX951F 19" monitor. The viewing distance was 60 cm, the radius of visual stimuli was 2 degrees of visual angle, and the presentation duration was 500 ms. The task for our participants was to discriminate the orientation of the grating, which was vertical or rotated to the right or left (Figure 3A). A psychophysical method, a 2 down-1 up staircase procedure, was used to measure contrast threshold for each spatial frequency.

The results of psychophysical assessment for contrast sensitivity function were showed in Figure 3B. We also measured the performance of CSF in two normal controls (S1 & S2). The results demonstrated that the patient had higher contrast thresholds than the controls at high, median, and even low spatial frequencies.

3.4. Visual attention

Useful Field of View (UFOV) assessment, which examines 3 aspects of visual attention—visual processing speed, divided attention, and selective attention—was used to determine the participant's visual attention abilities.[19] In the first subtest, the participant has to identify stimuli (either a car or a truck) that are briefly presented in the center of the screen (for 16-500 ms) (Figure 4A). In the second subtest, the participant needs to simultaneously identify the central stimulus (car or truck) and the location of a peripheral stimulus with a fixed eccentricity of 12.5 cm from the central stimulus (Figure 4B). The third subtest is similar to the second sub-test, except that the peripheral stimulus is embedded within distractors (small triangles) (Figure 4C). Each subtest assesses the exposure duration of visual stimuli required to maintain 75% accuracy. The maximum default exposure duration is set at 500 ms by the UFOV.

In this part, UFOV subtest scores and total scores for patient and controls are presented in Table 1. The differences between the patient and controls were small in the first subtest, but apparent in the other subtests. In the second subtest (for testing divided attention), the patient could not detect the peripheral stimuli when they presented in radial locations 7 and 8, but could detect most stimuli in other locations. However, she had great difficulty in the third subtest (for testing selective attention), in which distractors were added.

DISCUSSION

The patient complained mainly of blurred vision when she visited the emergency room at first. However, comprehensive visual assessment revealed that the patient had decreased abilities in visual acuity, contrast sensitivity, color perception, stereo acuity, visual field, and visual attention. In addition, she exhibited other visual perception deficits, such as disorder in global motion perception (data not shown here). Ischemic stroke usually leads to permanent neurological sequela, such as altered sensory and perceptual functions, motor impairment, and language and cognitive dysfunctions. Actually, various types of visual impairment also frequently result from stroke, with occurrence rates of 30% to 85%. These problems involve eye movement disorders,[20] impaired visual functions (visual acuity, contrast sensitivity, color perception and visual fields),[21,22] and visual perception, such as visual inattention, visual memory deficits, object agnosia, simultaneous agnosia,[7,23,24] and motion perception problems,[25] that depend on the lesion sites and severities. Furthermore, vision is not just about sight, for it also plays an important role in motor control, cognitive, communicative, and emotive functions; and interactions with the environment.[24] Therefore, there is a need to address the importance of comprehensive visual assessment, not only to define a stroke patient's deficits in visual function and functional vision, but also to determine further referrals for visual rehabilitation.

Most of the visual information from the retina and lateral geniculate nucleus of the thalamus is first sent to the occipital lobe, which contains a full retinotopic map of the visual world. But this lobe is also specialized, in particular the primary visual cortex, to analyze basic visual features, such as color, contrast, orientation, local motion, and depth, and further to integrate and process more complex information.[1,26,27] In this case, the stroke areas involved included the striate cortex and part of the parastriate areas, so it was predicted that there should be various visual problems and functional vision disturbance in this patient. For example, in an interview, she reported that she easily missed some information when walking in an unfamiliar or public environment. Decreased visual acuity and contrast sensitivity caused her trouble in reading, and she was easily fatigued by reading even a short paragraph. In addition, R-G color deficit was noted despite her having no history of color impairment, no diabetic retinopathy, and only very mild nuclear cataract (degree: +1). Deficits in color perception and contrast sensitivity function were associated with her report of foggy vision and faded colors when watching TV.[21] This visual impairment following the occipital stroke disrupted several aspects of her daily activities.

Visual attention deficits are common among stroke victims, and such deficits are not limited to those with stroke involving the frontoparietal network.[28] Visual attention is a very basic function that allows people to select information relevant to, and suppress information irrelevant to, their current activity, so a disability in visual attention can lead to impaired functional recovery in stroke patients.[29] In addition, the status of visual attention affects through top-down feedback the early neural activity and perceptual performance of the primary visual cortex, such as visual acuity and contrast sensitivity.[5] Therefore, it is important to assess visual attention in the field of visual rehabilitation. The UFOV test measures three different components of visual attention: visual processing speed, divided attention, and selective attention. Divided attention indicates the ability to pay attention simultaneously to different stimuli in different locations; selective attention refers to the ability to pay attention to important information and inhibit irrelevant stimuli.[28] During this test, the patient responded significantly more slowly on divided and selective tests than 2 controls and exhibited similar performance to the controls in the processing speed subtest. The findings suggest that this patient may have difficulty in executing tasks with more complex visual loads, such as discriminating a target in a complex and unfamiliar environment.[30] This result corresponded with the patient's complaint about easily missing information when walking in an unfamiliar or public environment. In addition, her MMSE test score of 26 points and series-seven-test score of 2 points also suggested that her performance on the UFOV was not affected by her cognitive ability.

The purpose of a comprehensive visual assessment is not only to help identify the possible underlying problems related with a patient's functional defects after stroke but also to help determine whether to make referrals to and plan further visual rehabilitation intervention. Although some spontaneous recovery of visual function occurred, different courses of visual function and persistent visual deficits were found in this patient in the subacute phase after stroke. For example, our patient had some natural improvement in color perception and contrast sensitivity to low spatial frequencies, but she also still showed deficits in R-G color perception, contrast sensitivity to median and high spatial frequencies, stereo acuity, and selective attention at one-month follow-up. Therefore, it is necessary to engage in early visual intervention to increase stroke patients' awareness of their problems and adopt early rehabilitation strategies including compensatory approach by using compensatory eye movements into the blind field, adaptive approach through using high contrast settings and proper lighting for defects of contrast perception, and remedial approach, which involves training in perceptual skills, visual search skills, and attention training to improve patients' basic visual function and higher visual perception. In addition, the results of early visual assessment can help clinical therapists to differentiate patient's problems (e.g., the influence of stereoacuity on mobility) and to correctly interpret the regular clinical assessment.[31]

In conclusion, in addition to visual field and visual acuity deficits, occipital lobe stroke can also lead to various disturbances in basic and higher levels of visual function and functional vision. Patient's performance on visual field and visual acuity tests was not enough to present the impact of occipital stroke in our patient. Although assessment of visual function after stroke is important to assist the understanding of reasons behind the various visual symptoms and to provide early and appropriate intervention, it is often inadequate in current clinical practice. Therefore, in-depth visual assessment to inform patient-oriented visual rehabilitation should be considered for inclusion in stroke unit practice and be clinically implemented by a multidisciplinary approach. The referral of assessment and intervention can be done when patient's condition is stable. In our case, visual assessment was conducted after two weeks of stroke. Early visual assessment and consultation will not only help patient to improve her capacities, such as reading training, and to compensate her deficits, such as scanning training to counteract the influence of left hemianopia, but also show benefits for other health professionals in providing medical care.

Table 1- UFOV subtests scores and total scores for patient and controls (S1 and S2)

Test type	Subtest 1- visual processing speed	Subtest 2- divided attention	Subtest 3- selective attention	Total of subtests
Patient	25 ms	400 ms	500 ms	925 ms
S1	25 ms	16 ms	76 ms	117 ms
S2	19 ms	70 ms	160 ms	249 ms

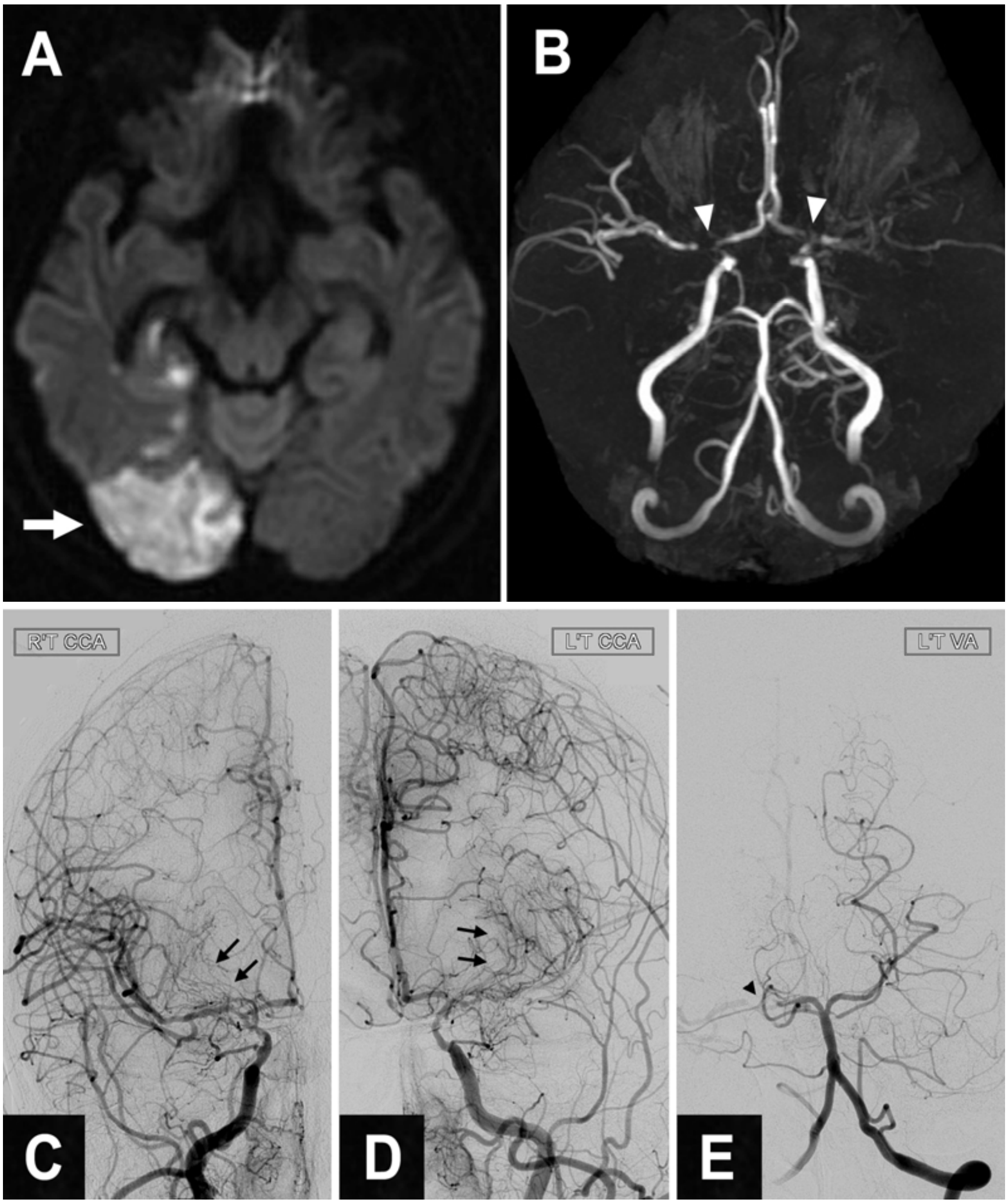

Figure 1. (A) Diffusion weighted axial MR image shows acute infarction at the right occipital lobe (arrow). (B) MR angiography demonstrates tight stenosis of bilateral terminal internal carotid arteries (arrow heads). (C) and (D) Cerebral angiography of carotid arteries discloses moyamoya syndrome of bilateral terminal internal carotid arteries with collateral moyamoya vessels (small arrows). (E) Digital subtraction angiography of vertebral artery displays occlusion of the right posterior cerebral artery (small arrowhead).

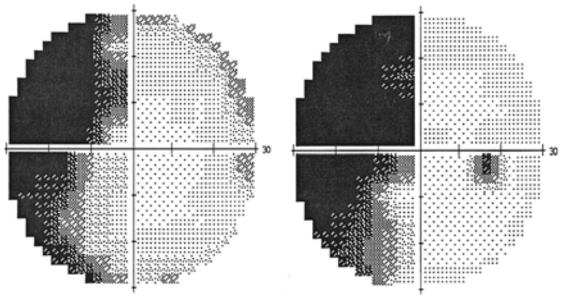

Figure 2. Perimetry test of visual field shows left homonymous hemianopia.

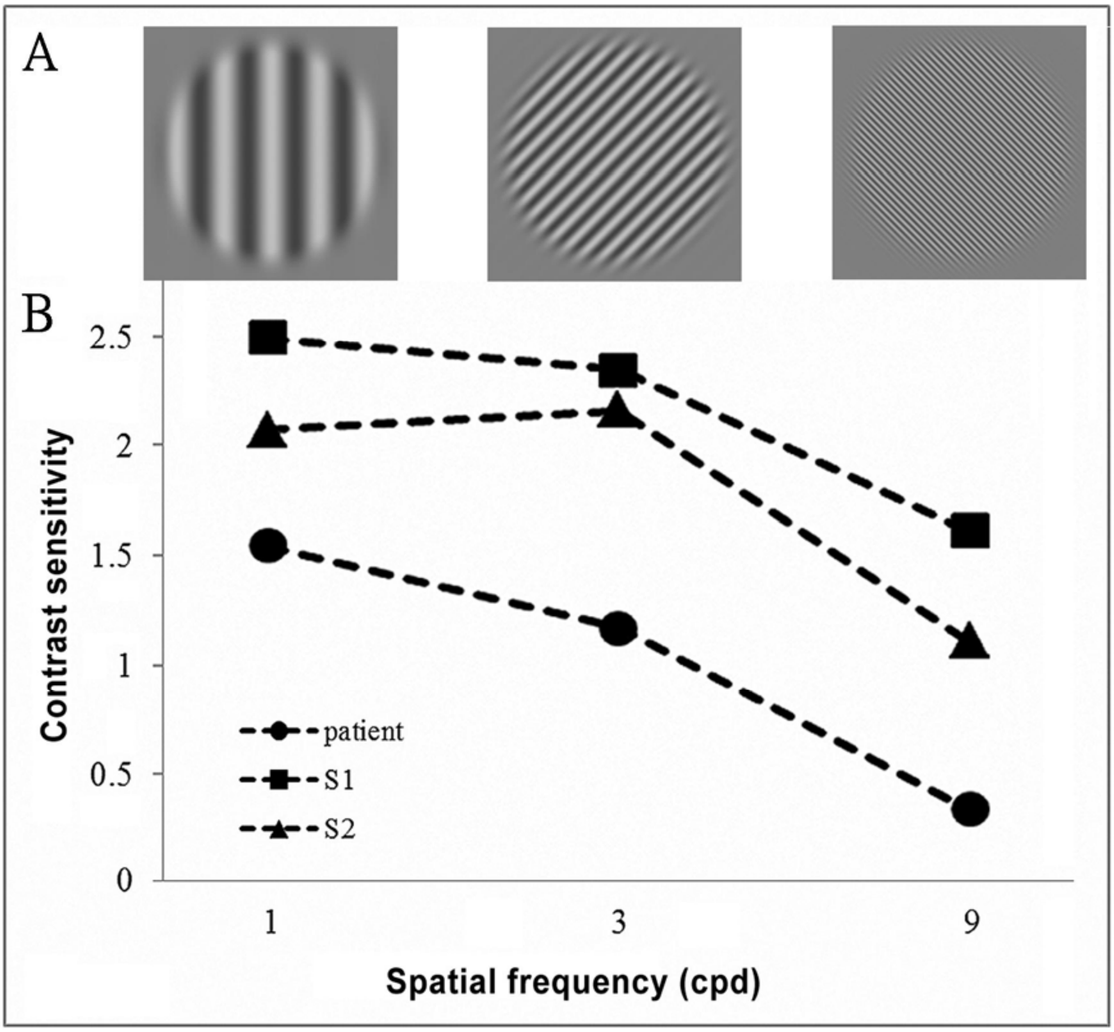

Figure 3. Performance of CSF measurement for 3 participants. Three types of grating used in CSF measurement with spatial frequencies of low to high (left, sf: 1cpd; middle, sf: 3cpd; right, sf: 9cpd) was tested. Y-axis indicates the contrast sensitivity, defined as the reciprocal of contrast threshold ("log (1/threshold) = log (1/%)"). Smaller contrast threshold indicates larger contrast sensitivity. *CSF: contrast sensitivity function, sf: spatial frequency, cpd: cycle per degree.

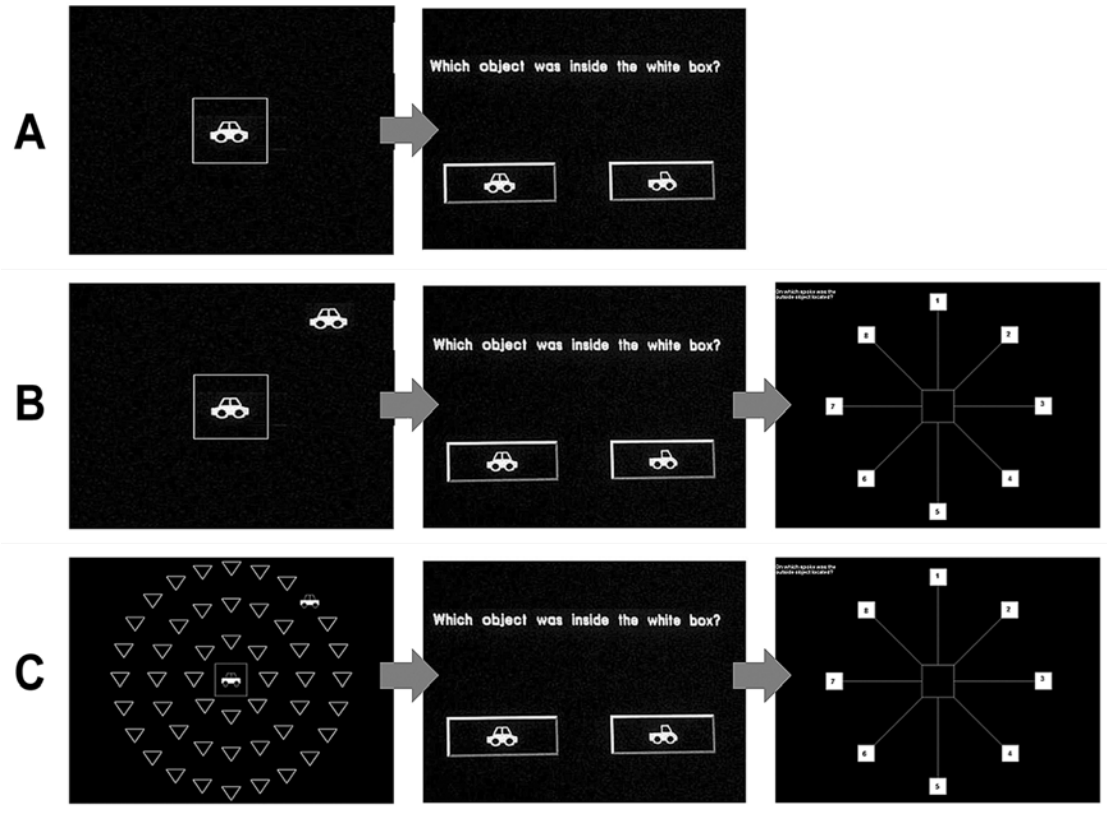

Figure 4. Diagram of UFOV conditions. Demonstration of the UFOV to measure (A) 1st subtest: the ability of visual processing speed, (B) 2nd subtest: divided attention, and (C) 3rd subtest: selective attention.

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右枕葉腦梗塞病患之視覺評估

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目的：評量一位右枕葉腦梗塞的病患，在初階和高階視覺功能之視覺狀況。枕葉是大腦皮質最早接收和處理視覺訊息的區域，枕葉損傷可能造成視野問題之外，還可能影響其他的視覺功能。但是過去少有文獻探討這樣的案例。

個案報告：一位 54 歲的女性病患漸進式的右側枕部頭痛兩週。有視力模糊及左半側偏盲情形。腦部磁振攝影發現右後大腦動脈區域有梗塞，而且主要在右枕葉部位。故予安排進一步的基本及高階視覺功能檢查評估，來確認她的視覺問題。進行多項的視覺功能評估後，確認個案除了視野問題之外，在基本視覺功能方面，同時有視力、色知覺、對比知覺和立體視覺之問題。在視覺注意力部分，個案在分散式注意力和選擇式注意力的表現，顯著低於其他正常受試者。此部分除受到視野的影響之外，還有其他的影響因素，特別在選擇式注意力項目。

結論：從此病患的臨床表現可發現，視野缺損無法完整呈現枕葉腦中風的視覺功能或具功能性的視覺能力。視力，色覺，對比敏感度，立體視覺以及視覺注意力都跟視皮質有關。從視覺復健的觀點，對枕葉中風患者做全面性的視覺功能評估，對後續視覺復健計畫的擬定是非常必要的。（台灣復健醫誌 2015；43(3)：191 - 200）

關鍵詞：缺血性腦中風(ischemic stroke)，枕葉(occipital lobe)，視覺功能(visual function)，視覺障礙(visual impairment)，視覺復健(visual rehabilitation)

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