Effect of whiplash injury on contrast sensitivity

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Abstract

The aims of this study were to compare the results of the measurement of distance visual acuity and contrast sensitivity for whiplash injured subjects and control subjects. A total of 35 whiplash subjects (mean age: 38 yrs, range 19-79 yrs; 71% female) and 72 control subjects (mean age: 35 yrs, range 18-62 yrs; 79% female) were examined. Measurements of uniocular distance visual acuity and uniocular contrast sensitivity were taken. There was no difference in visual acuity between the whiplash and control group subjects. There was a statistically significant reduction in contrast sensitivity in the mid to high spatial frequency range for the right eyes and in the mid spatial frequency range of left eyes of the whiplash subjects compared to the control subjects. These results indicate that an aspect of visual function (contrast sensitivity) was effected by whiplash injury.

Key words

Vistech Contrast Sensitivity Test System

Introduction

A variant of whiplash injury, the 'railway spine' was observed in railway passengers involved in train accidents in the 19th century.[1] The actual term 'whiplash' was apparently coined by Crowe[2] in 1928. Over the years various other terms such as 'acceleration injury', 'deceleration injury', and hyper-extension injury' have been used to describe this phenomenon, but whiplash has remained the most widely accepted descriptor.[3] There have also been a variety of bio-mechanical explanations of whiplash. However, the current view of the sequence of events leading to a whiplash injury is following a collision to the rear end of a car, the lower part of the victim's back is thrust forward and the head is thrown back causing hyperextension of the neck. The head is then thrown forward causing flexion of the neck. In addition to damage to neck structures,[3] whiplash has been shown to cause brain damage[4] and retinal changes.[5]

Visual and ocular disturbances following a whiplash injury have been numerous, but difficult to explain because by their very nature they manifest as subjective symptoms which cannot be demonstrated with objective testing. These symptoms have been attributed to: vascular disturbances;[2,6,7] stimulation of the cervical sympathetic pathway;[8,9] and impaction of the midbrain.[10,11]

Retinal damage, such as that caused in the 'shaken baby' syndrome, where it was hypothesized that the force of the whiplash caused macular changes has been reported.[5,12] Vitreous and retinal disturbances following a whiplash injury have also been published.[12,13,14,15,16]

In spite of common reports of visual disturbances, distance visual acuity has not been considered to be affected by whiplash.[10,15,17,18,19] With the exceptions of Daily[13] and Kelley et al.,[16] no evidence of defective visual acuity following a whiplash injury could be found in the literature. As with other ocular functions described by early investigators,[10,15,17,18,19] few details of the tests of visual acuity performed have been reported, and no comparison was made with a control group of normal subjects.

Research has demonstrated that standard visual acuity measurement does not test the majority of cells in the human visual system.[20] Following work by Arden,[20] contrast sensitivity testing has been used to examine loss of visual function not previously detected by measurement using standard vision test types. When a test requires the recognition of varying contrasts and spatial frequencies, a plot of visual performance (contrast sensitivity curve) can be determined. This involves the measurement of the subject's visual sensitivity to large, medium and small objects (spatial frequencies) under circumstances of varying contrast. The shape of the contrast sensitivity curve is dependent on the optical, retinal and neural properties of the visual system.[21]

Arden and Jacobson[22] found a reduction in contrast sensitivity in subjects with early glaucoma. Similarly in subjects with multiple sclerosis, Regan et al.[23] found a reduction of contrast sensitivity function was associated with normal or near normal visual acuity. Findings such as these have led to the conclusion that losses in differing ranges of the contrast sensitivity curve may be indicative of a particular type of loss, be it of a neurological, retinal pathological or optical origin. For example, a loss in the low spatial range has been shown in some cases of Alzheimer's disease.[24] A mid to high range loss has been found in some

pathological conditions such as macular and retinal disease[25] and a visual loss due to a simple uncorrected refractive error will be more marked in the high frequency range.[26]

The literature reports[16] that in the cases of retinal damage resulting from a whiplash injury there was almost total recovery suggesting that tests to detect such defects will need to be sensitive to minimal dysfunction. Consequently only specialized procedures are capable of detecting such a retinal lesion. Contrast sensitivity testing has been found to be effective in detecting visual dysfunction caused by ocular pathology before any retinal lesion is visible using ophthalmoscopy.[24] There has been no study which has investigated visual acuity and contrast sensitivity in subjects with whiplash injury. Therefore the aims of this study were to test distance visual acuity and contrast sensitivity of a group of whiplash subjects and compare the results with those of a control group of subjects.

Method

Whiplash Subjects

The criteria for subject inclusion in the study were: diagnosed whiplash injury by a physiotherapist or orthopaedic surgeon and no other head injury that would result in neurological damage.

A total of 35 subjects with a whiplash injury were tested in this study. All subjects had sustained a whiplash injury as a result of a motor vehicle accident. All subjects complained of neck pain and 24 of them complained of ocular or visual symptoms (Table 1). Some subjects had more than one symptom. The subjects' ages ranged from 19 years to 79 years. The mean age was 38 years. There were 25 females and 10 males.

Table 1 Symptoms of ocular disturbances reported by subjects in the whiplash group.
N = number of subjects with each disturbance.

Symptoms of visual and ocular disturbances	N
Intermittent blurred vision	15
Photophobia	7
Pain in & around eyes	4
Intermittent double vision	2
Stinging/burning sensation	2
Vision "comes and goes"	2
Print "jumping"	1
Flashes of white light at time of impact	1
"Blind spots" when reading	1
Worried by "things coming close"	1

Control Subjects

Seventy-two subjects participated as the control group for this study. None of the subjects had a history of a neck or whiplash injury. Their ages ranged from 18 years to 62 years. The mean age was 35 years. There were 57 females and 15 males.

Assessment of distance visual acuity

Each subject's distance visual acuity was measured using the Mentor B-Vat Monitor as the stimulus. A uniocular test of visual acuity was performed on each subject. The criterion for correctly reading a particular line of letters was that the subject should make no more than two errors. Normal distance visual acuity was considered to be 6/6 or better.

It was not within the scope of this study to determine whether subjects were tested with their optimal optic correction. Therefore, subjects were tested in their normal viewing situation ie without corrective lenses or with the corrective lenses normally worn for distance viewing. Where subjects presented without corrective lenses, they were tested without them.

Assessment of contrast sensitivity

A uniocular test of contrast sensitivity was performed using the Vistech Contrast Sensitivity Test System (VCTS) 6500 wall chart at three metres. The chart consists of five horizontal rows (A-E). On each row are nine circular sine wave grating patches. The gratings are displayed vertically, or tilted 15f in a clockwise or anti-clockwise direction. Each grating patch in a given row has the same spatial frequency: Row A is 1.5 cycles per degree (cpd); Row B is 3 cpd; Row C is 6 cpd; Row D is 12 cpd, and Row E is 18 cpd. While the spatial frequency per row remains constant, the contrast sensitivity decreases across the rows in 0.12 log unit steps from patch one to patch eight. Patch nine in each row is blank.

Care was taken to ensure that the chart was uniformly lit. The subjects were instructed to report the direction of the stripes on each of the eight patches in rows A to E. The contrast threshold level was recorded as the contrast prior to the first reported blank or incorrect response.

Statistical analysis

A descriptive analysis of the visual acuity results is given. The means and standard deviations were calculated for all contrast sensitivity scores for both the whiplash and control group subjects. T-tests were used to compare the means of the contrast sensitivity scores of the whiplash and control group subjects. The significance level was set at 0.05.

Results

Assessment of distance visual acuity

The right and left distance visual acuity was obtained from 35 whiplash subjects (note that one whiplash subject had vision in only one eye). Corrective lenses for distance viewing were prescribed for 14 (40%) of the whiplash subjects. The range of the optical correction, expressed as the spherical equivalent was from +2.375 D to -6.50 D for the right eye and from +2.75 D to -7.50 D for the left eye. Except for one subject (R. -7.00/+1.00x175; L. -8.00/+1.00x65), the optical correction of all subjects was within the range of the control group.

The right and left visual acuity of 72 control subjects was measured. Corrective lenses were prescribed for 30 (42%) of the subjects. Five subjects (7%) presented without their corrective lenses and were tested without them. Four subjects wore contact lenses. The strength of the lenses was not known.

Therefore, the range of the optical correction, expressed as the spherical equivalent was from +3.50 D to -5.00 D for the right eye and from +3.50 D to -5.75 D for the left eye.

The results of the right and left distance visual acuity testing are shown in Table 2. It can be seen from the table that the percentage of subjects with normal (6/6 or better) visual acuity was greater in the whiplash group than in the control group. Clearly there was no difference between the visual acuity of the right or left eyes of the whiplash group subjects compared with the control group subjects.

Assessment of contrast sensitivity

The contrast sensitivity of the right and left eyes of 35 whiplash and 72 control subjects was assessed (note that one whiplash subject had vision in only one eye).

As can be seen from Table 3 and Figure 1, the mean scores of the whiplash group subjects are consistently below those of the control group subjects. The reduction in contrast sensitivity is particularly evident in the mid to high spatial frequency range (Rows C, D and E) where there was a significant difference.

As with scores from the right eyes, the mean scores of the whiplash group subjects are consistently below those of the control group subjects (Table 4, Figure 2). This is particularly evident in the mid frequency range (Rows C and D) where there was a significant difference.

Discussion

The results of the present investigation showed no significant reduction in distance visual acuity of the whiplash subjects compared to the control group subjects. This finding is in agreement with those authors who considered distance visual acuity to be unaffected by a whiplash injury[10,15,17,18,19] and suggests that distance visual acuity is not significantly disturbed by a whiplash injury.

Contrast sensitivity testing has enabled detection of visual deficits in conditions where traditional visual acuity tests have failed.[27] When considering the results of contrast sensitivity testing, it is important to know that while a diagnosis of specific ocular disorders cannot be made on results of contrast sensitivity testing alone, they may show as an isolated loss of spatial frequency in a particular range.

In this study, there was an overall decrease in the contrast sensitivity curve of the whiplash subjects compared with the control subjects with the loss being most marked in the mid frequency range of the whiplash subjects which was statistically significant. These findings may be indicative of subtle retinal pathology.

Daily[13,14] and Kelley et al.[16] reported three cases who following whiplash injury had retinal/vitreous disturbance resulting in reduced distance visual acuity (ie less than 6/6). A vitreous abnormality was observed by Daily[13] in one case and Kelley et al.[16] described 2 cases with subtle retinal changes associated with reduced distance visual acuity. The

Table 2 Right and left distance visual acuity of whiplash and control subjects. N = the total number of subjects in a specific group.

Visual Acuity	whiplash subjects N=35 (100%)	control subjects N=72 (100%)	whiplash subjects N=34 (100%)	control subjects N=72 (100%)
6/4.5	13(37%)	31(43%)	11(32%)	27(37.5%)
6/6	14(40%)	27(37.5%)	16(47%)	30(42%)
6/75	4(11%)	5(7%)	4(12%)	5(7%)
6/9	2(6%)	3(43%)	1(3%)	6(83%)
6/10	2(6%)	0	0	1(13%)
6/12	0	1(13%)	1(3%)	0
6/15	0	1(13%)	0	1(13%)
6/20	0	1(13%)	1(3%)	0
6/24	0	0	0	1(13%)
6/30	0	1(13%)	0	1(13%)
6/60	0	2(3%)	0	0

Table 3. Means, standard deviations and p values of the contrast sensitivity scores of the right eyes of the whiplash and control subjects. * significant difference

Row	RE Mean (SD) cpd	RE Mean (SD) cpd	
A	5.40 (± 0.81)	5.75 (±0.8884)	0.051
B	6.00 (± 0.84)	6.29 (±0.99)	0.140
C	5.00 (± 1.11)	5.56 (±1.43)	0.046*
D	4.27 (± 1.60)	5.13 (±1.68)	0.012*
E	3.11 (± 1.75)	4.04 (±1.92)	0.018*

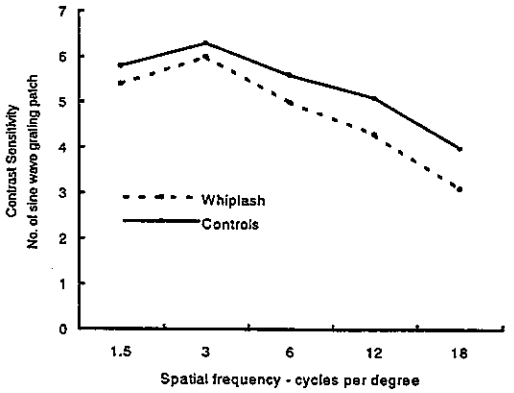

Fig. 1 Mean values of contrast sensitivity for each spatial frequency of the right eye of each subject in the whiplash and the control groups.

Table 4. Means, standard deviations and p values of the contrast sensitivity of the left eyes of the whiplash and control subjects. * significant difference

	Whiplash	Control	
Row	Mean (SD)	Mean (SD)	P values
A	5.53 (± 0.75)	5.67 (± 0.81)	0.4041
B	6.03 (± 0.63)	6.29 (± 0.88)	0.1217
C	5.00 (± 1.02)	5.71 (± 1.23)	0.0042*
D	4.27 (± 1.56)	5.00 (± 1.67)	0.0325*
E	3.24 (± 1.62)	3.82 (± 1.75)	

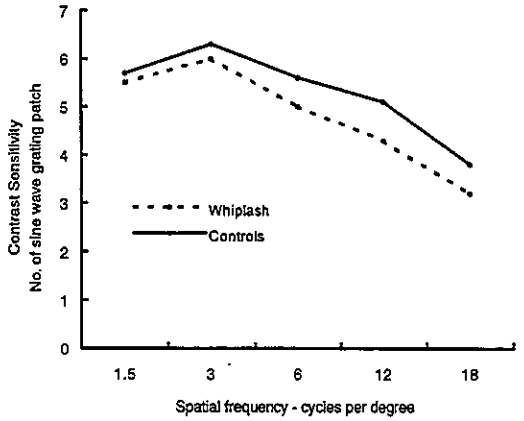

Figure. 2 Mean values of contrast sensitivity for each spatial frequency of the left eye of each subject in the whiplash and the control groups.

visual acuity improved in all cases to normal (6/6) within two weeks, while the retinal abnormalities remained observable. These authors hypothesized that the force of the whiplash caused traction on the macula by the vitreous creating a foveal pit[16] or that the lesion was the result of ocular and cranial concussion.[13]

If the retinal damage caused the reduced contrast sensitivity in this series, it might be expected that the damage might be uniocular or that there might be and inter-ocular difference as was the case in the majority subjects in this small series. In seven cases there was no reduction of contrast sensitivity. Of the 28 subjects with reduced contrast sensitivity, there was a difference between the eyes in 22 subjects (72%). Of these 22 subjects nine subjects had contrast sensitivity which was normal in one eye but reduced in the other eye, and in 19 subjects there was a reduction in both eyes with one eye being more effected than the other in 13 subjects.

This series differs from those of Daily[13] and Kelley et al[16] as all subjects in this study were tested months after the accident, and only 16 subjects had had a fundal examination. It is therefore not known if any of these subjects resembled those described by Daily[13] and Kelley and co-workers.[16]

However, it could be hypothesised that the force of the whiplash caused either vitreous or retinal damage that resolved sufficiently for the fundus to be judged as normal, in those examined, leaving a sub-clinical deficit which can only be detected by a sensitive test such as contrast sensitivity. As all subjects had normal visual acuity, it could be argued that the deficit was not of an optical nature. However without more detailed testing eg electro-retinogram (ERG) it is not possible to make a definitive diagnosis.

While it is not possible to specifically identify the reduction in the contrast sensitivity without more detailed testing, these results do indicate that an aspect of visual function (contrast sensitivity) was effected by whiplash injury. This finding may help to explain some of the visual disturbances reported by some whiplash suffers which until now have not be detected by a test of visual acuity.

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