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EVALUATION REPORT — THE CAMBRIDGE VIDEO REFRACTOR

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Abstract

Photoscreening is a technique that has been developed in an attempt to refine vision screening programmes, which aim to identify visual disorders in early childhood. Various groups have developed photorefracting tools in recent years. This study evaluates the role of one such tool–the Cambridge Video Refractor (CVR).

The CVR is an isotropic on-axis photorefractor, which utilises a computerised system to evaluate three photographs of a subject's eyes, and predict refractive error.

When the results of video refraction on 101 non cyclopleged eyes were compared with their retinoscopic refraction, 41.6% of the CVR predictions were correct. The video refraction of 83 cyclopleged eyes were compared to the retinoscopic refraction, and the accuracy of the CVR was 51.8%. For this evaluation, the video refraction prediction was within 1.0D and the axis within 20° of the retinoscopic refraction to be considered accurate.

INTRODUCTION

Photoscreening is a method of estimating the refractive state of the eyes by photographing the light returning from a subject's fundi, when the eyes have been illuminated by a light source centred in a camera lens.

It is a technique that has been developed in an attempt to refine screening programmes, whose aim is to identify visual disorders in early childhood. It is well accepted that treatment of refractive and strabismic amblyopia is most effective in the early years of life.

Numerous groups have produced photorefractive tools,[1,2,3] and these appear to have been helpful in dealing with the difficulties of traditional screening methods. An on-axis photorefracting technique was introduced by Howland and Howland[4] in 1974. This has since been modified by the Vision Development Unit of The University of Cambridge, to produce the Cambridge Video Refractor.[5,6]

The Cambridge Video Refractor (CVR) is an isotropic photorefractor in which the light source is mounted on a video camera. Three flash photographs are taken at different focal lengths. The fundal light reflections are compared and analysed on the monitor screen. The refractive status of the eye will determine the size and shape of blurred images. The principal meridians of the images are measured to predict refractive error using photographic data empirically calibrated in a computerised system.

In the study of Atkinson, Braddick, Ayling, Pimm-Smith, Howland and Ingram[7]

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photorefraction was used to screen 1096 infants aged 6 to 9 months. Those cases that were considered to have a significant refractive problem were followed up. Of those reviewed, retinoscopic refraction confirmed the photorefractive findings, with the only significant discrepancy being the anisometropes.

The Cambridge Video Refractor (CVR) was introduced to Australia in April, 1988. The Orthoptic and Ophthalmology Departments of The Children's Hospital, Camperdown were interested in this equipment, as the departments are involved in numerous visual screening programmes, as well as the promotion of preventative eye health and education of other groups performing vision screening.

Members of the departments had no previous experience with the CVR, so there was considerable interest in its effectivity and its ability to significantly improve current screening techniques.

The current study was therefore undertaken to evaluate the CVR's value as a screening tool. Prior knowledge of the demands of large scale vision screening programmes enabled the researchers to establish criteria for an effective screening tool, and it is against the following criteria that the CVR is evaluated:

- It should provide a consistent indication of significant refractive error and the need for formal follow-up.
- It should be effective without cycloplegia.
- It should be suitable for use by non-technical staff.
- The cost of the equipment should be acceptable.
- The equipment should be portable.
- The procedure should be rapid.

During this investigation, only the refraction component of the CVR function was evaluated, although it is acknowledged that it may also be used to detect strabismus.

METHOD

The subjects were patients of The Children's Hospital Eye Clinic undergoing either initial assessment or routine review of visual function and refractive error.

The visual acuity and orthoptic status of all subjects was initially assessed. Patients and parents were informed of the CVR's function and the evaluation project discussed.

A total of 62 subjects were involved in the study but in some cases it was only possible to test one eye. Ages ranged from 4 months to 16 years (mean age 4 years 11 months). (See figure 1). This sample was considered to represent a cross-section of patients seen in The Children's Hospital Eye Clinic who were available for testing during the trial period, including patients with a wide range of paediatric ocular and general conditions.

The results of video refraction on 101 non-cyclopleged eyes were compared with cycloplegic refraction, and an additional comparison of the video refraction of 83 cyclopleged eyes to their cycloplegic refraction was made.

The first series of photos were taken, in accordance with the CVR manual, with the subject seated 75cm from the camera and the lens aperture set at 0.75m to produce the "pupil photo", then repeated with lens settings of 1.5m and 0.5m to create the "blur photos". The subject's attention was directed towards a toy or the examiner's face, positioned just above the camera. The room was dimly lit.

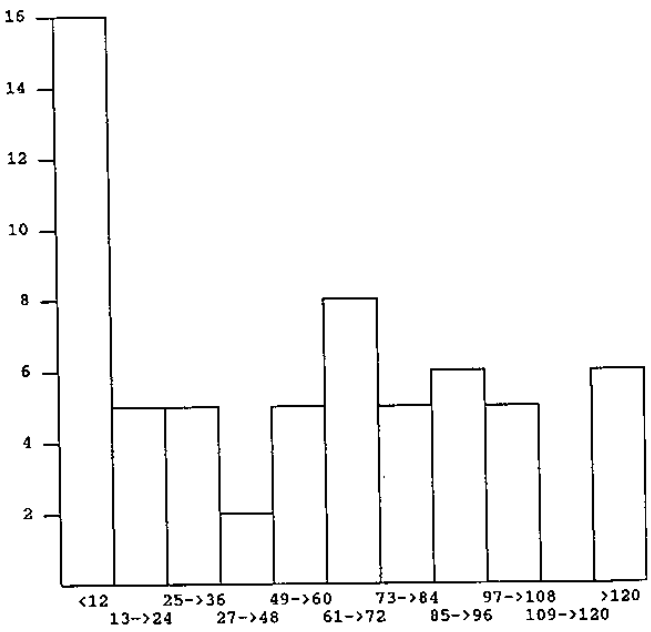

Figure 1: Frequency distribution of subjects by age.

TABLE 1
Video Refraction Predictions
Accuracy to within 1.0D and 20°

Non cycloplegic video refraction vs Retinoscopic refraction N = 101

		Hyper-metropic	Hyper. Astig	Myopic	Myopic Astig	Mixed Astig
Total No.		54	17	14	5	11
Correct	42	30	1	7	3	1
	41.6%	55.5%	5.9%	50%	60%	9.1%
Incorrect	59	24	16	7	2	10
	58.4%	44.4%	94.1%	50%	40%	90.9%

Cycloplegic video refraction vs Retinoscopic refraction N = 83

		Hyper-metropic	Hyper. Astig	Myopic	Myopic Astig	Mixed Astig
Total No.		49	20	1	1	12
Correct	43	34	5	—	—	4
	51.8%	69.4%	25%	—	—	33.3%
Incorrect	40	15	15	1	1	8
	48.2%	30.6%	75%	100%	100%	66.7%

The video and computer equipment was utilised to make the appropriate measurements of the focused and defocused photos. The relevant details of the resulting "video refraction" were recorded.

Where a myopic error was indicated, the procedure was repeated with the subject positioned 1m from the camera and the lens aperture set at 1m, 3m and 0.6m.

Cycloplegia was obtained using two to three drops of Cyclopentolate 1%OU. When possible the video refraction was repeated following cycloplegia. Unfortunately, due to the constraints of a busy Eye Clinic, not all subjects received a non-cyclopleged and cyclopleged video refraction.

Retinoscopic refraction was performed by an ophthalmologist. Retinoscopy was used as the reference, as it is a traditionally accepted method of evaluating refractive errors in children.

Results of non-cyclopleged and cyclopleged video refraction and cycloplegic retinoscopy were charted, with note made of the ophthalmologist's working distance.

RESULTS

Cases of hypermetropia, hypermetropic astigmatism, myopia, myopic astigmatism, mixed astigmatism and anisometropia were considered. Astigmatism was considered to exist when the refraction varied by more than 1.0D between the axes. Anisometropia was defined as a difference in refraction between the eyes of more than 1.0D.

Evaluation was made with acceptable limits of accuracy set at 1.0D and 20° (ie video refraction prediction must be within 1.0D and the axis be within 20° of the cycloplegic refraction to be considered accurate). Using these limits the predictions of the CVR were correct in 41.6% of cases of non-cycloplegged video refraction, and 51.8% of cycloplegged video refractions. (See Table 1).

Correlation co-efficients have been calculated to further compare the results of non cycloplegic and cycloplegic video refraction, to cycloplegic refraction. Table 2 presents these results. For the purpose of detailed analysis, the two meridians and each axis are considered separately.

The extent of variability shown by these figures is rather concerning and is perhaps an indication of the CVR's lack of consistent reliability. Whilst the correlation coefficients for each meridian are around 0.5 or higher, the best, 0.78 is still not sufficient to justify the clinical reliability of the test. We consider a correlation of at least 0.8 for each meridian a minimum requirement. In particular, the low correlations between the axes of astigmatism should be noted.

TABLE 2
Correlation Coefficients for Non cyclopleged & Cyclopleged
Video refraction vs Retinoscopic refraction

	Retinoscopic refraction			
	Meridian 1	Axis 1	Meridian 2	Axis 2
Video refraction non cyclopleged				
Meridian 1	0.69			
Axis 1		0.44		
Meridian 2			0.49	
Axis 2				0.27
Video refraction cyclopleged				
Meridian 1	0.78			
Axis 1		0.17		
Meridian 2			0.58	
Axis 2				−0.06

The CVR predicted anisometropia correctly in 72.7% of the non-cyclopleged video refraction group and 66.7% of the cyclopleged video refraction group. (See Table 3).

DISCUSSION

The comparison of video refraction and retinoscopic refraction produced rather disappointing results. Correlation values for the non cyclopleged video refraction group are below R = 0.69, and in the cyclopleged group R = 0.78 or less. At best, the CVR was found to have a reliability level of 51.8%, working with 1.0D error (ie 2.0D range) and 20° range, on cyclopleged patients.

Our findings do not reflect the result reported by the Visual Development Unit, where results of retinoscopic refraction confirmed the video refraction findings, in their group of 6 - 9 month old, cyclopleged infants.[7] They found a correlation of R = 0.77 or higher when photorefraction was compared to retinoscopic refraction.

There are a number of distinct differences in the Cambridge and Camperdown groups. The smaller number of subjects in the current group may detract from its significance, however, the trends observed in this group left the researchers reluctant to continue. The age range may also have influenced the results as this study made no attempt to restrict the age of subjects to the 6-9 month range used in Cambridge, but we did not observe an improvement in accuracy in the younger subjects. In fact, the reliability fell from 78.3% to 47.3% when cyclopleged infants under nine months only were considered.

Problems encountered during the trial of the CVR were numerous. Controlling the accommodation of the non-cyclopleged subjects during video refraction is an area of concern which is common to any form of non-cycloplegic photorefraction. As suggested by the CVR Manual, the subject's fixation was directed toward a toy or the examiner's face, positioned directly above the camera. However, we observed numerous cases of "over-accommodation" in the younger subjects, resulting in a false indication of myopia in the non-cycloplegic video refraction. It is realised

TABLE 3
Video Refraction Predictions
Anisometropia > 1.0D

	Non cycloplegic video refraction vs retinoscopic refraction.	Cycloplegic video refraction vs retinoscopic refraction
Total No.	11	12
Correct No.	8	8
	72.7%	66.7%
Incorrect No.	3	4
	27.3%	33.3%

that cycloplegia is recommended for CVR, but in view of our evaluation criteria, we felt compelled to assess a non-cycloplegic group.

The subjective nature involved in performing video refraction measurements prevented not only standardisation between examiners, but also between consecutive assessments by a single examiner. The "blur circle" seen in the defocused photos varies in clarity and can have quite a significant indistinct zone. The examiner must make the decision on where to place the measurement cursor on this zone. Error in placement obviously results in inaccuracies in video refraction. The difficulty also occurs in placement of the cursor to determine the axis of astigmatism.

Interesting is the finding that anisometropia was correctly predicted more frequently in the non-cycloplegic group (72.7%) than following cycloplegia (66.7%). This, we believe is also due to the problems of consistently dealing with the blur of the image on the screen.

The evaluation demonstrates that using a cycloplegic agent improves the CVR's ability to predict refractive error from 41.6% to 51.8%. Although the accuracy with cycloplegia is less than adequate, it is apparent that many refractive errors would go undetected if a video refraction screening programme were attempted without cycloplegia.

The accuracy and consistency of the video refractor as demonstrated by these findings, must be considered in terms of the CVR's intended role as a screening tool. It is not designed to replace retinoscopic refraction, but rather as a screening tool to indicate when a significant refractive error is present and formal follow-up is required. Hence it should not be expected to exactly determine refractive error. Taking this into consideration, and even when the evaluation extended the range in which video refraction would be considered correct the results suggest an element of unreliability. When the prediction was allowed to be within 2.0D of retinoscopic refraction, the accuracy only improved to select 67.3% of the non cyclopleged group and 78.3% of the cyclopleged video refraction group. With this generous range, the CVR predictions were incorrect in 22.7% of the subjects tested, which would produce a high level of errors in a screening programme.

The Cambridge Vision Development Unit advocate the suitability of the CVR for use by non-technical staff, after a short training period, though they actually employ an orthoptist for this task. The video refraction examiners in this study were all experienced orthoptists, who have a comprehensive understanding of the optics of refraction and video refraction. The confidence of the examiners did improve during the trial period, but the accuracy of results continued to be disappointing and were not felt to be influenced by a "learning curve".

The cost of the CVR is certainly prohibitive to the organisations involved in vision screening known to The Children's Hospital. Whilst it is well accepted that results of treatment of stimulus deprivation amblyopia will be more effective if the condition is detected and treated early, we were not able to demonstrate that the CVR significantly improved the results of screening to a level which could be equated to its cost.

Many vision screening services have adopted the philosophy of taking the service to the people, in order to reach the largest and most needy population. The screening venue may move frequently. Equipment must therefore be portable in this setting. Immediate access to the photorefractor images is a major advantage of the CVR's video camera and monitor system, which is not possible with many other photoscreening techniques. There is however, no facility to store the images. Other groups are reported to be developing a Polaroid system, that will combine the features of "instant results" and permanent images. The CVR can be moved successfully, but it is fragile, heavy, awkward and difficult.

CONCLUSIONS

The CVR has been evaluated in terms of its intended role as a tool to assist in screening for refractive error using an on-axis technique.

This study found that results obtained by cycloplegic video refraction were closer to retinoscopic refraction than were the results of

non cycloplegic video refraction. However, with a range of 2.0D permitted for video refraction to be considered correct, the level of accuracy of the video refractor was disappointing.

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