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THE COMPUTERISED VISUAL FIELD: THE COMPLEXITIES OF ITS ANALYSIS. A LITERATURE REVIEW

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Abstract

Computerised perimetry has revolutionised the examination of the visual field by its ability to provide reproducible quantitative threshold measurements of the "hill of vision". There is a growing body of research describing the complexities of obtaining these precise measurements and interpreting the information obtained in the computerised visual field printout. This report aims to extend the orthoptist's knowledge of how to interpret the computerised field printout. It presents an overview of current research, describing the factors that cause variation in threshold measurement, and methods that can be used to determine the presence or absence of visual field defects. Clinical examples using the Humphrey Visual Field Analyser are included to demonstrate important concepts.

Key words: *Automated perimetry, variability, visual threshold, visual field, glaucoma.*

INTRODUCTION

The development of computerised perimetry has made it possible to obtain quantitative static threshold measurements of the visual threshold at different points across the visual field. This has provided many avenues for data analysis and comparison of visual thresholds both between subjects and over time, and consequently has made a major impact on the detection of diseases affecting the visual pathway, primarily glaucoma.

There has also been a growing awareness that variability of these threshold measurements may occur as a result of the testing procedure and be independent of the disease process. Therefore considerable research has been directed towards describing the complexities of measuring visual threshold and factors that influence the interpretation of results for normal, ocular hypertensive and glaucoma subjects.

The aim of this report is to draw together the conclusions and suggestions made by researchers regarding:

1. Factors that contribute to variation of results,
2. Identification of abnormal from normal field results,
3. Classification of visual defects identified by static perimetry,
4. Limitation of statistical global indices.

Differential Light Threshold

Before considering the complexities of interpretation of computerised visual fields, it is necessary to consider the basic principle of static perimetry: the differential light threshold (DLT).

The ability of a subject to see a stimulus depends on the luminance, duration and size of the stimulus, and the background illumination. Flammer, Drance and Zulauf[1] define the DLT

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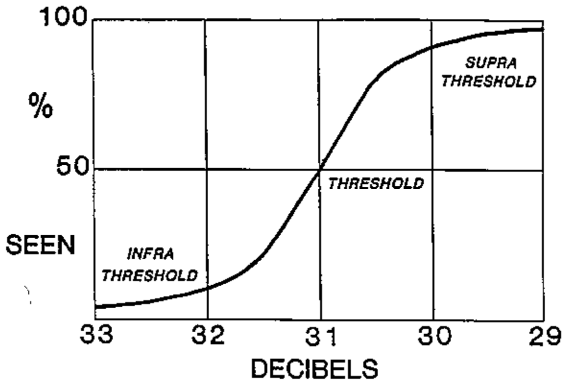


Figure 1: Probability of seeing curve.

as "that light stimulus that can be recognised above the background with a probability of 50% in a given retinal location". Therefore the threshold levels on the printout represent the 50% point on the "probability of seeing curve" (Figure 1). This graph represents the curve between the stimulus rarely seen (ie slightly brighter than infrathreshold) and the stimulus almost always seen (ie barely dimmer than suprathreshold).

1. VARIABILITY OF VISUAL FIELD RESULTS

Automated visual field testing will always give rise to some variability of results during the test and from one test to another. A knowledge of factors contributing to this variation helps in the ability to control them and interpret the visual field printout.

Werner, Adelson and Krupin[2] consider that variability may be either nonrandom or random.

Nonrandom Variability

These are external factors and include pupil size, uncorrected refractive error, cataracts and actual progression of the visual field defect. If the first three are identified, they can be controlled when performing the test and considered when analysing the field results.

(a) Pupils: Small pupils have a greater effect on static perimetry than kinetic perimetry. Pupils less than 3 mm cause an apparent constriction in the field. It is recommended that miotic pupils be dilated to greater than 3.5 mm, and that repeat field examinations be performed with the same sized pupil.

(b) Uncorrected refractive error: This has the largest effect on threshold values within 10°, and even as low as 1.00 dioptre miscorrection can effect threshold values.[3] The effect of correcting versus not correcting moderate to large astigmatic errors has not yet been evaluated.

(c) Cataract: This causes a overall depression of the threshold values across the field and can be detected by examining the statistical analysis.

Random Variability

This occurs as a result of the actual testing process and nature of the visual system and generally cannot be controlled by the operator. Factors include performance effects such as patient reliability and the learning effect, and fluctuations both during the test and between tests.

(a) Performance Effects

(i) Patient Reliability

The "reliability" of the visual field test is measured by most automated perimeters. The Humphrey Visual Field Analyser (HVFA) tests fixation losses (FL), false positive (FP) and false negative (FN) responses and subjects with >33% FN or FP, or >20% FL are labelled unreliable.

Katz and Sommer[4,5] studied these statistics in normal, ocular hypertensive and glaucoma subjects. Normal subjects with >33% FN had an average 7dB depression when compared with normal subjects with low FN rates. Glaucoma subjects with a high FN rate had an average 9dB depression of the visual field results, when compared with glaucoma subjects with low FN rates. They also found that glaucoma subjects have a higher incidence of FN errors and suggest that the increased FN rate in glaucoma subjects may not be due to patient attention, rather increased visual fatigue associated with the disease.

The defects shown on the field printout of subjects with high FN errors were mostly in the superior nasal and nearby arcuate area, and the results of unreliable normal subjects looked identical to those of reliable glaucoma subjects.

The incidence of fixation losses also affects the final interpretation of visual fields. Katz and Sommer[5] found that when glaucoma subjects with previously identified field loss were reassessed with computerised field testing; those with poor fixation (>20%) showed less depressed fields and fewer localised defects were localised. The HVFA assesses fixation by presenting a stimulus in the blindspot, if the subject responds a fixation loss is recorded regardless of whether there was an actual loss of fixation. In fact Sanabria, Feuer and Anderson[6] found that nearly half of the recorded fixation losses were due to artifacts in the testing procedure and could be easily minimised by the operator taking corrective measures early in the testing procedure. The main artifact found by these researchers occurred when the blind spot of the eye being tested was not located where the stimulus was presented. They suggest that the perimetrist closely observe the beginning of the test and correct the location of the blindspot before more than two losses of fixation are recorded.

When considering the sensitivity (identification of abnormal fields as abnormal) and specificity (identification of normal fields as normal) of automated perimetry, Sommer[7] found that the HVFA Statpac analysis of results is highly influenced by reliability measures. For a reliable subject the field results have a sensitivity of 98% and specificity of 93%, but for the unreliable subject the sensitivity drops to 86% and specificity maybe as low as 52%. Therefore for the unreliable patient Statpac analysis will classify a large number of normal fields as being abnormal.

(ii) Learning Effect

This is an artifact demonstrated in computerised fields where improvement in threshold values occurs as a result of experience with the testing procedure. Fields of inexperienced subjects are characterised by concentric narrowing of the field. Figure 2a shows the visual field printout of a subject's initial test result showing generalised constriction of the visual field. Figure 2b is the same subject's field performed 10 months later.

Several researchers have examined this effect in normal, ocular hypertensive and glaucoma subjects.[2,8-11] Heijl, Lindgren and Olsen[10] found that normal subjects show a minimal learning effect, only 1-2 dB, and a similar finding was made by Werner[2,11,12] for glaucoma and ocular hypertensive subjects. Most of the improvement occurs in the mid-periphery, points near fixation remaining stable.

(b) Fluctuation

Due to the nature of the DLT, methods used to measure it, and the fact that perimetry is a subjective test, the visual field results obtained by computerised perimeters will always show variability. When this occurs during one field test it is termed short-term fluctuation (STF), and from one field test to another long-term fluctuation (LTF).

(i) Short-term Fluctuation

Two components of STF need to be considered: local and global STF. Local fluctuation refers to the threshold variability that occurs at each discrete visual field location (noted on the HVFA by comparing the threshold values in brackets). Werner and Drance[12] demonstrated that in the fields of glaucoma suspects points in the visual field showing local STF subsequently developed field loss.

Global fluctuation is computed as the root mean square of fluctuation across the whole field. Research by Flammer, Drance, Fankhauser and Augustiny[13] shows that this global STF varies between patients and is not affected by age, reaction time or pupil size.

(ii) Long-term Fluctuation

Since glaucomatous field changes occur over a period of months and years it is important to determine if changes recorded are due to LTF or actual field change. If considering the visual field as a "island of vision", Lieberman and Drake[14] suggest the analogy of LTF representing strong winds blowing across an island that is planted with wheat, where the overall contours remain the same but will vary from one point in time to another.

Katz and Sommer[15] studied LTF in normal

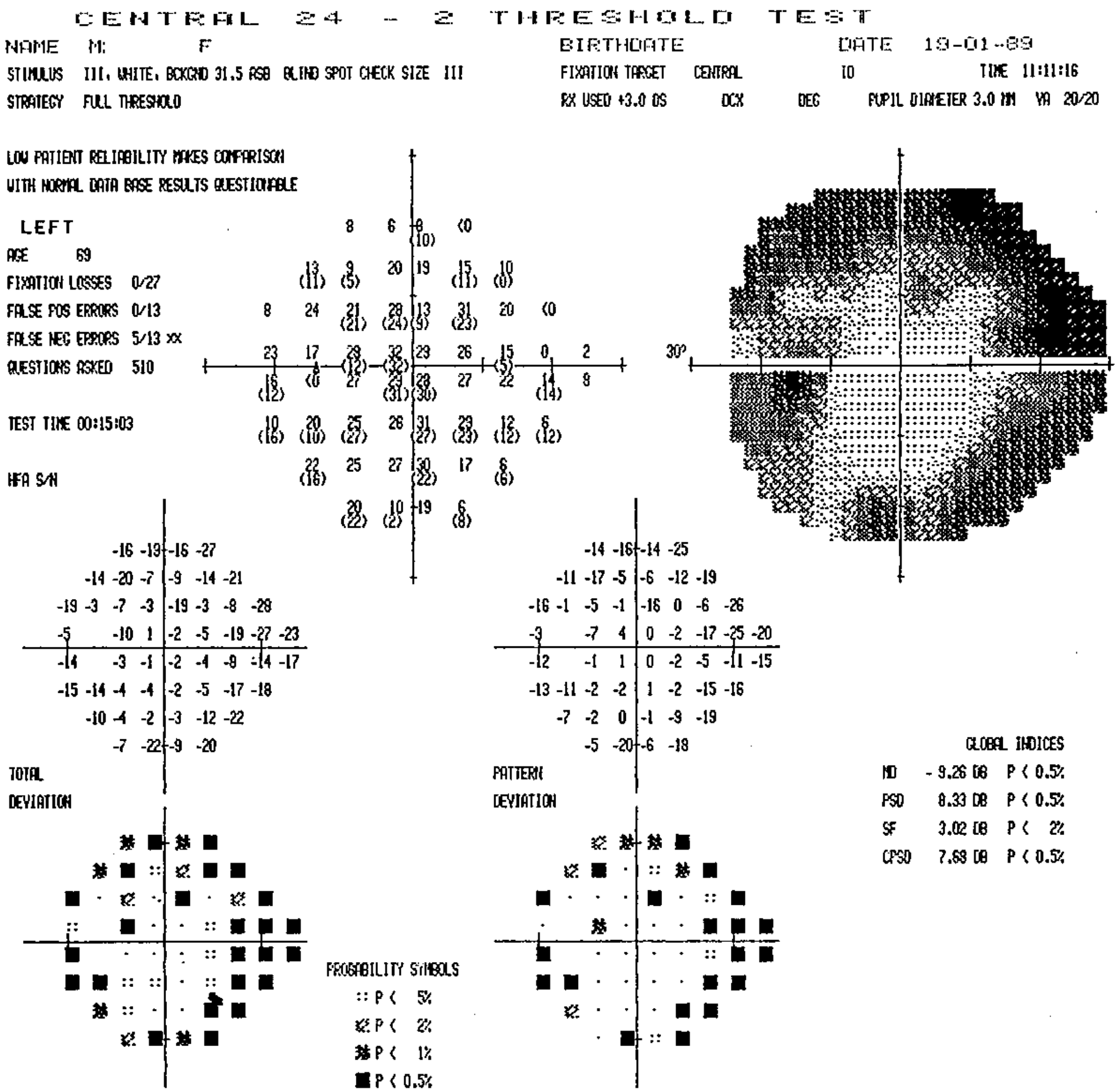


Figure 2a.

subjects three times over a period of one to two years and found that the average variation was 3.3 dB. They also found that LTF varies with the patient's age and location in the visual field. For subjects under 60 years it varies by an average 1.9 dB, whereas for subjects over 60 years this variation was 4.8 dB. Areas of greatest variability were in the superior field between 20 and 30°.

Heijl, Lindgren and Lindgren[16] examined LTF in glaucoma subjects and found that the normal areas of the field had the least LTF and abnormal areas the greatest variation, sometimes up to 16 dB difference in threshold value being recorded from one test to another occurring by pure chance. They conclude that caution is needed before interpreting localised threshold changes between two tests as a sign of visual field progression. Both the defect depth and point location needs to be considered when looking for

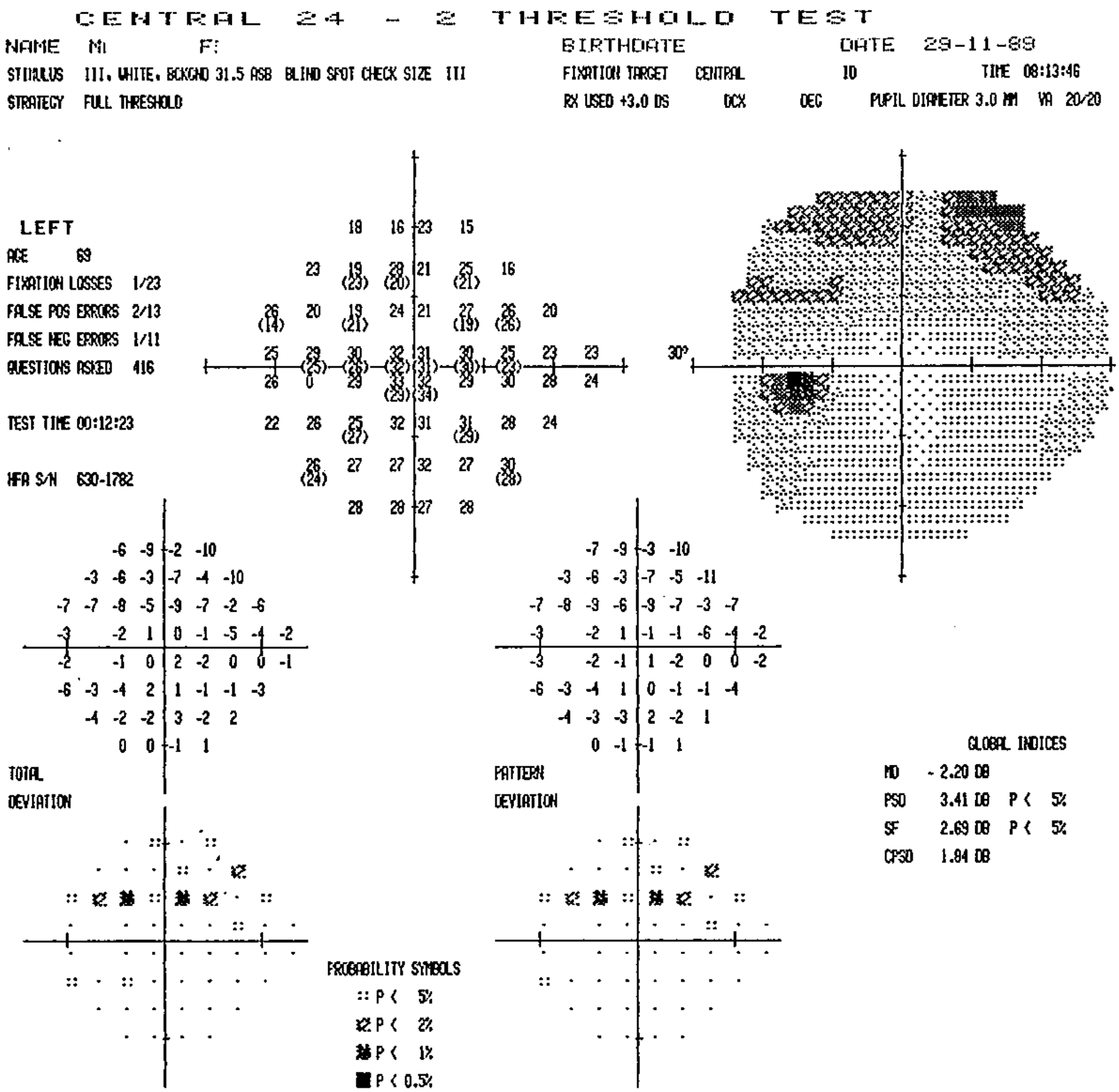


Figure 2b.

field changes and the sum total of variation across a series of fields should be zero. Figure 3 shows a series of six visual field results with large LTF of several threshold points (circled). Despite these variations of individual points from one field to the next, the overall change in the visual field is minimal.

2. *IDENTIFYING ABNORMAL FIELDS FROM NORMAL FIELDS*

What is normal?

A prerequisite of recognising a pathological visual field loss is a knowledge of normal values. Manufacturers of automated perimeters have spent a great deal of time collecting data on a

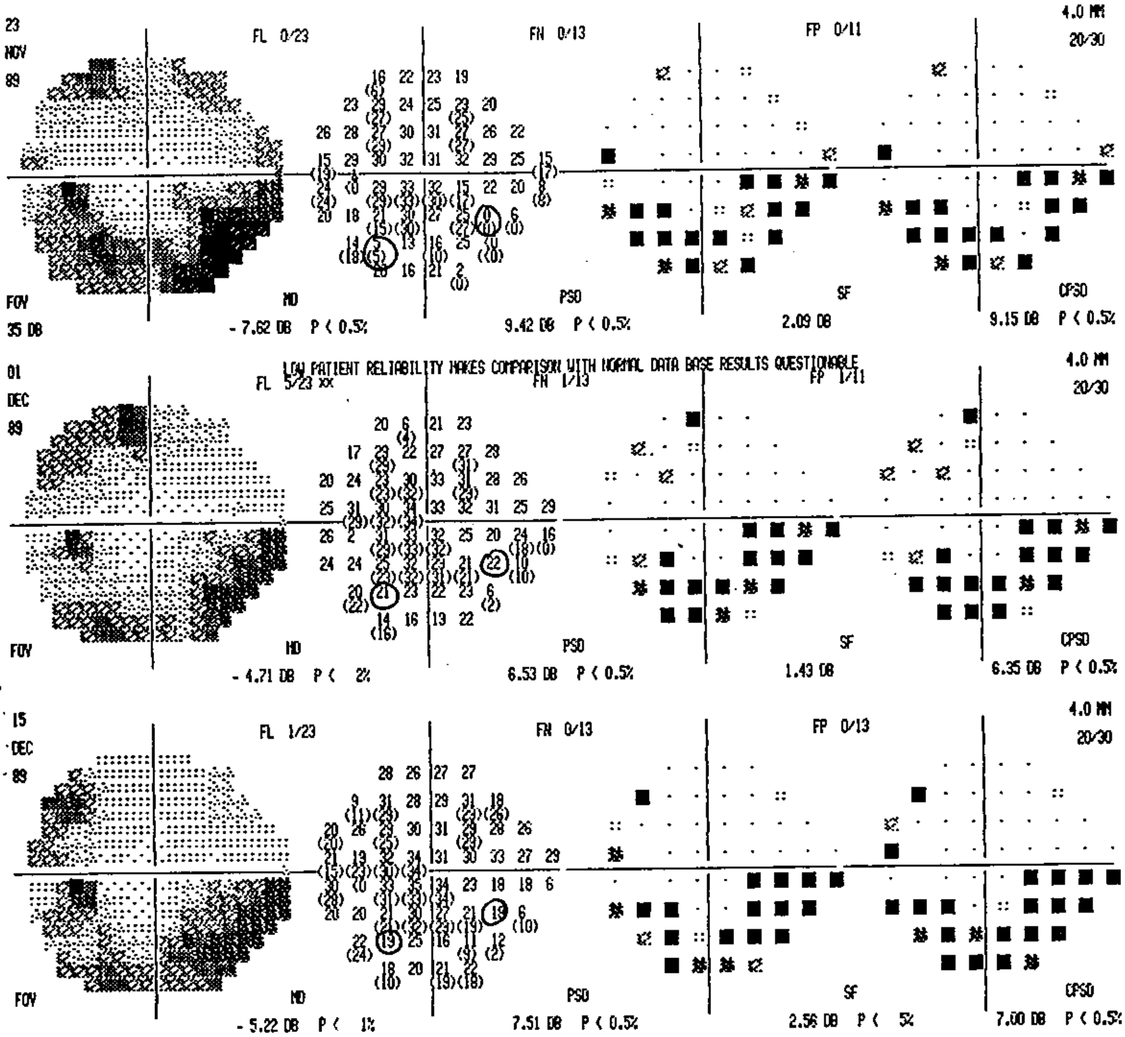


Figure 3.

wide age range of subjects. However, due to the variability of perimetric thresholds described above the differentiation of normality from abnormality is far from easy.[17] For this reason other techniques of analysing data are becoming available such as mirror image analysis[18] (where points in the superior half of the field are grouped and compared to corresponding groups in the inferior half of the field), and comparison of a patient's present field with their own previously defined values.[19]

Haas, Flammer and Schreider[20] and Jaffe, Alvarado and Juster[21] have studied the influence of age on the visual field of normal subjects. In kinetic perimetry age changes are seen as a reduction in size of isoptres. For static perimetry the DLT reduces in sensitivity throughout life by approximately 0.58 dB per decade, with the upper half of the field being more affected. The central points and area at 30° are also more affected, with the rate of decline at 30° being twice as much as at fixation. Jaffe et al consider

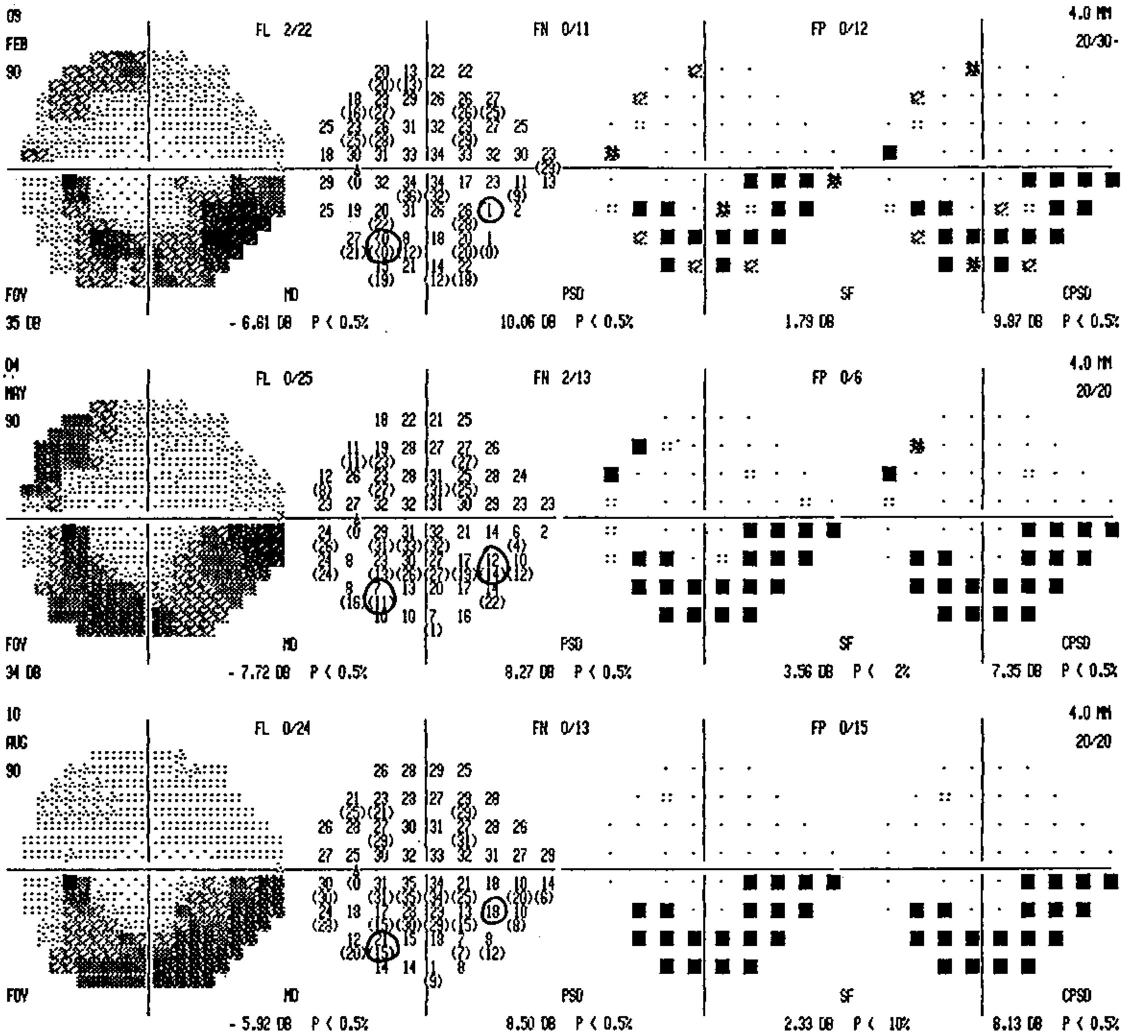


Figure 3 continued.

this to be due to a functional or anatomical loss of photoreceptors, ganglion cells and higher structures.

3. CLASSIFICATION OF VISUAL FIELD DEFECTS IDENTIFIED BY STATIC PERIMETRY

Although the classification of visual field defects can become daunting, Lieberman and Drake[14] suggest grouping them into diffuse depressions and localised defects.

Diffuse Depressions

This refers to a generalised depression of the DLT across the whole visual field, but with the contour of the visual field closely matching the contour of the normal visual field. Diffuse depressions are characterised on the HVFA by a depressed total deviation plot and normal pattern deviation plot, and a reduced Mean Deviation index but normal Pattern Standard Deviation value.

Reasons for diffuse loss include cataract,

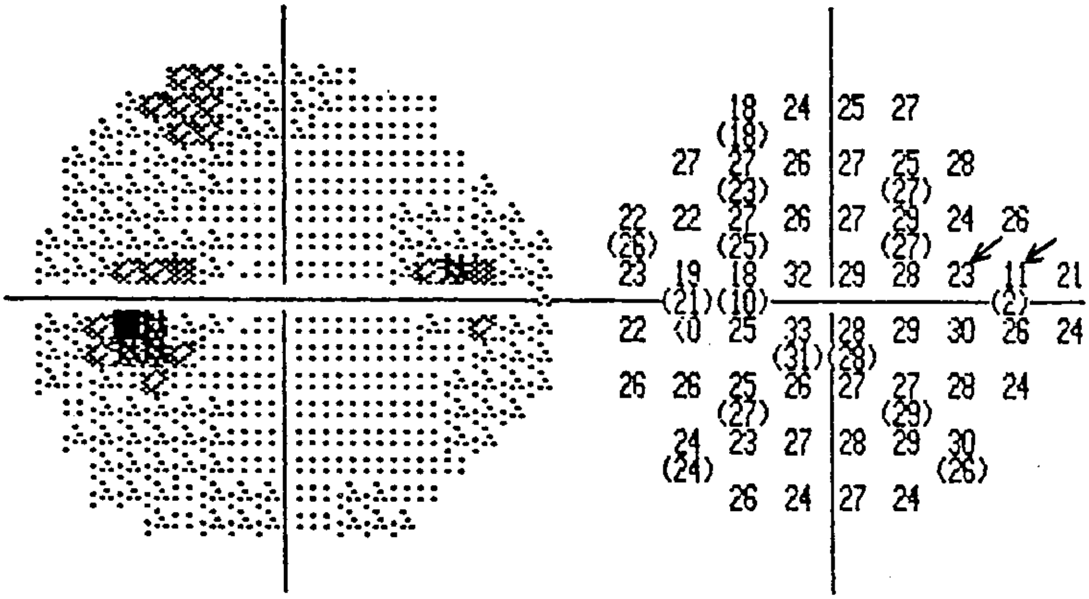


Figure 4. Localised depression.

uncorrected refractive error and, rather more controversial, a sign of early pathology of glaucoma damage.[22]

Localised Depressions

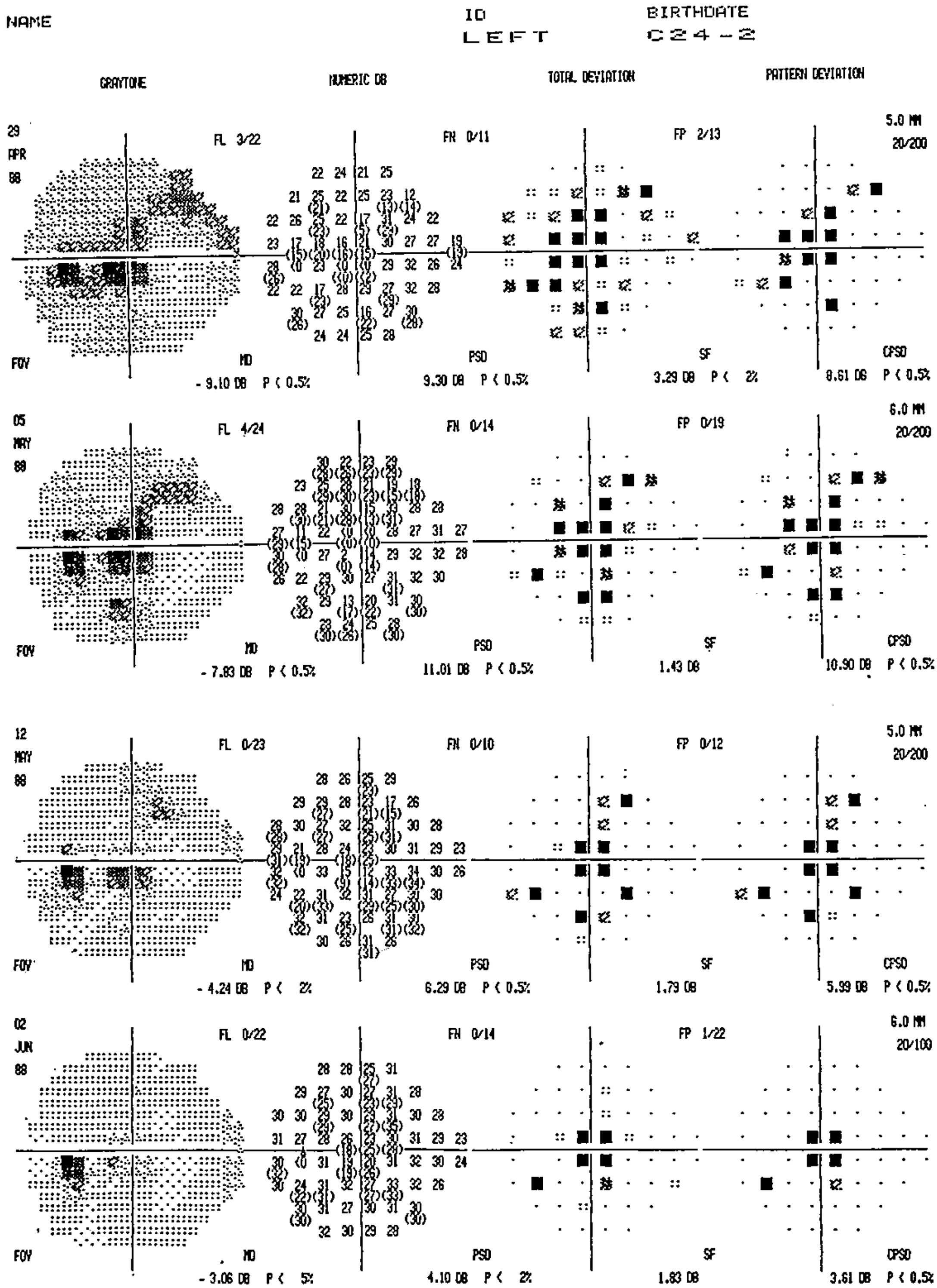
These defects are limited to small areas of the visual field and the use of static testing has increased their detection. However, in order to determine that a localised depression is in fact a field defect and not just due to variability of the DLT Heijl[23] and Lieberman and Drake[14] suggest considering the following:

- the location of the depressed point: if in the superior field beyond 20° it is likely to be a false positive,
- the sensitivity of the neighbouring points surrounding the depression: local STF suggests that isolated depressed points will occur randomly across the visual field. However, two points slightly depressed and adjacent to each other are more likely to be an actual localised depression,
- large localised fluctuation: this may be due to the fact that the visual system is weakened and is not able to produce a consistent response. If an area of increased fluctuation is adjacent to a depressed point then this further suggests an actual field defect (see Figure 4).

4. LIMITATIONS OF STATISTICAL GLOBAL INDICES

Global indices attempt to describe the visual field by a mathematical statement of probability. In the case of HVFA the Mean Deviation (MD) index estimates the uniform part of the field and the Pattern Standard Deviation (PSD) index estimates the irregular, non-uniform part of the visual field. Irregular visual fields with localised defects increase the PSD. On the other hand the MD can be reduced by both diffuse and localised field loss.[24] Unfortunately the global indices do not take into consideration the important information about the position of the depression that is needed to differentiate abnormal from normal variation in results.

For example, Figure 5 shows a sequence of four fields. The mean deviation in the first two fields is misleading as it indicates an overall improvement in the second field. However, on


NAME
ID
LEFT
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C24-2
GRAYTONE
NUMERIC DB
TOTAL DEVIATION
PATTERN DEVIATION
29 APR 88
FL 3/22
FN 0/11
FP 2/13
5.0 MM
20/200
FOV
MD
- 9.10 DB P < 0.5%
PSD
9.30 DB P < 0.5%
SF
3.29 DB P < 2%
CPSD
8.61 DB P < 0.5%
05 MAY 88
FL 4/24
FN 0/14
FP 0/19
6.0 MM
20/200
FOV
MD
- 7.83 DB P < 0.5%
PSD
11.01 DB P < 0.5%
SF
1.43 DB
CPSD
10.90 DB P < 0.5%
12 MAY 88
FL 0/23
FN 0/10
FP 0/12
5.0 MM
20/200
FOV
MD
- 4.24 DB P < 2%
PSD
6.29 DB P < 0.5%
SF
1.79 DB
CPSD
5.99 DB P < 0.5%
02 JUN 88
FL 0/22
FN 0/14
FP 1/22
6.0 MM
20/100
FOV
MD
- 3.06 DB P < 5%
PSD
4.10 DB P < 2%
SF
1.83 DB
CPSD
3.61 DB P < 0.5%

Figure 5:

examining the central threshold values it can be seen that they have in fact become worse, the improvement in mean deviation suggesting a performance effect where learning has occurred and points beyond 20° have improved. In these examples the Total Deviation and Pattern Deviation plots in the last field better highlight the central depression and aid in the field's interpretation.

CONCLUSION

Although computers are now responsible for performing much of the visual field test, the orthoptist plays an important role both before, during and after the test. Understanding the factors that influence the reliability and reproducibility of results is required in setting up the patient and during the testing sequence. Knowledge of the meaning of threshold values, statistical data and normal variation needs to be combined with information about the disease process, associated visual field defects and patient clinical data. Only when all have been considered can the field results be adequately interpreted and related to the management plan for each patient.

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RETINAL PHOTOGRAPHIC GRADING: THE ORTHOPTIC PICTURE

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Abstract

Signs of the major retinal causes of blindness in Australia are readily identified from stereoscopic fundus photographs. This study involved the masked grading of 922 photographic slide sets which included 400 cases of advanced Age-related Macular Degeneration (AMD) and a similar number of age and sex-matched controls.

Photographic colour slides of the retina showing AMD lesions, including drusen (size, number and confluence), focal pigment, geographic atrophy and neovascular disease, were graded individually by an ophthalmologist, orthoptist and a nurse using the protocol set by the Waterman Chesapeake Bay study. These grades were then used to define four categories of AMD severity.

Kappa statistics were generated from the data to show inter-observer variability between the ophthalmologist and orthoptist and the orthoptist and nurse. The resulting high level of agreement in all areas graded (between 0.45 . . . 0.83) indicated that the orthoptist compares favourably to the ophthalmologist and the nurse in grading expertise.

Orthoptic involvement in this area of ophthalmic research opens new spheres of interest and professional development.

Key words: *AMD, Grading, Fundus photographs, kappa, inter-observer variability.*

INTRODUCTION

Masked grading, that is grading which obscures other subject characteristics, is becoming standard in modern clinical trials throughout the world. Many present studies in ophthalmology, as well as many planned studies, utilise non-ophthalmological staff to grade lesions of the eye. This has the effect of reducing observer bias of the investigating party.

This paper gives some insight into how two non-ophthalmologists, an orthoptist and a nurse, were trained in the grading of retinal lesions. It attempts to address the viability of using non-ophthalmologists in studies of this and similar types by comparing the inter-observer variability between an orthoptist and ophthalmologist. Kappa statistics were also calculated between the orthoptist and nurse comparing the results to a similar study done in Beaver Dam U.S.A.[1]

Age related macular degeneration is the most common blinding disease of the elderly community in Australia. Up to 55% of registrations for the blind pension now have vision loss attributable to AMD.[2] In 80% of cases, where blindness is attributable to AMD, a haemorrhagic lesion appears which then passes through the stages of fibrosis and atrophy. This is termed a disciform lesion or "wet" AMD. The other

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20% of AMD presentations are entirely atrophic and can be termed as geographic atrophy or "dry" AMD.[3] Early AMD lesions that precede these blinding stages include the presence of drusen and other abnormalities of the retinal pigment epithelium in the macular region.[4] The aetiology and pathogenesis of AMD is poorly understood.[3]

Grading standards in this study were based on the AMD protocol of the Waterman Chesapeake Bay study.[5] This involved grading lesions of the fundus which may be related to AMD. These included drusen characteristics such as type and size, drusen confluence and the space they occupied, focal hyperpigmentation, geographic atrophy and non-geographic atrophy. Neovascular and non-neovascular lesions, as well as any other fundal anomalies, were noted and classified as per the protocol.

MATERIALS AND METHODS

Nine hundred and twenty two photographic slide sets from the Newcastle AMD case control study[6] were randomly selected for grading. These included 400 cases of advanced AMD and a similar number of age and sex-matched controls selected from the Newcastle age-restricted electoral roll.

The involvement of the orthoptist and the nurse in the grading process was as follows.

(i) Establishment of a slide grading centre

A slide grading centre was established within Westmead Hospital where slide grading, computer entry of data and storage of slides and sheets occurred.

(ii) Training

Grader training took place over a two month period. This involved attending ophthalmology registrar training lectures and many hours of tutoring in retinal disease. Training was performed by Associate Professor Paul Mitchell at Westmead Hospital who acted as an adjudicator throughout the grading process. Experience was gained with the grader training programme of the "Beaver Dam Eye Study" that took place in Wisconsin U.S.A.[1]

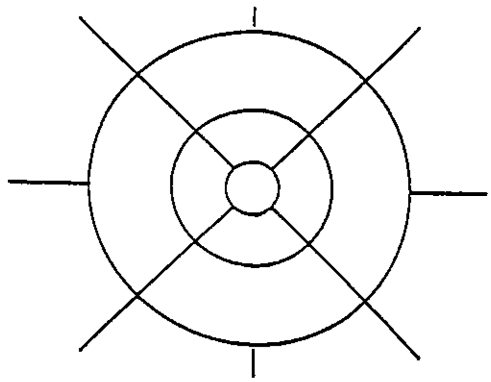


Figure 1: The grid which centred onto the slide by aligning the lines at 12 and 3 o'clock

(iii) Assembling the required materials

Before any grading could be carried out the following materials were needed:

(a) Viewing Box

This had Kelvin rating of 6200° which is bluer than daylight. The Wisconsin Age-Related Maculopathy grading system states that "light of a lesser rating emits a yellowish hue that makes it difficult to define more subtle drusen".[1] Placement of grids and the grading process was carried out on this box.

(b) Slide mounting sheets

These allowed the placement of stereoscopically paired slides ready for viewing.

(c) Viewer

Accurate placement of the grid and all grading was performed using a Donaldson viewer, which provides 5× magnification which combined with the camera's 3× totalled some 15× magnification.

(d) Gridding templates

Consisted of three concentric circles, which were supplied by Professor R. Klein, Wisconsin U.S.A. (Fig. 1). The gridding circles had diameters of 1000 μm, 3000 μm and 6000 μm. The two inner most circles represented the central zone and the space between the 3000 μm and 6000 μm circles represented the pericentral zone. The grid also contained two diagonal lines which divided each zone into segments.

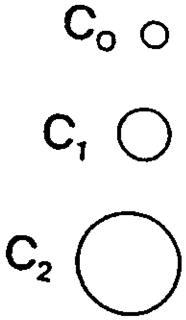


Figure 2: The measuring tool which was used to determine drusen size.
Circle C_0 represents 63 μm
Circle C_1 represents 125 μm
Circle C_2 represents 250 μm

(e) Measuring tool template

These consisted of three concentric circles, varying in size (as specified by the protocol), superimposed on transparent sheeting (Fig 2). These are introduced between the slide and the Donaldson viewer by the grader in order to measure the various characteristics found.

(f) Grading forms

The recording form is based on the Waterman Chesapeake Bay study grading sheet template. This form has identifying information, eye graded, photographic quality and sections that list specific grading characteristics.

(iv) Pre-Grading

Prior to grading, a grid was placed on one of the stereoscopically paired slides (usually the left slide). The grid was then centred on the fovea using lines at 12 o'clock and 6 o'clock as positioning tools. Finally the grid was secured to the cardboard mount of the slide using sticky tape and placed back into the mounting sheet ready for grading.

(v) Grading

The following characteristics were assessed when grading:

(1) Photo and Stereo Quality. These were graded as adequate, fair, poor or missing. Poor photo and/or stereo quality were often caused by opacity present in the media of the eye (eg cataract, corneal disease or asteroid hyalosis). If the photo was graded as poor this automatically precluded the slide from further grading poor Stereo quality, however, did not preclude the eye from grading but was noted if no stereo view could be attained (eg. missing slide).

(2) Neovascular disease. All neovascular diseases were identified and categorised into the following types.

Disciform lesions

These consist of subretinal elevation beneath or adjacent to the fovea, surrounded by an area of serous retinal detachment. The lesion is usually associated with a subretinal haemorrhage. It is common for exudates to appear around the margins of the serous detachment and in late stage disciforms massive exudation and fibrosis is prominent.[7]

The disciform lesions were classified into categories of:

(a) Haemorrhagic
(b) Fibrous
(c) Atrophic
(d) Treated
(e) unclassified.

Retinal pigment epithelium detachment (RPE)

Fluid collects beneath the RPE and Bruch's membrane to form a localised detachment. It appears as a well demarcated elevation in the macular area and can be distinguished from serous elevation due to this more defined appearance.[7] Any detachment of the RPE, with or without serous elevation, precluded the eye from further grading.

These diseases precluded grading of other characteristics.

(3) Drusen

Drusen are areas of amorphic, non cellular material that lie between Bruch's membrane and the retinal pigment epithelium layer. They are commonly found around the macular region and vary in appearance from fine granular deposits to large confluent areas of deposition.[8] Drusen may be defined as hard, soft, calcific or reticular.[9]

In this study drusen number, size, percentage of grid occupied and confluence were graded regardless of type. Grading of lesions were divided into two zones, central and pericentral.

The options — none, questionable, can't decide and can't grade were available in this section as well as all other sections covered in the grading.

(a) Number

In each zone the amount of drusen present (if seen to be as prominent as determined by the protocol) were classified into the following categories:

(i) 1-4 present
(ii) 5-19 present
(iii) ≥20 present.

(b) Size

Drusen size was measured using a measuring tool consisting of circles of varying sizes. These circles were labelled as follows:

C_0 = circles that measured any drusen ≤ 63 μm
C_1 = circles that measured any drusen 64-124 μm any drusen greater than C_1 was categorised as ≥ 125 μm

The measuring tool was placed over the largest drusen in each zone. The size findings were then categorised as above.

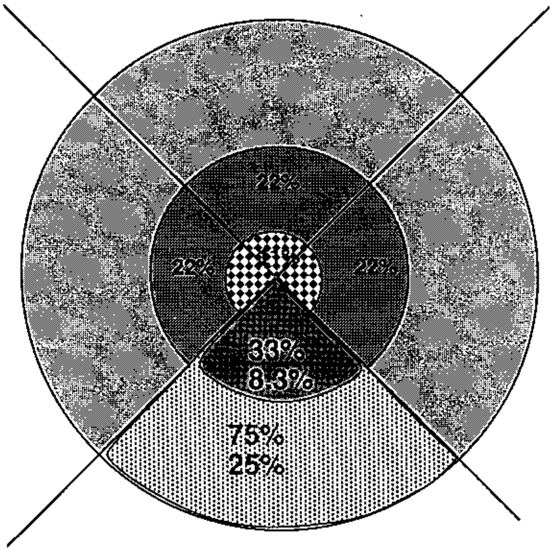
(c) Percentage of area covered

If drusen size was greater than 63 μm (considered large drusen) a measurement was performed by estimating the percentage of each zone covered by large drusen. These were recorded as follows:

(a) not applicable i.e. drusen size ≤ 64 μm
(b) ≤10%
(c) 11-33%
(d) 34-67%
(e) >67%.

A graph representing the gridding circles was created and allowed quick reference to percentage of area covered. (see Fig 3) This graph was quickly devised by using the formula πr^2 (area of a circle), then dividing the area into appropriate segments as displayed on the grid.

All areas of geographic atrophy and non geographic atrophy (RPE disease) were excluded



Central circle is 3.7% of pericentral zone and
11% of central zone = one central circle
33% of central zone = one 22% pie + central circle
67% of central zone = three 22% pie sectors.
11% of pericentral zone = 3 whole central circles
33% of pericentral zone = whole of central zone
67% of pericentral zone = 2 whole central zones

Figure 3: The gridded area of the slide was broken up into areas (shown here as percentages) by using the formula πr^2.

from the area ie. were thought of as non diseased retina. Areas of reticular drusen were included in the area covered.

(d) Confluence of pairs (>63 μm)

Confluence is defined as a merging or touching of two of more drusen.[1] Only drusen of size 64 μm or more are graded in this category. Any druse that had become confluent were counted and recorded as being <or> 10 pairs.

(4) Focal Hyperpigmentation

These are areas where excessive pigment has been generated. This phenomenon is common in AMD and is associated with RPE disturbances.[8] Any areas where pigment was exuded from the RPE layer were noted and recorded as being either less than or greater than or equal to the standard.

Care was taken to distinguish fine pigment deposits from dirt on the slide or mounting sheet.

(5) Geographic Atrophy
This is an area of well demarcated drop out of the RPE, or complete depigmentation of the RPE, exposing the large choroidal vessels.[9] The area often appears as would a country on a map. Grading consisted as being less than or greater than/equal to the standard. If the geographic atrophy (GA) was greater than 50% of the circles then the slide was precluded from grading other anomalies.

(6) Non-Geographic Atrophy (RPE Degeneration)
Faded drusen often contribute to marked depigmentation of the retina leaving areas that are ill defined but still not advanced enough to see the choroidal layer through them.[9] These are termed as areas of non geographic atrophy (non GA). Again these areas were graded as being less than or greater than/equal to the standard.

(7) Other Macular/Retinal Disease
Any lesions of the retina that did not fit into the categories defined above were noted. Disease such as arteriolar opacity, vein or artery occlusions, micro-aneurysms, haemorrhage or premacular fibrosis were some of the more often encountered lesions.

Data Collection/Calculation and Storage
Information from the slides were recorded onto the grading form and then entered into a computer using a multi-relational data base. Upon entry into the data base, automatic AMD grades were calculated. These grades were developed by Bressler and Taylor and have been used in the Chesapeake Bay Waterman study.[3]

TABLE 1
Kappa Scores of Inter-observer Variability between the Orthoptist and Ophthalmologist (n = 65)

Variable	Kappa
Neovascular disease	0.727
Drusen number	0.618
Drusen size	0.453
Focal Hyperpigmentation	0.624
Geographic Atrophy	1.000
AMD Grade	0.578

Key to Cohen Kappa Statistic
>0.75 = strong agreement
0.40-0.74 = fair to very good agreement
<0.40 = poor agreement

TABLE 2
Kappa Scores of Inter-observer Variability between the Orthoptist and the Nurse (n = 922)

Variable	Kappa
Neovascular Disease	0.888
Drusen number	0.695
Drusen size	0.685
Focal Hyperpigmentation	0.833
Geographic Atrophy	0.892
AMD Grade	0.671

Sheets and slides were then filed away in numerical order to allow easy reference if any problems arose.

Statistical Calculation
All statistical calculations (Cohen Kappa or as commonly referred to as Kappa statistic) were performed using the Systat 5.1 programme which was accessed through a Macintosh SE/30 microcomputer.

RESULTS
Computer analysis of data entered from the grading process compared the agreement levels of some of the various characteristics graded. The statistical analysis of this data using the systat programme provided the following statistics that can be found in the Tables labelled 1, and 2.

Orthoptist and Ophthalmologist inter-observer variability
Kappa statistic was calculated on a sample group ($n = 65$) for a number of variables and the results shown in Table 1.

Grader one and two inter observer-variability
Kappa statistic was calculated on a large sample group ($n = 922$) and the results shown in Table 2.

Inter-observer variability in the Beaver Dam Eye Study
Kappa statistic was used in the Beaver Dam Eye study[1] to determine the inter-observer variability of two of the studies graders.[6] Slides were graded from a large sample group ($n = 857$) which is

TABLE 3
Shows Kappa Scores of Inter-observer Variability between two graders in the Beaver Dam Eye Study (n=857)

Variable	Kappa
Drusen size	0.51
Focal Hyperpigmentation	0.70
Geographic Atrophy	0.83

Key to Cohen Kappa Statistic
>0.75 = strong agreement
0.40-0.74 = fair to very good agreement
<0.40 = poor agreement

similar in number to the Newcastle study. The results are shown in Table 3 and are comparable to our own results.

DISCUSSION

From the results it has been shown that there is statistically good agreement between the orthoptist and the ophthalmologist. The kappa statistics indicated a good level of agreement in grading neovascular disease, drusen number, focal hyperpigmentation and the final AMD grade (which is of course influenced by the aforementioned). A fair level of agreement was attained in judging drusen size. This slightly worse result (although still statistically acceptable) may be explained by the problems with measuring significant drusen. Some faint large drusen may not have been included by one grader because they felt its appearance was below the protocol standard, yet the drusen may have been included by the other grader. The perfect agreement found in grading geographic atrophy should be overlooked because a very small number of this lesion type were included in the random sample. This makes the result statistically invalid.

The statistical calculations between graders showed a strong level of agreement in judging neovascular disease, focal hyperpigmentation and geographic atrophy. In fact near perfect agreement is considered >0.81. A very good level of agreement was attained for drusen number and size and AMD grade. This indicates that a similar understanding of the protocol and grading procedures existed between the two graders.

A high level of agreement, between graders one and two, can be attributed to the many sessions of "problem solving" that took place. These sessions offered times where the two graders and the adjudicator met and discussed areas of difficulty. One of the most often encountered problems was in the determination of whether or not a characteristic was of protocol standard. This can be attributed to the subjective nature of determining the standard set in the protocol. It was also difficult to assess the standard if the photograph was slightly blurred, due either to a lens opacity or other quality diminishing characteristics.

Inter-observer variability between graders one and two and the orthoptist and ophthalmologist compare favourably to the kappa statistics analysed in the Beaver Dam Eye Study. This study, however, differed from the Newcastle Study in that it used a more complex grading format. The variables shown in Table 3 are the ones most similar to the grading system employed in the Newcastle Study.

It can be interpreted from these results that with adequate training and knowledge a statistically good correspondence, between an orthoptist and ophthalmologist, as well as between other graders, can be attained in the identification of retinal lesions.

Grading retinal photographs can be tedious and frustrating at times but on the other hand is often rewarding as it provides a good knowledge of medical retina. Entering a grader training programme is not suited to everybody but it is certainly more interesting if you have an "eye" background and you are able to utilise the skills learnt.

As there are a growing number of studies that will be utilising a masked grading system then this type of training and knowledge may provide an increasing number of opportunities for orthoptic involvement in ophthalmological research.

CONCLUSIONS

This study has shown that the orthoptist compares favourably with the ophthalmologist and the nurse in grading lesions of the retina. This result was attained following a period of specialised training and the use of a well defined protocol. Ongoing problem solving and adjudication sessions provided a continuing high standard of agreement through-out the grading process and a comparable agreement rate was shown with that of the Beaver Dam Eye Study.

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CONSECUTIVE EXOTROPIA

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Abstract

From a retrospective study of the records of one hundred and seventy four patients who underwent surgical correction of esotropia, nineteen were found to develop consecutive exotropia. A study of these patients was undertaken to identify characteristics common to patients with consecutive exotropia.

A lack of any significant differences between the consecutive exotropia and the non divergent groups pre-operatively suggested that consecutive exotropia is difficult to predict. Post-operatively the only differences found were a higher percentage of patients in the divergent group with "V" patterns and with two or more lines of amblyopia. No associated inferior oblique overaction or superior rectus underaction was found to explain the higher percentage of "V" patterns in the divergent group.

No patients became divergent within six months post-operatively. Divergence occurred from 0.50 to 25 years post-operatively, with a mean of 5.0 years.

Key words: *Consecutive exotropia, esotropia, surgical correction.*

INTRODUCTION

Consecutive exotropia following surgery for esotropia has been associated with characteristics such as high hypermetropia, post-operative changes in refraction, amblyopia, the presence of a vertical deviation, "A" or "V" patterns and weak binocular function.[1-6,9]

A retrospective review of one hundred and seventy four patients who had undergone surgical correction of their esotropia found that a number of patients had developed consecutive exotropia. Patients with consecutive exotropia following a single operation were evaluated by comparing them with patients who did not diverge post-operatively in an attempt to isolate any indicators of consecutive exotropia.

PATIENTS AND METHODS

The records of patients examined by one Ophthalmologist and one Orthoptist and who underwent surgical correction for esotropia were reviewed. Cases were included if the following criteria were met:

- more than three years follow up.
- no prior surgical intervention by another Ophthalmologist.
- absence of any congenital or acquired medical condition affecting the central nervous system, thought to be a contributing factor of the squint.

Consecutive exotropia was defined as greater than five degrees of divergence with and without glasses (measured with the synoptophore), for at least three consecutive visits. The pre-operative visit refers to the visit immediately prior to the first or only operation. The final visit refers to the last recorded entry prior to any further surgery.

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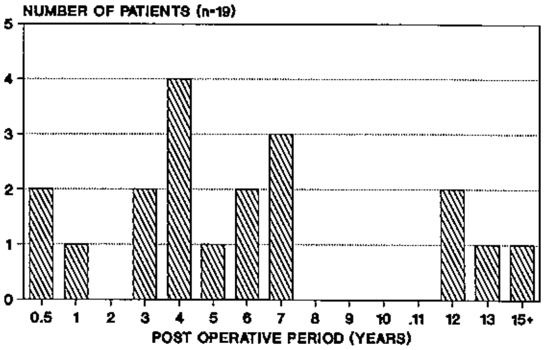

Figure 1: Time post operatively at which divergence occurred.

Statistical tests used included, *t*-test, One way analysis of variance, Fischers exact test, Mann-Whitney and Chisquare.

RESULTS

One hundred and seventy four patients were found to meet the criteria for inclusion in the study. Of these nineteen developed consecutive exotropia (CE) after one operation to correct their esotropia. The remaining six patients became divergent after a second operation and were not considered.

The number of patients with congenital esotropia was not statistically different between the CE group (64%) and the non divergent (ND) group (57%) ($p > 0.05$).

The number of patients with an accommodative esotropia pre-operatively did not vary significantly between the ND (19%) and the CE group (15%) ($p > 0.05$).

The mean age of patients at the time of surgery was 4.4 years (±3.2) for the ND group and 3.6 years (±2.0) for the CE group. This difference was not significant ($p > 0.05$).

TABLE 1
Mean angle measurement at the pre op., post op. and final visits

	Mean Deviation		
Group	Pre op.	Post op.	Final
ND group ($n = 149$)	30.1(±9.0)	14.64(±8.4)	13.3(±8.8)
CE group ($n = 19$)	26.1(±7.2)	7.16(±7.1)	−11.0(±5.5)

TABLE 2

Operation Type	ND Group	CE Group
5 mm recess 3 mm resect	11	2
5 mm recess 4 mm resect	15	6
5 mm recess 5 mm resect	43	5
5 mm recess 6 mm resect	35	4
5 mm recess 7 mm resect	11	0
Other	34	2

The average time of follow up between the pre-operative and final visit was 9.6 years (±6.5) for the ND group and 13.92 years (±7.0) for the CE group. The mean post-operative period at which divergence occurred was 5.02 years (range = 0.2-25 years) Refer Figure 1.

ANGLE SIZE

No statistical difference was found between the mean pre-operative angle size of the ND and the CE group ($p > 0.05$). The measurements between the two groups at the post-operative and final visits were significantly different ($p < 0.05$). Refer Table 1.

SURGICAL DETAILS

The majority of patients in both the ND and CE groups had monocular recess/resect procedures as an initial operation. There was no significant difference in the type of surgical procedures used for the two groups ($p > 0.05$). Refer Table 2.

OCULAR MOTILITY

The incidence of a "V" pattern post-operatively was significantly higher in the CE Group compared to the ND group ($p < 0.001$). The small number of patients with a "V" pattern pre-operatively meant the two groups were unable to be compared statistically. Refer Table 3.

The incidence of "A" patterns post-operatively did not appear to differ between the CE (3/19) and ND group (0/149), however the lack

TABLE 3
Number of patients with a "V" pattern pre operatively and during the post operative follow up period

Group	Pre op.	Post op.
ND group ($n = 149$)	2(1%)	6 (4%)
CE group ($n = 19$)	1(5%)	8(42%)

TABLE 4
Number of patients with a vertical deviation at the pre operative visit or during the post operative follow up period

Group	Pre Op.	Post Op.
ND group	8(5%)	47(32%)
CE group	1(5%)	10(53%)

of numbers meant they were unable to be compared statistically.

No significant difference was found in the number of patients with an inferior oblique overaction between the ND group (96/149) and CE group (16/19) ($p>0.05$). Only two patients in the CE and twenty one in the ND group were found to have a superior rectus underaction. These numbers were too small to compare statistically.

The proportion of patients with a vertical deviation present at the pre-operative visit or during the post-operative follow up period was not significantly different between the ND and CE groups ($p>0.05$). Refer Table 4.

AMBLYOPIA

There was no significant difference found in the number of patients with visual acuity of 6/9 or less in the squinting eye, or in those with 1 line or more difference in the visual acuity, between the ND group and the CE group at the final visit ($p>0.05$).

The CE group was found to have a higher percentage of patients with two lines or more difference in the visual acuity at the final visit than the ND group ($p<0.05$). Refer Table 5. Over 50% of patients in both the ND and CE group were too young to have their visual acuity tested at the pre-operative visit, therefore the presence of amblyopia was based on fixation behaviour. No significant difference was found in the number of patients with amblyopia at the pre-operative visit between the CE (10/19) and ND groups (77/149) ($p>0.05$).

TABLE 5
Number of patients with and without amblyopia at the final visit

Group	AMB >/=1 line	AMB >/=2 lines	>=6/9 in the squinting eye
ND group	83(56%)	37(25%)	53(36%)
CE group	12(63%)	9(47%)	11(58%)

BINOCULAR FUNCTION

Only two patients in CE group had fusion demonstrable on the synoptophore pre-operatively. This number was too small to compare statistically with the ND group (17). At the final visit seven (37%) of patients from the CE group had demonstrable fusion compared to forty five (30%) from the ND group. This was not significantly different ($p>0.05$).

HYPERMETROPIA

The difference in the number of patients with low, medium or high hypermetropia, between the two groups, was not statistically significant ($p>0.05$). Refer Table 6.

Each of the histories for the nineteen patients in the CE group was searched to determine the number of patients who had a change in refraction of greater than 1.00 dioptres sphere within three visits of divergence occurring. Only four patients were found to have a change in refraction, all becoming less hypermetropic. This did not appear to be a predisposing factor in consecutive exotropia.

TABLE 6
Number of patients with low, medium or high levels of hypermetropia

Group	Low (<=3.0DS)	Med (3.0–6.0)	High (>6.0)
ND group ($n=149$)	47(31%)	87(58%)	15(10%)
CE group ($n=19$)	9(47%)	10(52%)	0

DISCUSSION

The incidence of consecutive exotropia in this series of patients (11%) was higher than the three to seven percent range previously reported.[1-4] However these studies either had a follow up period shorter than five years,[2,4] or failed to specify the follow up period.[1,3,5] In an editorial comment by Dr. R. Aebli on the study conducted by Cooper (1961) it is suggested that "if these patients should be followed over a longer period of time through the adolescent years, his cases of secondary exotropia would be considerably higher". This study supports this with the mean post-operative period at which divergence occurred being 5.02 years with 36% not becoming divergent until after this time. Therefore a true representation of the percentage of patients who developed a divergent deviation may not be given if the follow up period is less than five years.

A smaller pre-operative angle and/or larger recess resect procedures were considered as possible causes of consecutive exotropia. The results show this not to be the case with no significant differences found between the groups in the pre-operative angle size or operation type.

No difference was found in the percentage of patients who had an onset of squint of six months of age or less between the two groups ($p>0.05$). Windsor (1966) suggested that a higher proportion of patients (57%) with consecutive exotropia had a congenital onset, however the number of patients with a congenital onset in those patients that did not diverge was not given.

Other authors suggest that consecutive exotropia is associated with a high incidence of vertical deviations.[1,2] In this study the percentage of patients in the CE group with a vertical deviation post-operatively appears larger then in the ND group, however no statistically significant difference was found ($p>0.05$).

From Table 3 it can be seen that the CE group developed a higher proportion of "V" patterns post operatively ($p<0.001$). Stanworth (1968) and Mein et al. (1986) both associate a "V" exotropia pattern with an overaction of the inferior oblique, an underaction of the superior rectus or to a lower than normal lateral rectus insertion. In our study there was no associated inferior oblique overaction or apparent superior rectus underaction to account for the "V" patterns in the CE group. As all but one patient in this group had a monocular recess/resect procedure, the possibility that the lateral rectus insertion was inadvertently lowered during surgery could provide a possible cause for the higher percentage of "V" patterns, however this remains hypothetical.

Folk et al (1983) reported 38% of patients with two or more lines of amblyopia while others found that high degrees of amblyopia may contribute to the development of consecutive exotropia. Our results support these theories as a higher proportion of patients in the CE group had two or more lines of amblyopia at the final visit than in the ND group.

Arruga (1965) commented that poor binocular function may contribute to the development of consecutive exotropia while in contrast Cooper (1961) and Windsor (1966) both suggest that binocular function is more common in overcorrected than undercorrected esotropia. This study was unable to support either finding as no difference was found in the percentage of patients with fusion demonstrable between either group.

Previous studies have suggested that consecutive exotropia commonly follows an increase in the optical correction of moderate to high degrees of hypermetropia.[2,3,10] The range and distribution of refractive errors was not significantly different between the ND and CE group and of the nineteen patients in the CE group we found only four patients who appeared to diverge following a change in refraction. Therefore a refractive component did not seem to be a factor in the development of consecutive exotropia for this group of patients.

CONCLUSION

The findings in this study conclude that the development of consecutive exotropia is difficult to predict. Pre-operatively, the presence of amblyopia, ocular motility abnormalities, in particular vertical deviations and the range of refractive errors were not statistically different between the ND and CE patients.

Patients with large or small pre-operative angles were equally susceptible to consecutive exotropia. No difference in the pre-operative angle size was found between the groups and both exhibited a large range of pre-operative angle size.

Consecutive exotropia was associated with the development of a "V" exo pattern post-operatively with no apparent associated inferior oblique overaction or superior rectus underaction. Post-operative amblyopia of greater than or equal to two lines was more common with patients who developed consecutive exotropia.

In the majority of cases (78%) consecutive exotropia appeared before seven years post-operatively with an average of five years. The possibility of consecutive exotropia occurring cannot be conclusively excluded with a short (<5 years) post-operative follow up.

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THE EFFECT OF CLUSTER SEATING IN THE CLASSROOM ON VISUAL FUNCTION

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Abstract

Cluster seating arrangements (where children sit in small groups facing each other) have been suggested to cause increased incidence of strabismus, particularly divergent deviations.
A study was undertaken to ascertain whether there is a difference in the incidence of strabismus in children seated in cluster seating arrangements, compared to those seated in a traditional manner.
Seventy-eight school children were tested. Thirty-seven sat in cluster seating arrangements, the remaining forty one did not. Results of orthoptic assessment did not support the concern that cluster seating caused an increase in the incidence of strabismus.

Key words: *Incidence, strabismus, divergent deviation.*

INTRODUCTION

Traditionally, classrooms were arranged with rows of desks and chairs, facing the front of the room and the blackboard. Modern teaching techniques suggest that children's learning is enhanced by participation in group work.[1] Seating in "clusters" facilitates this group participation.

In recent times the question, of whether seating arrangements in the classroom have an effect on ocular posture, has been debated. Individual professionals, such as optometrists and medical service nurses, have expressed their personal opinions to the authors, that "cluster seating", where children are seated facing each other rather than the front, may in fact be causing an increase in incidence of divergent deviations. It has actually been suggested that cluster seating has induced an "epidemic" of exophoria! Unfortunately, these concerns could not be substantiated or refuted with existing data.

In order to assess the validity of this claim, a sample of school children, normally seated in a traditional linear fashion were tested. The results of their visual acuity and ocular posture were compared to a sample of students who were normally seated in cluster formations. Our aim was to determine if there was a difference in incidence of strabismus or standard of visual acuity between these groups of children.

A survey of the incidence of defective vision and strabismus in children in their first year of formal education in Sydney, by Brown and Jones,[2] reported that of 5430 children, 3.5% had strabismus; the most common type being inter-

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mittent divergent squint. Just over half the children (55.8%), were found to have heterophoria, with exophoria for near being the most common type of deviation (36.4%). It is important to note that this sample was taken from children in their first year of infant school, therefore they should not have been exposed to either cluster seating or linear seating for any great length of time. Their study has clearly demonstrated the high prevalence of divergent deviations in a young school-aged population. The prevalence of strabismus reported in the Brown and Jones study is similar to that found by Macfarlane, Fitzgerald and Stark[3] and Friedman, Neumann, Hyams and Peleg.[4]

An extensive literature and Medline search found no data specifically relating classroom seating arrangements to ocular posture.

METHOD

The authors were able to gain access to two State schools, located in one Departmental administrative region. The age, socio-economic and epidemiological characteristics of the populations were similar. They offered to provide adequate numbers of students who had been placed in the specified arrangements, according to the class teacher's preferences. The proposed study was presented to and approved by the Department of School Education.

Seventy-eight children were derived from these two State schools and were used as subjects. Two different classes were used from each school; one, where the children were seated linearly and facing the front of the room, and the other, where the teacher chose to use cluster formations. Children from Years 2, 3 and 4 were tested (their ages were not recorded, but assumed to be between 7 and 10 years old) and all children were able to read the letters on a Snellen's chart. In one school, the students were from a Year 2 and a Year 3 class, the other school provided students from a Year 4 and a Year 3/4 composite group to fit the linear/cluster seating criteria.

Testing was carried out at the end of the school year, so that any effects that seating arrangements may have caused would be maximised.

All students in the target classes were invited to participate in the study. Informed consent was sought from the parents/guardians of each child in a participating class before testing. All children who were permitted to be a part of the study and who were present on the day of testing, were included in the analysis.

The children were assessed in a manner in which the examiners were uninformed as to whether the child came from a cluster or linear class. The examiners were three orthoptists and one ophthalmologist on staff at the Children's Hospital, Camperdown, and all were present at both schools. All have considerable screening experience but cross examiner validity has not been specifically assessed. Details of previous ocular and family history were not requested in order to simplify the procedure and as we were most interested in population prevalence information. The children were questioned as to the use of spectacles, and where appropriate, these were worn during testing.

Testing at each school was conducted in a well illuminated, quiet environment where it was possible to set up standard testing conditions. Only those children who were currently being tested were in the room and supervised by an orthoptist.

Fixation was directed to a detailed target for near cover testing, 6/6 (or larger where necessary) letter for distance testing, and an object of interest, beyond 6 m, for far distance testing.

Visual Assessment: A standard orthoptic screening was performed on children in both groups. The children's pupils were not dilated.

The following were assessed:

- Monocular Visual Acuity at 6 m using a Snellen's chart.
- Cover Test at 1/3 m, 6 m and Far Distance.
- The Lang's Stereotest was used to assess binocularity.

The sequence of testing was randomised to avoid the influence of ordering and to speed the procedure.

RESULTS

The null hypothesis that there is no difference in the incidence of deviation or standard of visual acuity between children seated in the cluster

TABLE 1
Visual Acuity

	Seating Groups Linear N=41	Seating Groups Cluster N=37	Total N=78
6/6 or better both eyes	80% (33)	84% (31)	82% (64)
6/6 or less both eyes	15% (6)	8% (3)	12% (9)
6/6 or less one eye	5% (2)	8% (3)	6% (5)

classroom and those seated in the linear classroom was examined. A one-tailed chi-square test, with a significance level of 0.01, was appropriate for this analysis. (Critical chi-square [χ^2 crit] = 5.41).

The results of both the cluster seating and linear seating groups were analysed and compared in terms of the presence and type of deviation for near, distance and far distance; and the level of visual acuity.

Children who were normally seated linearly accounted for 41 of the total subjects (18 boys, 23 girls). The remaining 37 were normally seated in cluster groups (16 boys, 21 girls).

Visual Acuity

A standard of 6/6 or better in both eyes was achieved in 33 (80%) of the linear seating group, and 31 (84%) of the cluster seating group (observed chi-square [χ^2 obs.] = 0.10). The standard was less than 6/6 in each eye in six (15%) of the linear seating group and three (8%) of the cluster seating group (χ^2 obs. = 2.08). The acuity was less than 6/6 in one eye only in two (5%) of the linear and three (8%) of the cluster seating groups (χ^2 obs. = 1.7). See Table 1.

The null hypothesis was accepted in all cases, suggesting that there was no significant difference in the visual acuity of the two groups.

Near Deviation

There was a near exophoria in 16 (39%) of the linear seating group and 19 (51.3%) of the cluster seating group (χ^2 obs. = 1.6). Six (14.5%) of the linear seating group were esophoric as were three (8.1%) of the cluster seating group (χ^2 obs. = 2.08). Nineteen (46.5%) of the linear and 15 (40.5%) of the cluster seating group were orthophoric (χ^2 obs. = 0.29). One child was found to have a vertical phoria combined with an esophoria. This child was part of the cluster seating group and as this was the single case, analysis was not appropriate. See Table 2.

Analysis did not reveal a significant difference in the prevalence of esophoria, exophoria or orthophoria between the two groups.

Distance Deviation

Cover testing for distance demonstrated orthophoria to be present in 35 (85.4%) of the linear and 30 (81.1%) of the cluster seating group (χ^2 obs. = 0.10). Exophoria was revealed in five (12.2%) of the linear and five (13.5%) of the cluster seating group (χ^2 obs. = 0.16). There was one case of esotropia in the linear seating group (χ^2 obs. = 2) and the cluster seating group included one case each of esophoria (χ^2 obs. = 3.25) and exotropia (χ^2 obs. = 3.25). See Table 2.

Whilst there is some variation in the type and manifestation of detected deviations between the two groups, the size of the sample is inadequate to reveal any significant trend.

Far Distance Deviation

The incidence of orthophoria in the linear seating group was 35 (85.4%) and 33 (89.2%) in the cluster seating group (χ^2 obs. = 0.01). Exophoria was found in five (12.2%) of the linear seating group and in three (8.1%) of the cluster group

TABLE 2
Deviations

		Seating Groups Linear N=41	Seating Groups Cluster N=37	Total N=78
Near	Orth	46.5% (19)	40.5% (15)	43.6% (34)
	Exo	39.0% (16)	51.4% (19)	44.9% (35)
	Eso	14.5% (6)	8.1% (3)	11.5% (9)
	XT	— (0)	— (0)	— (0)
	ET	— (0)	— (0)	— (0)
Dist	Orth	85.4% (35)	81.1% (30)	83.3% (65)
	Exo	12.2% (5)	13.5% (5)	12.8% (10)
	Eso	— (0)	2.7% (1)	1.3% (1)
	XT	— (0)	2.7% (1)	1.3% (1)
	ET	2.4% (1)	— (0)	1.3% (1)
Far Dist	Orth	85.4% (35)	89.2% (33)	87.2% (68)
	Exo	12.2% (5)	8.1% (3)	10.3% (8)
	Eso	— (0)	— (0)	— (0)
	XT	— (0)	2.7% (1)	1.3% (1)
	ET	2.4% (1)	— (0)	1.3% (1)

(χ^2 obs. = 0.8). One student in the cluster seating group was found to have an exotropia (χ^2 obs. = 5) and one student with an esotropia in the linear seating group (χ^2 obs. = 2). See Table 2.

Again the differences in deviation between the groups failed to reach the significance level.

Lang's Stereotest

All children but one, reached the 550'' level. The exception was noted to have a small esophoria with left hyperphoria for near and distance with no movement recorded for far distance.

DISCUSSION

The sample used in this study failed to demonstrate a significant difference in the ocular posture of children seated in clusters compared to children seated linearly. It is from this we conclude that seating arrangements have no adverse effect on a child's ocular posture.

In comparing the results of the current study to that of Brown and Jones,[2] we find that there are some variations in the prevalence of divergent, convergent and vertical deviations. These variations are possibly due to differences in population characteristics and sample size.

Cluster seating is a popular choice for most classroom settings. In fact, the authors had difficulty finding a linear classroom design, as earlier defined, being used.

Extensive searches through teaching and medical literature failed to find any definitive evaluation of the effects of cluster seating on ocular posture to substantiate concerns regarding an "epidemic", as related to the authors.

A claim that the positioning of children in the classroom could affect their ocular posture, is a serious one. If the claim could be proven, teaching methods would need to be revised. Left unproven, any uncalled for sensationalism should be stopped, as it causes panic and worry to carer's of children.

A teacher's main concern would have to be to provide children with the best opportunities for learning and incorporate this with all important social skills, aside from providing appropriate positioning in the classroom for children with visual impairment, visual field defects and ocular motility anomalies, it is apparent that most find cluster seating a useful tool for this.

ACKNOWLEDGEMENTS

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ECCENTRIC VIEWING POSITION AS A PREDICTOR OF POTENTIAL LEVEL OF NEAR VISUAL ACUITY

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Abstract:
The records of clients who have undergone eccentric viewing training have been used to collect the data presented in this study. Pre and post training near visual acuity measurements are presented and in each instance the degree of eccentricity of fixation is noted. Analysis of the relationship between near visual acuity and fixation distance from the fovea is discussed. Whilst there is a trend toward decreased acuity with increased distance from the fovea other factors appear to influence this relationship. The degree of eccentricity of fixation in isolation was not found to be a good predictor of post training near visual acuity. Other factors such as client age and viability of the peripheral retina appear to be better predictors of potential level of near acuity.
Key words: *Central field loss, eccentric viewing, visual acuity, visual rehabilitation.*

Visual acuity is one parameter used to assess the level of retinal function. A reduction in the level of visual acuity has a significant effect upon a persons ability to perform many basic tasks, for example high levels of visual acuity are associated with reading and tasks of visual discrimination such as recognition of a persons face. An ocular disease resulting in reduced visual acuity potentially presents a severe handicap to the person concerned. Disorders which effect the macular region of the retina or the optic nerve fibres which originate from this area result in significantly reduced levels of visual acuity and potential handicap in the performance of visually based tasks.

The visual process begins when light stimulates the receptors within the retina, an impulse is generated which is ultimately transferred to the brain where it is interpreted and "seeing" occurs. The structure of the retina which facilitates the transmission of the impulse is not consistent across the entire retina. The structure within the macular region at the fovea differs from that found in the remaining retina and these differences facilitate an increased degree of resolution. The modified anatomy of the foveal region includes: a reduction in the number of retinal layers, this minimizes interference in the transmission of light; thickening of the retinal pigment epithelium to reduce the secondary stimulus from reflected light and modifications to the cone cells which are the only receptors in this region. The foveal cone cells are thin, densely packed and the transmission of impulses to the cortex is direct. These modifications increase the levels of discrimination (visual acuity) within this region of the retina. The remaining retina does not have this structure and the level of discrimination correspondingly decreases with distance from the fovea. This decrease in discrimination can be

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illustrated by assuming the fovea to be one hundred percent sensitive, relocation by five degrees from centre reduces this sensitivity to about twenty five percent and at fifteen degrees eccentricity, sensitivity is reduced to fourteen percent (Davson 1980).

When foveal function has been lost as a result of macula pathology vision using the peripheral retina remains. The level of visual acuity demonstrated when using the peripheral retina is markedly reduced an observation which is consistant with the anatomy of this retinal area. The hypothesis that the level of demonstrable visual acuity will decrease with eccentricity from the fovea is supported by the known difference in structure between the fovea and the peripheral retina. Clinical observation also supports a trend toward decreased acuity with increased angle of eccentric viewing from the fovea. Data has been collected from a retrospective study of client records to determine if a positive relationship between level of visual acuity and degree of eccentric viewing can be demonstrated.

METHOD

Information was collected from the records of sixty one clients who have undertaken programs of eccentric viewing training. The age of the clients ranged from eleven to ninety two years with a mean age of fifty three years. Data recorded for each client is presented in tables 1 & 2 and includes:

(i) The estimated angle of eccentric viewing based on the most viable area of retina available as indicated on the Bjerrum field chart and the target size used to perform the field test.

(ii) The pre-training and post-training levels of near visual acuity assessed using the British Faculty of Ophthalmologists near vision chart.

(iii) The client age and where known the diagnosis of the retinal pathology.

None of the clients were aware of eccentric viewing prior to training and were either not attempting to use sight for any detailed task or were using the peripheral retina randomly unaware of the angle of refixation being used.

The data was analysed to determine if a significant difference between pre-training and post-training levels of visual acuity existed using a t-test. Pearson R correlation analysis was performed to determine if a positive correlation between the level of post-training visual acuity and the angle of eccentricity; target size and age could be demonstrated. Possible correlation between angle of eccentricity and target size was also considered.

TABLE 1
Summary of client characteristics

	Range	Mean
Angle eccentricity	1°–15°	3.7°
Target size (mm)	2–40	10.6
Pre-VA	N5–N48	N36
Post-VA	N5–N48	N16
Age (years)	11–92	52.5

RESULTS

The results of the pre-training and post-training visual acuity tests indicate 68% of clients had a visual acuity of N24 or worse prior to training, where as 74% of clients demonstrated visual acuity better than N24 post-training (Figure 1). The difference between pre- and post-training visual acuity was shown to be significant at the .0001 level of confidence (two tailed paired t-test).

Figures 2 to 4 are scattergrams illustrating the relationship between post-training near visual acuity and degree of eccentricity; target diameter and client age. Regression analysis of figure 2 supports a trend toward increased level of near acuity with an increase in the angle of eccentricity of viewing ($R = .264$), this supports a probable relationship significant at the 5% level of confi-

TABLE 2
Ocular diagnosis

Diagnosis	Clients (%)
SMD	42
Stargardt's	18
O/A	7
Myopic R/pathy	7
Leber's O/A	5
Inverse R.P.	5
PXE	5
Toxocara	2
Other	9

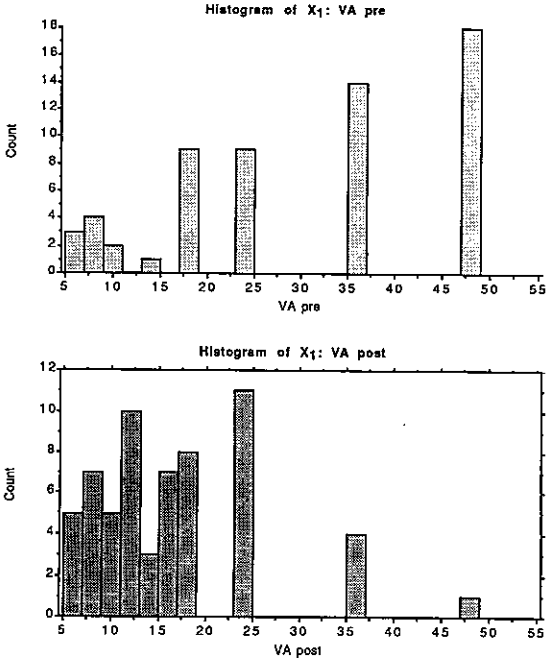

Figure 1: Histograms showing pre and post near visual acuity.

dence (t = 2.1, confidence level 5%). Figure 3 illustrates a positive correlation between the post-training level of near acuity and the target diameter (R = .578) this relationship was highly significant at the 0.1% level of confidence (t = 5.2, confidence level 0.1%). Figure 4 illustrates a positive correlation between post-training near acuity and client age (R = .531) this relationship was highly significant at the 0.1% level of confidence (t = 4.3, confidence level 0.1%). There was no relationship found between degree of eccentricity and target size.

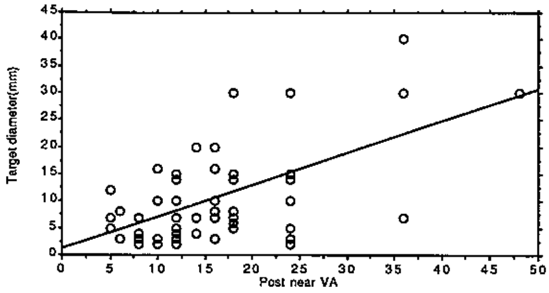

Figure 3: Target diameter/post near VA.

DISCUSSION

The results of this study indicate that when the central retina including the fovea is not functional, levels of near visual acuity can be improved by using an eccentric viewing point at an angle immediately adjacent to the damaged retinal area. Eighty seven percent of clients demonstrated an improved level of near acuity post-training compared to the level of acuity demonstrated when using a random peripheral retinal viewing point pre-training.

A trend toward improved near acuity with smaller angles of eccentricity from the fovea was found. As a sole indicator of potential level of post-training near acuity the angle of eccentricity was not found to be a reliable predictor. Client age and size of target used to perform the visual field test were found to be more reliable predictors of post-training near acuity.

The results of this study are consistent with the hypothesis that the structure of the peripheral retina does not support high levels of visual discrimination. The smaller print sizes (N5-N12) were obtained by 93% of clients using an eccen-

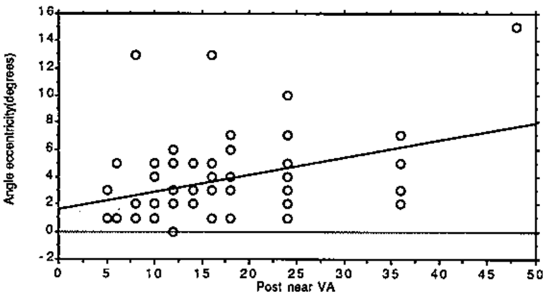

Figure 2: Angle of eccentricity/post near VA.

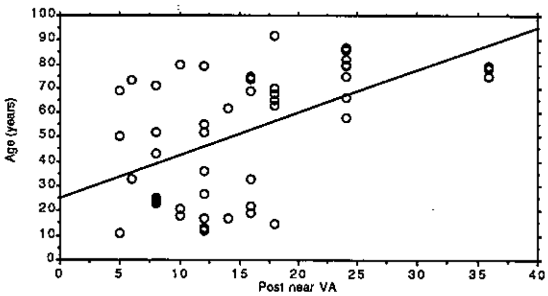

Figure 4: Client age/post near VA.

tric viewing point within the macular area. Some clients using an eccentric viewing point within the macular area demonstrated post-training near acuities in the larger print range (N14-N48). These results indicate that the angle of eccentricity is not the only factor to influence potential levels of visual acuity.

The results of this study suggest that target size is another factor which will influence the level of post-training near acuity. A positive correlation between target size and level of post-training near acuity was demonstrated and regression analysis supported target size as a good predictor of potential level of near acuity. The size of the target used to perform a visual field test reflects the viability of the retinal area being tested; pathology does not always result in total non function (absolute scotoma). In the early stages of retinal pathology function may be reduced but some visual response is still possible. The use of a larger target will illicit this visual response. In such cases a client may have for example, an absolute scotoma of three degrees whilst the adjacent retina has reduced function. When considering the visual field loss of such a client the angle of the eccentric viewing point, that is three degrees, would indicate a good visual prognosis post-training. The print size of the post-training near acuity is likely to be much larger than anticipated because the retina adjacent to the three degrees of absolute scotoma is not fully functional.

In this study client age was another factor shown to be positively correlated and a good predictor of the level of post-training near acuity. The reasons for this were beyond the scope of this study, however clinical observation indicated motivation may be a related influence. The effect of age on potential retinal function is an area for further study.

This study did not take into account the length of time spent on fixation retraining or if the program was terminated rather than completed. These factors might also effect the potential level of post-training near acuity.

The records of sixty one clients who have been trained to use an eccentric viewing point have been studied. A positive relationship between the ability to read smaller near print sizes and the distance of the eccentric viewing point from the fovea was found. This relationship is influenced by other factors such as client age and the level of function of the peripheral retina used for fixation. The ability to predict the outcome of refixation training programs is of value both as a motivator to the client and to ensure the most efficient use of resources. Such predictions must be accurate and to ensure accuracy this study indicates a range of factors will need to be considered.

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VISION TESTING OF ADULT DRIVERS WITH A VISION SCREENER

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Abstract:

This study uses an automated vision screener to examine the incidence of a range of ocular dysfunctions in a group of adult drivers. The instrument enables screening of a range of ocular functions including visual acuity, heterophoria, fusion, stereopsis, colour vision and visual field. It was found that 20% of those screened had unacceptable results in one or more area of ocular function.

Key words: *Vision Screener, ocular function, ocular dysfunction.*

INTRODUCTION

In driving, as in many tasks, a range of visual factors occur. The most essential is visual acuity. Other visual functions are assessed in some countries when determining visual standards of drivers.[1-3] These factors include the detection and measurement of heterophoria, binocularity, stereopsis, colour vision, night vision and visual fields.

'Vision Screeners' have been used to assess the visual standards of drivers in many countries. Unger[4] who reviewed the tests available for screening drivers vision found that vision screeners were used by licensing authorities in "The United States of America, in Canada, Sweden and Switzerland and in one area of Germany".

The vision screener is a small, portable instrument designed to screen a range of ocular functions. In a few minutes a variety of monocular and binocular ocular functions can be assessed both with and without glasses. These screening devices enable a non-professional to screen a large population under standard conditions, in a short period of time.

Unger[4] further reported that one of the most widely used vision screeners is the Keystone VS II Vision Screener manufactured by the Keystone View Company in America. This particular model provides for the screening of the following ocular functions:

- visual acuity, right, left and both eyes together
- heterophoria, horizontal and vertical
- fusional ability
- stereopsis
- colour vision

Except for colour vision, each of these functions can be tested at near and far (6 m) distances. It also tests horizontal peripheral visual fields.

Currently in Victoria, the minimal visual standards for drivers of a private vehicle are 6/12 in the better eye and 6/60 in the worse eye. Basic

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recognition of the colours used for traffic lights is another requirement. The assessment of vision is performed by Vic Roads personnel using a Snellen's or modified chart. Colour recognition is tested by asking applicants to identify a variety of coloured materials. It was decided to retest driver applicants at the Vic Roads centres using an automated vision screener.

The results would provide information on:

1. The suitability of using a Vision Screener to test vision of drivers.
2. The visual status of a large population of adult eyes.
3. The incidence of a range of ocular funtions as detected by a Vision Screener.

It should be noted that this study does not attempt to evaluate the reliability or suitability of the automated vision screener as a screening tool, but uses the device as a recognised method of screening a population. Further studies could be undertaken to compare the results found by an automated vision screener and an orthoptist's conventional screening assessment.

METHOD

Subjects

The candidates screened on the Vision Screener were volunteers who had passed the Vic Roads eye sight test as part of their driver licence or learner permit test.

Apparatus

A Keystone View VS II Vision Screener was used to screen the candidates. The instrument measures 25 cm wide, 40 cm long and 16 cm high and houses eight stereoscopic targets which are illuminated internally by a series of miniature lamps. The stereoscopic targets test not only vision but also if the eyes are working together. This is a major advantage of the instrument as the results are indicative of how the eyes are used by the individual in his everyday activities such as driving. A bifocal lens system provides for testing at far (6 m) and near (40 cm) test distances. The candidate's forehead is rested against the headrest which has an optical sensor to ensure that the candidate's head is properly positioned in the instrument. All tests are operated under push button control by the tester.

The screener has its own internal light source ensuring identical operating conditions at all times. The test cards can only be viewed from the correct testing distance as the targets are enclosed within the unit and cannot be viewed prior to testing. Standardised instructions and recording forms further ensure uniformity of testing across large populations.

Procedure

The automated vision screener was operated by a single tester at three of the Vic Roads Driver Licensing Centres. These centres were able to provide a suitable working area for the instrument and operator, as well as large numbers of candidates. The testing was performed between April and July 1991.

Candidates who had passed the Vic Roads eye sight test wearing their corrective lenses performed the tests on the vision screener with their lenses. Conversely those who had elected to do the Vic Roads test without their lenses, performed the tests on the screener without their lenses. Testing took 3-4 minutes and data collected was recorded on a score sheet.

RESULTS AND DISCUSSION

Seven hundred and twenty seven candidates were assessed on the vision screener. Those assessed were aged between 16 and 52 years with 98.3% being under the age of 40.

Vision

The vision of each eye and with both eyes open was assessed on the screener for both 6 m and near (40 cm) distances. It was found that 566 candidates (77.8%) demonstrated 6/6 in the right eye, while 572 candidates (78.7%) demonstrated 6/6 in the left eye. When both eyes were tested together 651 (89.5%) demonstrated 6/6. During the vision test, 14 candidates (2%) exhibited suppression — 6 of the right eye and 8 of the left eye.

When assessing near vision it was found that 635 candidates (87.4%) had 6/6 equivalent in the right eye and 626 candidates (86.1%) in the left eye. With both eyes together, 687 candidates (94.5%) obtained this level.

TABLE 1
Number and types of phorias

	Far		Near	
Horizontal phoria	eso	76	eso	85
	orthophoric	272	orthophoric	222
	exo	367	exo	408
	suppression	12*	suppression	12*
	eso>6△	2*	eso>4△	6*
	exo>4△	6*	exo>6△	11*
	FAR		NEAR	
Vertical phoria	R/L	8	14	
	orthophoric	354	362	
	L/R	353	339	
	SUPP	12*	12*	
	>1△R/L	0	1*	
	>1△L/R	20*	13*	

* Unsatisfactory

Heterophoria
The normal limits for heterophoria, according to the manufacturer, were not more than 6 prism dioptres esophoria or 4 prism dioptres exophoria for distance, and not more than 4 prism dioptres esophoria or 6 prism dioptres exophoria for near. For hyperphorias, not more than 1 prism dioptre of right or left hyperphoria was acceptable.

The majority of candidates 707 (97.2%) were within normal limits for horizontal heterophoria and 695 candidates (95.6%) for vertical heterophoria at far. For near, 698 candidates (96%) were within normal limits for horizontal heterophoria and 701 candidates (96.4%) for vertical heterophoria. Table 1 shows the numbers and types of heterophorias detected on the vision screener. It was not possible to assess the heterophorias in 12 candidates as they exhibited suppression.

Fusional Ability
Fusional ability was demonstrated by 701 candidates (96.4%) for far and by 703 candidates (96.7%) for near.

Heterophoria and Fusion
As the control of a heterophoria is dependant on good fusional ability it was decided to examine the relationship between these two as assessed on the vision screener.

Of the 30 candidates (4.1% of total) who exhibited unacceptable phorias, 6 of these candidates had an unacceptable level of fusion. The manufacturers of the Keystone Vision Screener recommend a clinical eye examination for these people.

It is conceivable that problems in these two areas of ocular function could intefere with one's visual ability during driving.

TABLE 2
Other test results for candidates with unacceptable levels of stereopsis
FAR 123 candidates (17%) had unacceptable stereopsis
NEAR 85 candidates (12%) had unacceptable stereopsis

	Far	Near
Suppression	15	14
Visual difficulties	73	46
Failed distance vision test	4	—
Problem phorias	4	—
Problem phorias and/or problematic fusion	—	7
No obvious anomaly	27	18
	123	85

Stereopsis
Stereopsis for far was acceptable in 604 candidates (83.1%) and for near in 642 candidates (88.3%).

For those candidates with unacceptable levels of stereopsis, their results to other tests are shown in Table 2. It is possible that their poor stereopsis is a consequence of the other unacceptable results or is a consequence of the sensitivity of the stereopsis test within the screening device.

Colour
The vision screener claims to detect severe (red/green) and mild (blue/violet) deficiencies in colour discrimination. Table 3 shows the candidates colour screening results. Fifty candidates (6.9%) had difficulties with the colour discrimination task.

Horizontal Peripheral Vision
The vision screener assesses horizontal peripheral

TABLE 3
Results of colour discrimination screening

	Red/Green	Blue/Violet
Acceptable	714 (98.2%)	690 (94.9%)
Borderline	5 (0.6%)	28 (3.9%)
Unacceptable	8 (1.2%)	9 (1.2%)

visual fields up to 85° on the temporal side and 45° on the nasal side. All candidates exhibited complete horizontal peripheral visual fields.

Suppression

Suppression was detected during one or more tests in 16 candidates (2.2%). In this group 4 people (25%) had unacceptable levels of fusion. All candidates with suppression had unacceptable levels of stereopsis. There was no detectable stereopsis for far and near in 12 candidates (75%).

Overview of Results

A review of results for all candidates to each test of ocular function reveal that 148 candidates (20.4%) had unacceptable results in one or more areas. Of these, 102 candidates (14%) had unacceptable results in two or more areas. Furthermore, 30 candidates (4.1%) had unacceptable results in three or more areas.

These figures reinforce the desiribility of examining a wider range of ocular functions of drivers, thus ensuring that drivers have compotent visual skills suited to the task of driving.

CONCLUSIONS

The results to testing with an automatic vision screener support the following conclusions:

1. That the Vision Screener was able to provide consistent and reliable testing of a large range of ocular functions in only a few minutes.
2. That the use of the Vision Screener could be justified when screening a large population and could be applied to the vision screening of drivers.
3. That the Vision Screener can provide information about the ocular status of a large population of adult eyes.
4. That the Vision Screener was able to detect a range of visual dysfunctions in those tested. In total 148 (20.4%) of those screened exhibited an unacceptable result to one or more test.

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DRIVER REHABILITATION REFERENCE POINTS FOR THE ORTHOPTIST

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Abstract:

This paper describes the clinical conditions of patients referred for Orthoptic assessment in relation to their ability to drive a motor car. Referrals follow failure of a visual screening test. A description is given of the orthoptic evaluation with reference to official visual requirements laid down by the Roads' and Traffic Authority (RTA) as well as reference points evolved through personal experience and observation of clients in the driving situation.

Key words: *Driving skills, ocular skills, field defects, neglect, monocular function, nystagmus, ocular movement defects, strabismus.*

INTRODUCTION

The 1990 N.S.W. "Guide for Medical Practitioners in determining the fitness to drive a motor vehicle or ride a motor cycle" states that:

> "The driver of a motor vehicle operates in a rapidly changing environment where perception, good judgement and rapid response are essential for safe driving. The most important human factors for this task are adequate vision, mental alertness, short reaction time and adequate physical capacity. The impairment of any of these factors requires assessment."

This statement establishes the basis for the assessment of driving skills. The need to have physical skills that can cope in an active situation and the need for a visual standard is clearly identified.

The Guide also raises the importance or objectivity in the assessment and that where a medical practitioner has doubt about the ability of a patient to drive, that they may recommend the patient undertake a practical driving test. Where there are any doubts about the patient's ability, they can be referred to a driver assessment centre, such as the Driving Rehabilitation Centre at Cumberland College, to determine the capabilities of the patient to operate a vehicle.

At the Driving Rehabilitation Centre at Cumberland College, an assessment is carried out and a report with recommendations regarding the abilities of the patient to drive is sent to the RTA Medical Officer. The Officer makes a decision as to whether the patient can drive or have their licence suspended. At the Centre the initial assessment is carried out by an occupational therapist. The assessment involves an off-road assessment of the physical and cognitive abilities and where the patient has passed the off-road assessment, an on-road assessment will be carried out. When a patient has limitations of general physical function modifications can be made to the car, e.g. a knob can be attached to the steering wheel to help the patient with limb problems handle the car.

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TABLE 1
Australian recommended visual levels for driving

State	Minimum static acuity	Visual field
Qld	2 Eyed 6/12 better eye 6/60 worse Eye 1 Eyed 6/18	130°
SA	6/18 with or without correction 1 or 2 eyes	45° in one or both eyes to each side of the midline
WA	6/12 better eye 6/18 with and without correction 1 or 2 eyes	Normal monocular field one eyed
Vic	6/12 better eye 6/60 worse eye	
NSW	6/12 1 or 2 eyes 6/18 with advanced age	130° monocular and binocular
ACT	6/12 1 or 2 eyes	
TAS	6/12 1 or 2 eyes	
NT	Pass an eye sight test	

VISUAL ASSESSMENT

Part of the assessment includes an eye examination. The initial visual screening tests are carried out by the occupational therapist, and any patients found to have visual defects are referred to the orthoptist for further testing and recorded measurement of any visual defects. The examination carried out by the orthoptist determines the sensory and motor function of the eyes. The results are related to the official requirements of the RTA and unofficial reference points. When the orthoptist is unsure whether any visual defects that are present will affect the patient's driving skills, he/she participates in the on-road test, sitting behind the driver and observing their eyes and head movements through the rear view mirror. The orthoptic information is then presented in a report and included with the occupational therapist's report that is forwarded to the RTA Medical Officer.

OFFICIAL VISUAL REQUIREMENTS

Table 1 shows the recommended visual levels across Australia and demonstrates the considerable variation that exists from State to State.

The official requirements are supported by The Royal Australian College of Ophthalmologists (RACO). In N.S.W. these requirements are stated in the RTA Guidelines with two areas, visual acuity and visual fields, having a numerical standard. A patient failing to reach this standard may loose their licence.

The remaining areas described in the RTA guidelines, which relate to conditions of monocular vision, sudden loss of binocular vision, diplopia and aphakia, do not prevent a patient from holding a licence but merely suggest a delay until the patient has adapted to their condition.

Problems arise when results are borderline, for example, the visual acuity in the better eye may be 6/12 part. In such a circumstance, where the patient needs to drive in order to maintain his job e.g. as a courier, the decision to remove the licence is difficult. The final decision is made by the RTA Medical Officer or taken to Court.

Flexibility of standards allows for exemptions for patients who barely meet the standards but who are otherwise alert and have normal reaction times and good muscular co-ordination.

UNOFFICIAL REFERENCE POINTS

These points have been developed following observations of drivers with visual difficulties and relate to ocular skills that are required by the driver, rather than a visual standard. The skills are named in Table 2. Failure to demonstrate these skills will not automatically cause the patient to loose their licence, as will failure to achieve the official visual standards. Therefore an extra challenge arises for the orthopist, that

TABLE 2
Ocular skills required when driving

Visual skills within the car	Visual skills external to the car
• Location of the gears • Ability to read dashboard information • Ability to use rear and side view mirrors	• Ability to remain to the left of the middle of the road • Ability to remain within marked lanes • Ability to keep adequate distance from the left of the road (gutter and parked vehicles) • Ability to change lanes • Ability to reverse park • Identification of objects external to the car • Ability to turn the vehicle to the right or left

TABLE 3

Age distribution of the patients in the study

Years	Patients with CVA	Patients with other conditions	Patients with CVA and other conditions
61-70	0000	X	5
51-60	000		3
41-50	000		3
31-40	0		1
21-30		XXXXX	5
16-20		XXX	3

of developing adaptations that will enable the patient to drive comfortably and safely in the presence of their ocular deficiencies.

REVIEW OF PATIENTS REFERRED FOR ORTHOPTIC ASSESSMENT OF VISUAL SKILLS FOR DRIVING

Twenty patients are presented:

- 9 with cerebro vascular accident (CVA)
- 2 with treatment for a tumour
- 2 with head injuries
- 2 with spina bifida
- 5 with various medical conditions which included multiple sclerosis, spinal cerebellar degeneration, ocular haemorrhage, asthma combined with cardiac arrest and retinopathy of prematurity (ROP) combined with retinal detachment

The ages of the patients ranged between 18 and 70 years. Table 3 shows the distribution, in intervals of 10 years. Those with CVA were older than 40 years with the greater number in the over 60 years. Those with other causes were younger with the largest number of patients being in the age group 21 to 30 years.

There were 4 females and 16 males.

Nineteen of the patients were found to have one or more ocular defects that could be considered to cause problems when driving. One patient who saw halos around lights had an adequate visual standard for driving and was referred to an ophthalmologist for examination. The ocular defects that were found included the following:

Fields Defects — 7 Patients

The defects were quadrantanopia (2 patients), constricted field (2 patients), central or paracentral loss (2 patients) and half field loss in one eye (1 patient). The fields were assessed using the Goldmann Perimeter with interest being on the extent of peripheral field with a V4e target.

Neglect — 2 Patients

Neglect was present in 2 patients, both of whom had a right CVA. In both patients the condition was subtle, revealing itself in one patient during use of the City University Colour Test and the other following observation during an on-road test of the patient's failure to include information to the left of his midline. In both patients the "bilateral simultaneous presentation" test showed a variable and so questionable response.

Monocular Function — 4 Patients

Each of these patients had recently lost the function of one eye, with the vision in the affected eye being at the level of 6/60 or worse. In each case the good eye had a level of 6/12 or better. Some of the reasons for the loss of vision in the affected eye included: retinal detachment; central retinal artery occlusion associated with a carotid artery block; and ocular haemorrhage which was a consequence of surgery to remove a tumour.

Nystagmus — 11 Patients

This was the most frequently occurring defect and was associated with all categories. Ten of the patients had gaze evoked nystagmus, with three having a rotary component, one of which was associated with an acoustic neuroma and 2 were associated with CVA. The remaining patient had nystagmus present in the primary position which increased on horizontal gaze.

Ocular Movement Defects — 7 Patients

There were 4 constant and 3 intermittent strabismic patients. One patient with intermittent strabismus had an incomitant deviation following a III Nerve Palsy which had been partly corrected by surgery. The remaining patients with intermittent strabismus had concomitant deviations.

Stabismus — 7 patients

There were 4 constant and 3 intermittent strabismic patients. One patient with intermittent strabismus had an incomitant deviation following a III Nerve Palsy which had been partly corrected by surgery. The remaining patients with intermittent strabismus had concomitant deviations.

THE EFFECT OF THE VISUAL DEFECTS ON THE OCULAR BASED DRIVING SKILLS

Table 4 shows the area in which visual defects caused problems for patients during the on-road assessment.

Those patients with field defects had quadrantanopias, and demonstrated several areas of difficulty, particularly when during driving they were required to make quick and continuous judgements and adjustments to the position of the car. Location of the gears and of the mirrors were adequate when the car was stationary and the patient could take time and concetrate on that specific skill. When the field defect was on the left side, the car regularly drifted to that side. If neglect was also present, the patient was unaware of the drift and argued that they were in the correct position. Reverse parking was observed to be a particular problem.

When patients have lost their binocular vision and become monocular, the RTA Guidelines suggest that "driving should cease for three months to enable them to re-learn the judgements of depth and distance. The patients who presented had fulfilled that requirement and had also had installed the recommended rear view mirrors on each side of the vehicle. Changing lanes and reverse parking still continued to be a problem because of the loss of peripheral field on the side of the affected eye. Even turning the head could not compensate fully.

The effect of nystagmus was to cause a reduction in acuity out of the primary position e.g. 6/6 in the primary position could decrease to 6/60 on side gaze. Patients with nystagmus when looking into the periphery were observed to blink or adjust their head. Some patients complained of flicking images and that if given time they would be able to see more clearly.

In the presence of limitation of ocular movements, there were complaints about diplopia or blur. In the presence of over and under shoot of the eyes there were complaints of blurring of vision. In many situations patients were also noted to shut one eye when the images were

TABLE 4
The ocular based driving skills that are affected by visual defects

Visual defect	Ocular based skills within the car			Ocular based skills used external to the car						
	Locate gears	See dashboard	Use mirrors	Stay on left	Avoid left	Stay in lanes	Change lanes	Reverse park	Turn	External object identification
Field defect (7) Quadrant (2)	X		X	X	X	X	X	X	X	X
Neglect (2)	X		X	X	X	X	X	X	X	X
Monocular (4)							X	X		
Nystagmus (11)			X				X	X		
Ocular movement limitation (4)		X	X				X	X		
Over (1)/ Undershoot (2)	X		X				X	X		
Strabismus										
constant (4)				X		X	X		X	
intermittent (2)	X	X	X			X	X		X	

X = Problem possible

unsatisfactory e.g. double or blurred vision.

Strabismus has been observed to have variable effects on driving skills. One patient with a constant alternating exotropia described his awareness of a panoramic field of vision and the ability to change fixation with an associated shift of the field. With this shift of the field, the direction sense also changed and the patient drove the car in a different or crooked direction. Three patients with intermittent strabismus complained of insecurity when judging distances, changing lanes, reverse parking as well as difficulty in judging the distance from other cars. Observation of their eyes during the on-road assessment revealed the eyes changed from straight to exotropic. When the eyes were exotropic the patients described the above difficulties.

COMMENT

Observation of patients who have visual defects when they are driving has demonstrated the many ways in which visual defects can affect the driver's accuracy. Experience in the field of driving rehabilitation has required the use of orthoptic knowledge to translate the significance of patient responses in the driving situation and relate them to actual ocular defects.

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DUANE'S RETRACTION SYNDROME TYPE 1 ASSOCIATED WITH DISSOCIATED VERTICAL DEVIATION: A CASE REPORT

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Abstract

A case is reported of an eight year old girl with a left Duane's retraction syndrome type 1, bilateral dissociated vertical deviation (DVD) and an infantile esotropia. The patient also had congenital hydrocephalus which was treated with a ventriculoperitoneal shunt. This is the third case report of a Duane's syndrome and DVD presenting together. The clinical characteristics are discussed.
Key words: *Hydrocephalus, infantile esotropia.*

INTRODUCTION

The retraction syndrome as described by Stilling (1887), Turk (1896) and Duane (1905) has the following typical and most frequently observed clinical characteristics: marked restriction or complete absence of abduction, normal or a slight restriction of adduction, narrowing of the palpebral fissure and retraction frequently with an upshoot or a downshoot of the affected eye on attempted adduction, widening of the palpebral fissure on attempted abduction.[1] The various manifestations of Duane's retraction syndrome have been categorised by Huber[2] into the 3 types:

1. palsy of abduction
2. palsy of adduction
3. palsy of abduction and adduction

Other reported associated signs include horizontal strabismus (mainly esotropia), 'A', 'V' or 'X' patterns, defective convergence and a compensatory head posture, upshoot of the affected eye on attempted adduction, elevation or depression on attempted abduction and bulging of the orbital fat through the septum orbitale.[2-4]

Duane's retraction syndrome is most commonly of congenital origin and may also be acquired.[3,5,6] The syndrome is more common in females and on the left side. Bilateral cases have been reported in about 20% of cases,[5] though it has been argued by Rowe et al. that bilateral Duane's may be more common.[4] There have also been reports of associated abnormalities including congenital deafness, seizures, congenital facial palsies, microcephaly, generalised hypotonia and crocodile tears and oculocutaneous albinism.[4,7-9]

The aetiology of this syndrome proposed by

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Huber was 'paradoxical anomalous innervation of the lateral rectus'.[2] More recent electrophysiological studies have proved this hypothesis and have shown an abnormality of the brainstem in which the lateral rectus is innervated by the third nerve.[10]

Dissociated vertical deviation is characterised by an upward movement of the eye when occluded. On removal of the occluder, the eye "drifts" downwards. Other associated signs are: extorsion, latent nystagmus, horizontal deviations, asymmetry of Optokinetic nystagmus (OKN), a positive Bielschowsky phenomenon where the affected eye elevates behind the occluder, but as the density of the red filter is increased, the eye behind the occluder returns to the primary position, inferior oblique overaction, 'A' pattern and weak (at best) binocular functions.[3,11]

DVDs are commonly associated with infantile esotropia, though it may become manifest after surgery for the correction of the horizontal deviation. Since Stevens was reportedly the first to describe DVD in 1895[7] a plethora of descriptions have been used to describe this condition. In 1990, Wilson and McClathey[12] argued that DVD implied a purely vertical deviation, and suggested the term 'dissociated strabismus complex', to be divided into vertical, horizontal and torsional components.

Various hypotheses have been put forward to explain this phenomenon.[13-15] To date the aetiology is unknown though it is apparent that there is a disturbance of both the sensory and motor systems.

This paper presents a case of a patient with a Duane's retraction syndrome type 1 and an infantile esotropia with a DVD. This is only the third case reported of a Duane's retraction syndrome type I occurring with DVD. It is the first case report of these two conditions occurring with an infantile esotropia.

CASE REPORT

E.O. was born at term after a normal pregnancy. The labour was of fifteen hour duration and there was a forceps delivery. The circumference of E.O.'s head at birth was noted to be 36.5 cms. This increased to 37.5 cms five days later. Neonatal jaundice was also evident and was treated with phototherapy. One week after birth E.O. presented with a low occipital encephalocele, which was repaired. Hydrocephalus then developed and required a ventriculo-peritoneal shunt.

At 7 months of age, E.O.'s shunt became occluded. A cerebral ultrasound revealed grossly dilated lateral ventricles, a moderately dilated third ventricle and a slightly dilated fourth ventricle. The shunt was replaced. At this time a left esotropia was noted by the neuro-surgeon, though E.O.'s mother has reported subsequently the presence of the esotropia since birth.

Six months later E.O. was referred to an ophthalmologist. The presence of a right esotropia of approximately twenty degrees and rotary nystagmus was confirmed. The right visual acuity was thought to be reduced. There was bilateral failure of abduction and cross fixation was queried.

The neuro-surgeon's report at this time diagnosed a midline syndrome. The term 'midline syndrome' encompasses developmental, neuroplastic, vascular and/or traumatic damage to any of the following: corpus callosum, cingulate gyrus, septum pellucidum, septal area or fornix. The features may include ocular abnormalities, especially optic atrophy, strabismus, nystagmus and chorio-retinitis. Epilepsy and mental retardation are often present, but were not in this case.[16]

At three years of age E.O. underwent a right medial rectus recession and a maximal right lateral resection for correction of the esotropia. Cosmesis was good post-operatively in the presence of a left hypertropia. As time progressed a left esotropia became manifest when E.O. was tired.

Later that year E.O. was admitted to hospital with symptoms of right sided headaches, drowsiness and vomiting. The CT scan was normal, but a right 6th nerve palsy was queried by the neurosurgeon. At this time, an ophthalmological investigation revealed the presence of a left esotropia and a left Duane's syndrome type 1 with lid retraction in abduction. No papilloedema was evident. One month later, E.O.'s shunt blocked once again and a new catheter was inserted.

E.O. was investigated at the Orthoptic Clinic at La Trobe University in 1991 at eight years of age. Poor cosmesis was the presenting complaint. The hydrocephalus was under control and E.O. was not on any medication. There was an insignificant refractive error of hypermetropic astigmatism. The fundi and media were normal. There was a family history of strabismus. E.O.'s father (now deceased) and her two paternal aunts had a history of strabismus, but the types of deviations are unknown.

The orthoptic examination revealed a face turn to the left; visual acuity of 6/9, N5 in both the right and left eyes. On cover testing at both ⅓ metre and 6 metres there was a moderate left esotropia with left hypertropia, bilateral DVD (left greater than right) and extorsion. Measurements were made by prism cover test. At near with either eye fixing the esotropia was measured at 18△; the right hypertropia was 6△ and the left hypertropia was 30△. At 6 metres with either eye fixing the esotropia was measured at 12△. The right hypertropia was 7△ and the left hypertropia was 20△. The measurement of the vertical deviations is considered to be an estimate only due to the variability of the deviations. OKN was intact with both eyes open when the drum was rotated from left to right and from right to left. When each eye was tested separately, OKN was present when the drum was rotated from temporal to nasal, but was absent when the drum was rotated from nasal to temporal. The Sbiza bar was used to examine the Bielschowsky phenomenon. However, it could not be demonstrated. Testing of ocular pursuit movements showed no movement of the left eye beyond the midline with an upshoot of the left eye and widening of the palpebral fissure on attempted abduction, retraction of the left eye and narrowing of the palpebral fissure on adduction. The left eye diverged on elevation. Binocular functions were tested with Worth's lights, Bagolini glasses, the Lang two pen test and the synoptophore. Simultaneous perception could be demonstrated only on the synoptophore; fusion and stereopsis could not be demonstrated. A visuscope examination revealed latent micro-nystagmus.

DISCUSSION

Based on the well documented history and the most recent orthoptic investigation, the diagnosis of a Duane's retraction syndrome, type 1 associated with an infantile esotropia and bilateral DVD was made.

This is only the third case to be documented. The first (case 1) was reported by Clarke et al. in 1988[15] and the second (case 2) by Rimmer and Katz in 1990.[7]

Both previously reported cases were of Duane's syndrome type 1 with bilateral DVD. There was no detailed past history available for either Case 1 or Case 2. Case 1 had an associated alternating esotropia and Case 2 had a small hypertropia. Case 2 had an upshoot of the affected eye on attempted abduction. Both cases had latent nystagmus. No fusion or stereopsis could be demonstrated in Case 1. There was no report of assessment of binocular function in Case 2. Neither had undergone any treatment.

E.O.'s findings demonstrate some similarities and differences between these two cases and frequently reported characteristics of Duane's syndrome and DVD. E.O. had a type 1 Duane's syndrome with an upshoot of the affected eye on attempted abduction. This is in contradiction to most reports which are of an upshoot on attempted adduction. Micro latent nystagmus was evident, which is frequently reported in association with DVD. Only simultaneous perception could be demonstrated therefore the head posture of a face turn to the left was not in the interest of binocularity. In this case a detailed past history was available, which confirmed the presence of an infantile esotropia.

The most significant difference between this case and the other two cases was that E.O. had hydrocephalus. The sudden appearance of a squint in patients with hydrocephalus is diagnostic of sudden raised intra-cranial pressure. While the first documented appearance of the squint at 7 months of age was prior to an episode of raised pressure, the presence of the squint was reportedly noted at birth. This cannot be confirmed. The DVD was first documented when E.O. was eight years of age, so the exact time of onset is impossible to determine.

Duane's syndrome is generally considered to be a congenital condition. However, there are reported cases of acquired retraction syndrome[6] and Raab[5] has quoted findings of a patient in which a Duane's syndrome apparently evolved. Was E.O.'s Duane's syndrome a congenital condition or was it an acquired condition secondary to complications caused by the hydrocephalus? While the diagnosis of Duane's in this case was first documented when E.O. was 5 years, limitation of abduction had been noted at 13 months, but this was considered to be associated with the infantile esotropia. It is possible that the presence of the infantile esotropia associated with cross fixation masked the Duane's syndrome until E.O. was old enough to be more accurately examined. Conversely, when the Duane's syndrome had been diagnosed the upshoot of the left and the divergence of that eye on elevation may have masked the presence of the DVD.

Neither Clarke et al.[15] nor Rimmer and Katz[7] could offer an explanation for the concurrence of these conditions. Clarke et al. commented that it was "interesting to speculate that our patient may have a single abnormality accounting both for the presence of a Duane's syndrome and DVD" and Rimmer and Katz stated that "the concurrence of both syndromes implies that a clinically common strabismic entity can occur with differing underlying neuroanatomy". The authors are in agreement with Clarke et al. that if both conditions are caused by a brain stem anomaly the co-existence of these conditions would be more commonly found. The most likely explanation is one of coincidence, though it is interesting that within four years there have been three case reports.

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A CASE STUDY — BROWN'S SYNDROME ASSOCIATED WITH ACCOMMODATIVE ESOTROPIA

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Abstract

Mechanical limitation of eye movement is a relatively common occurrence in orthoptic practice. Less common is an associated concomitant type squint. This paper reviews the literature reporting Brown's Syndrome in association with accommodative squint and illustrates the clinical features of a case of Brown's Syndrome with a fully accommodative esotropia.

Key words: *Mechanical limitation, fully accommodative esotropia.*

INTRODUCTION

It is well known that Brown's Syndrome is mostly associated with normal binocular single vision and that it remains well compensated without treatment. However there are some patients who demonstrate an associated horizontal strabismus, usually esotropia. Sandford-Smith 1975[1] observed that six out of a series of nineteen patients with Brown's Syndrome developed a secondary esotropia and concluded that Brown's Syndrome can pose a threat to binocular vision. Eustis and co-workers 1987 (cited in Wilson et al 1989[2]) reported a 15% incidence of co-existing strabismus.

In this paper, a case of Brown's Syndrome in association with a fully accommodative esotropia is presented. Such a co-incidence was first reported by Nutt 1955[3] not long after Brown first described the condition in 1950. Crosswell and Haldi 1967[4] described a case of bilateral Brown's Syndrome with an accommodative esotropia. Other cases have also been reported by Roper-Hall and Roper-Hall 1972[5] and Raab 1976.[6] Raab in fact described three cases — one with a fully accommodative esotropia, one with a convergence excess esotropia, and one with a partially accommodative esotropia.

CASE STUDY

L.M. aged eight years first presented with Brown's Syndrome at the age of twenty two months. At the age of four years, L.M. began to show an intermittent esotropia mainly when looking above the mid-line. At this time visual acuity was equal, and normal binocular single vision demonstrable. On refraction she was found to be moderately hypermetropic and was prescribed a + 3.00 DS with a + 0.50 cylinder in either eye. Following the wearing of glasses and an improved ability to carry out test procedures, a small difference in visual acuity was noted. A small esotropia with apparent diplopia was

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present without glasses but could be controlled. However, over time L.M.'s ability to control the deviation deteriorated and although she preferred and still prefers to wear her glasses most of the time, it was decided to carry out some anti-suppression treatment to prevent a further deterioration and to regain the earlier control. Following a month of part time total occlusion, L.M.'s control of the accommodative deviation improved — simply by eliminating the suppression as evidenced by the presence of diplopia. At this stage she was unable to carry out any more active treatment. It is interesting to note that the child has subsequently requested a resumption in occlusion treatment as the suppression returns and diplopia disappears in the presence of a manifest deviation. Further evidence of the return of suppression was found on tests for stereopsis the results of which became negative.

The current findings show equal visual acuity of 6/4.5, N5, a small esophoria with and without glasses except on accommodation without glasses for both near and distance fixation, with a Binocular Visual Acuity of only 6/60 without her glasses in the primary position. This improves to 6/9 with the chin slightly elevated. It is very important to observe the exact position of the fixation target in relation to the mid-line as a fraction above the mid-line immediately results in a right esotropia. L.M. demonstrates a small suppression scotoma on Bagolini glasses and with the Four Dioptre Prism Test. The ocular movements show the typical picture of a Brown's Syndrome with downgaze unaffected, although the patient is finding it increasingly difficult and uncomfortable to look into the elevated positions. The Hess chart is typical for Brown's Syndrome. One of the most interesting features of L.M.'s condition is the fact that she has only ever noticed vertical diplopia — never horizontal. This is the case even after anti-suppression treatment — both active (cheiroscope) and passive (occlusion) and subsequent improvement in control.

DISCUSSION

The association between Brown's Syndrome and accommodative esotropia has been regarded as uncommon and unusual (Raab, 1982[7]; Raab, 1976[6]). Raab reported in the cases that he described, there was no obvious aetiological relationship in the simultaneous occurrence of the two conditions. Although Brown's Syndrome is most commonly a congenital condition and accommodative esotropia a developmental condition it could be postulated that there is a causal relationship between the two. According to Gowan and Levy 1968,[8] and Wilson et al. 1989,[2] the binocular single vision in Brown's Syndrome whilst present is somewhat tenuous. It could be suggested therefore that the presence of hypermetropia (in this case) together with weak motor fusion caused by the mechanical eye movement defect may potentiate the accommodative esotropia. This supports a view that the presence of sensorial abnormalities is far more significant in the aetiology of squint than the motor factors. In other words, it is not so much the Brown's Syndrome per se that induces an accommodative squint, but the effects that the ocular-motor anomaly has on the binocular visual system which is weakened by such an anomaly, and therefore vulnerable to decompensation. In this case the hypermetropia that may have been compensated for with negative fusional vergence, has lead to an inability to maintain full control due to the added deficit of a Brown's Syndrome.

The interesting features in this case include the nature of the suppression, the possible causal relationship between both defects, and the pragmatics of testing. In this case it is vital to be precise about the position of the fixation target so that it is quite clear which part of the deviation is being measured or assessed. As L.M. advances in age, then more detailed investigation of the suppression can be undertaken. This report adds to the very small number of reports of mechanical defects of eye movements in association with concomitant accommodative squint. The importance of reporting on relatively rare clinical problems is stressed in order to build up a 'case-law' of conditions which will gradually add to our knowledge of the mysteries of binocular vision and its decompensation.

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Obituary

DIANA SOPHIE CRAIG (NEE MANN) 1912-1992

Members of the Orthoptic Association of Australia were saddened to hear of the death of Diana Craig (Mann) in Melbourne on the 7th of February, 1992.

Di was a remarkable person, providing intelligence, inspiration and wisdom for orthoptists for over fifty years.

Her own path in orthoptics was that of a true pioneer. As her secondary education at Clyde School for Girls did not prepare her sufficiently to enter University to study science, she became a student at the Working Man's College (now the Royal Melbourne Institute of Technology) to study chemistry, enabling her to then enrol at Melbourne University, and graduate in 1932 with a Bachelor of Science, having studied chemistry, physics, zoology, physiology, biochemistry and bacteriology. In the patriarchal mode of the time, this in itself was remarkable.

Her entrance to orthoptics was via her role as scientific secretary to the eminent ophthalmologist Dr Ringland Anderson, where she gained a solid grounding in data collection, diagram compilation and the preparation of books and journals. As well as performing clinical skills of binocular vision and visual field measurements, Di schooled herself in binocular vision and its anomalies by reading the classic texts of Duane and Worth. Travelling to the Central London Ophthalmic Hospital in 1937, she worked and studied under the impressive Shiela Mayou. On returning to Melbourne she was appointed orthoptist at the Alfred Hospital, initially on no pay, then later at one pound per week. In 1939, after the formation of the Orthoptic Board of Australia, she was declared, on a viva voce examination with Drs Travers and Fenton, to be competent to practise orthoptics.

Di set up private practice at 55 Collins St until 1972, moved across the road until 1976, then spent her final two years in Collins St with Drs Coote, Lidgett, Borger and Markwick. During the war she tested aircrew for defective stereopsis and worked with Dr Hugh Ryan at the RAAF Medical Centre in Spring St. Whilst pioneering the profession in these ways, she also returned to Melbourne University to obtain a psychology major and become a member of the Australian Psychological Society.

Di became the orthoptist in charge when the orthoptic clinic at the Royal Victorian Eye and Ear Hospital reopened following a poliomyelitis epidemic, working closely with Drs Fenton and Ringland Anderson, and also was in charge of the training course for orthoptists in the tower room above the old eye theatre until 1956. An interim period to 1963 was covered by Leonie Collins and Winifred Brown whilst Di cared for her parents, then she resumed this role until 1969. She continued with some lecturing up to the transition of orthoptics from its hospital base into the tertiary system at the Lincoln Institute of Health Sciences in 1974. Her clinical work continued to 1982, when Victorian orthoptists marked her retirement with a dinner in her honour.

Throughout her career she was a prolific publisher, writing 32 papers, most of them as the sole author. Her papers were published in the Transactions of the Orthoptic Association of Australia, the Australian Orthoptic Journal, the British Orthoptic Journal, the Transactions of the Ophthalmological Society of Australia, the British Journal of Ophthalmology and the Australian Journal of Ophthalmology. In her 1975 treatise on objective orthoptic treatment she says: "The orthoptist deeply involved in the troubles of her patient across the synoptophore, perhaps gains glimpses of the workings of the visuo-motor mechanisms that are hidden from others", highlighting both her concerns for the patient's welfare and her thirst for solving the mysteries of binocular reflexes.

For all her expertise in clinical work and academia, she became, in 1944, a foundation member (later to be made a fellow) of the OAA and remained one of its significant activists. She held the office of President over four terms, was secretary for five terms, was for sixteen years the editor of Australian Orthoptic Journal and was a member of the Orthoptic Board of Australia for ten years. Many members will also remember how she, and her husband Jim, would frequently host the annual Christmas parties of the Victorian branch of the association at their house which reflected their love of gardens and of Eastern art and culture, occasions made even more enjoyable by the cider from her family's property at Packenham Upper where she grew up, a place she remained close to for her whole life.

Throughout her entire career she had a tireless pursuit of academic excellence. She was a distinguished teacher because of her active and intelligent mind and her generosity of spirit. She strived to further education and research, always saying that there was so much to do. She would sit in a seminar or a conference, or in her garden or at her table over a cup of tea, and say about an orthoptic puzzle "I've sometimes noticed such and such . . . have you seen this, what do you think?" She asked many questions and raised many issues for those who follow her.

To honour Di, the Victorian branch of the OAA has established the "Diana Craig Memorial Prize" for an outstanding contribution by an honours student from the Bachelor of Applied Science degree in orthoptics. She was delighted at the maturity of the profession today, and we are the ones who will be forever grateful for having known her, and for her vision into the future.

Julie Green

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This must be stated in a covering letter.

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