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White Light Interferometry in Amblyopic Children—A Pilot Study

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Summary
Interferometric acuity using the IRAS white light interferometer was compared with Snellen acuity in nine amblyopic children between the ages of five and nine years, and nine aged matched controls. All of the amblyopic eyes achieved better grating acuities than Snellen acuities. Fifty-seven per cent of the amblyopes with a best corrected Snellen acuity of 6/18 or less in their amblyopic eye, achieved grating acuities indistinguishable from normal. The hand held white light interferometer may have a role in the assessment of meridional amblyopia and in children with high astigmatic errors.

The use of interferometry to measure visual function was first described by Campbell and Green in 1965.[1] Interferometers project a high contrast sinusoidal grating pattern on the retina using the interference fringe phenomenon.

Interferometers usually employ a laser to generate the two point sources of light necessary to produce the interference fringes and have two principal advantages over external visual chart assessment when measuring fine central retinal function. Firstly, minor abnormalities in the ocular media, and in particular the lens, may degrade the target image on the chart resulting in a reduced best corrected acuity despite normal retinal function. The narrow beam of the interferometer is only minimally degraded by such abnormalities and most reports on the use of such instruments concentrate on the prediction of acuity following surgical procedures on the lens.[2]

The second advantage relates to refractive error. Chart acuity is highly dependent on an accurate subjective refraction, particularly in astigmatism when both power and axis are variables. The narrow interferometer beam produces grating patterns on the retina which are independent of low and moderate refractive errors in a similar manner to the much used pinhole.

Subjective refraction is difficult in children and there is little in the literature on the use of interferometers in the assessment of their acuity, particularly in relation to amblyopia.

To our knowledge, the only, and much cited, report on the use of interferometry in amblyopic subjects was by Gstalder and Green in 1972 on a small mixed group of amblyopes, most of whom were adults.[3] They concluded that grating acuity (using a nine degree target size) tended to overestimate chart acuity measured with the Snellen chart. Reducing the target size to 20 minutes of arc reduced the grating acuity in just over half of their subjects.

In order to investigate further the effect of amblyopia on grating acuity in children as

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measured with an interferometer, we designed the following pilot study.

Subjects and Methods

Nine amblyopic children aged between 6 and 9 years of age, and 9 age matched children with normal acuity in both eyes were tested with a Site IRAS white light interferometer (see Fig. 1). Amblyopic children were defined as having eyes with a best corrected linear Snellen acuity difference of <1 octave, normals having a best corrected linear Snellen acuity (BCSA) of at least 6/9 in each eye with an inter-eye difference of <1 octave.

The IRAS interferometer is a hand held instrument which utilises a holographic phase grating to produce two equal intensity white light sources'. These interfere 'projecting' a grating pattern on the retina. A 3 degree retinal target size was used throughout the study, gratings being presented either horizontally or vertically as preordained by the protocol. (Gratings can be displayed at any angle by the interferometer).

Normals had their right eye tested first and amblyopes their better eye. The following staircase system using a forced choice procedure was used on each eye of all subjects, the child being asked to identify the direction of the 'stripes' as 'up and down' or 'side to side'.

Each test run was commenced at a grating acuity equivalent to a Snellen acuity two lines below the BCSA for the eye being tested. The operator then followed the preordained random sequence of grating presentations, a maximum of seven presentations being available for each acuity level (Fig. 2).

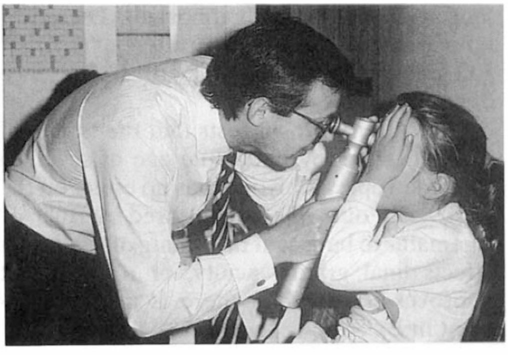

Fig. 1. *The hand held IRAS interferometer in use. The child observes the grating pattern with one eye whilst covering the other. The operator monitors fixation and adjusts the instrument/eye distance having preset the grating frequency and orientation.*

We operated a 'three up, two down staircase'. If the child correctly identified three of the first four presentations, the operator increased the grating frequency one level and continued until the 6/5 acuity level or until two errors were made at any level. If the former, the test continued until six of the seven presentations were correctly identified or until two errors were made. If the latter, the operator decreased the grating frequency one step on the staircase aiming to detect the greatest grating frequency at which 6/7 responses were correct.

To complete the test, therefore, a child must have correctly identified 6/7 of the presentations on a line which was then defined as the best grating acuity (BGA). This method has a <95% chance of identifying the minimum BGA for the eye under test.

BCSA was then compred to BGA for each eye, both results being converted to resolution angles (eg 6/6 = 1 min of arc, 6/12 = 2 min. of arc, an interval of one octave).

Results

All of the eyes of the normals and the better eyes of the amblyopes achieved a BGA within one octave of their BCSA, 12 (45%) recording identical results, nine (33%) better and six (22%) worse. All of the amblyopic eyes achieved a better BGA than BCSA, 7/9 (78%) had a BGA within one octave of their fellow 'good' eye, and 6/9 (66%) a BGA equivalent to 6/9 Snellen or better. Of the seven amblyopic eyes with a BCSA of 6/18 or worse, four (57%) achieved a BGA equivalent to 6/9 or better.

Discussion

The results of this pilot study would suggest that, in children able to perform the test, white light interferometry with the Site IRAS interferometer equates well with BCSA in normal eyes. Using preferential looking, Birch noted interocular grating acuity differences of 0.5 to 1 octave in normal 3–5 year olds.[4] Our study would suggest that this difference persists, in some individuals, at least up to the age of 9 years.

3 ' FIELD

	RIGHT/LEFT AMBLYOPIC	pass	RIGHT/LEFT NONAMBLYOPIC	pass	
6/60	V V V V H H V		H V V V H V H		10'
6/36	V H H H H V H		V H V H V H V		6'
6/24	H H V V V H H		H H H V H V H		4'
6/18	H V V V H H V		V V V V V V V		2.5'
6/12	V H V H V V V		V H V H V H H		2'
6/9	H V H H V V V		V V H H V V V		1.5'
6/6	H V H H H V H		V H V H V H H		1'
6/5	V H V H H H V		H H H H V H H		0.8'

Fig. 2. *Protocol sheet for the forced choice grating staircase. Snellen acuity on the left with equivalent acuity in minutes of arc on the right. H = horizontal, V = vertical.*

It would also appear that many amblyopic eyes, even those with <6/12 BCSA, will achieve a BGA indistinguishable from normal with a 3 degree target. All of our amblyopes improved on assessment with the interferometer confirming the findings of Gstalder and Green.

By extrapolating the contrast sensitivity curve to obtain an estimate of high contrast grating acuity, Volkers showed that, in amblyopic adults, the Snellen acuity tends to be lower than the grating acuity.[5] Our study, in which grating acuity was measured directly, suggests a similar finding in children.

All of our amblyopic children had undergone a course of orthoptic therapy with spectacles and occlusion prior to the study and therefore our observations appertain to treated amblyopia. Why some amblyopic eyes with 6/18—6/36 BCSA achieve a BGA within the normal range and some do not is unclear. Our results include only six cases that fall into the above category, four cases achieving 'normal' BGA and two abnormal. There was no apparent correlation between a "normal" BGA and amblyopia subtype or the presence of stereopsis.

A recent report suggests that the timing of orthoptic therapy under the age of seven in anisometropic amblyopia has no effect on the final visual outcome as measured by BCSA.[6] It remains to be seen if the timing of treatment effects final grating acuity, or if treatment improves BGA when there is no improvement in BCSA.

The frequent observation of a normal pattern of BGA in our cases of well documented amblyopia in children casts doubts on the value of preferential looking utilising simple grating targets as a screening tool for amblyopia, as a considerable number of amblyopic eyes would be expected to perform within the normal range.

Although the white light interferometer cannot be relied upon to detect amblyopia, even in the older child, it may have a role in the investigation of meridional amblyopia and amblyopia associated with high astigmatic errors where accurate refraction is difficult. For example, a child of six with four or more dioptres of astigmatism at an oblique angle may be difficult to refract above 6/12. Amblyopia or refractive error? A finding of an abnormal BGA would indicate amblyopia requiring treatment although a normal BGA would not, of course, eliminate it.

References

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