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Treatment of amblyopia with the CAM vision stimulator: a review

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Abstract

Recent reports on the CAM vision stimulator have generated great interest because of the effectiveness and simplicity of this form of treatment for amblyopia. Results have shown rapid improvements in visual acuity and contrast sensitivity without any adverse side effects. The efficacy of the CAM vision stimulator was comparable to conventional occlusion. However, the contibution of grating stimulation to the gains in vision were insignificant. The improvements were attributed to short term occlusion in association with intensive use of the amblyopic eye.

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Treatment of Amblyopia with the CAM Vision Stimulator: A Review

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with the CAM Vision Stimulator:

A Review

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Evaluation

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The management of amblyopia takes up a large part of the working life of most vision care specialists. Amblyopia affects between 1% and 5.5% of the children in this country (1). It is defined as reduced visual acuity not corrected by refractive means and not attributed to obvious structural and pathological anomalies (2).

Our understanding of amblyopia has blossomed over the last two decades (3-5); Yet the treatment has remained essentially unchanged for over 200 years. Although new forms of therapy have been introduced, treatment by correction of the refractive error followed by occlusion therapy developed by deBuffon in 1746 (6) has stood the test of time.

Recent reports on a controversial new treatment for amblyopia (7-9) have generated great interest because of the magnitude of the clinical problem and the simplicity of the proposed treatment.

Occlusion therapy

1. Full time occlusion

The efficacy of conventional full time occlusion has been shown in children (10) as well as adults (11). Although reductions in the original visual acuity improvements have been observed in follow-up studies, a patch has generally been considered "the most effective, cheapest and easiest method of treating squint amblyopia"(12).

It has been suggested by some that occlusion should be

total and continuous so long as the deviation remains uniocular and so long as any improvement in the deviating eye takes place. A positive attitude towards occlusion is essential throughout therapy if it is to prove successful. However, the speed with which the deviating eye improves varies considerably. Prolonged occlusion is a psychologically and educationally disruptive technique and its failure rate is high among children (13).

2. Part time occlusion

Others have found part time occlusion in connection with active stimulation of the amblyopic eye sufficient. Improvement in vision is more rapid if the vision of the deviating eye is stimulated by organizing tasks suitable for the age of the child such as playing with toys, watching television or constructing jigsaw puzzles (13,14). As an alternative to total occlusion, daily occlusion of the preferred eye for 20 minutes was recommended while the patient was given increasingly difficult visual tasks to perform (7-9). The vision improved almost to the full extent with this treatment. 83% of children improved their acuity to 20/40 or better in the amblyopic eye (63% to 20/30 or better). The results were achieved in an average of 13 weeks. Therapy was more acceptable to the child and the family and there were very few failures because they could not manage the treatment (7-9).

CAM therapy

1. Physiological background

Because of the success of the abbreviated occlusion therapy, careful consideration was given to what would be the most effective stimulus for the visual system during this period of occlusion. Recent experiments help us understand the way in which the normal visual system encodes and analyzes the retinal image (15). They have demonstrated that the animal visual system has channels highly tuned for spatial frequency and orientation (16-18). Similar observations have been reported in the study of the human visual system (19,20). If amblyopia is a disorder affecting the visual cortex, perhaps the entire population of cortical neurons involved in the development of amblyopia could be activated and receive optimal visual stimulation by concentrated viewing of a range of high contrast gratings of continuously changing orientation and selective spatial frequency. This should then result in improved visual function (7-9,21).

These experiments along with the management problems of occlusion therapy prompted F.W. Campbell to develop a new therapeutic technique for amblyopia. A device was constructed on which sharp edged high contrast gratings were placed and rotated so as to occupy all orientation positions. The high contrast stimulus minimized the effects of reduced contrast sensitivity in the amblyopic eye and maximized cortical cell

stimulation. Gratings corresponded to the spatial frequency channels affected and their rotation stimulated a large number of orientation channels. If stimulation of these channels improved their function then the therapy should have improved vision (22).

2. Methods

This new approach to therapy was tested on a wide selection of amblyopic children. All patients had full ocular examination including a cycloplegic refraction and orthoptic assessment. Any refractive error was fully corrected. The visual acuity was measured according to standard procedures. Contrast thresholds of the normal and the amblyopic eye for low, medium and high spatial frequency gratings were assessed with simplified clinical plates. This procedure established what grating size should be used for treatment since some amblyopes have a contrast sensitivity abnormality for fine gratings whereas others have an abnormality for all size gratings (23). If the amblyopic abnormality was limited to only medium to high frequencies then only spatial frequencies in this range (8 or 16 cpd) were selected for treatment and subsequent assessment. On the other hand if the abnormality extended to include low as well as high spatial frequencies, a low spatial frequency (0.5 cpd) was selected initially. After therapy the contrast threshold was used along with acuity measurements for assessing visual performance (7-9).

Treatment consisted of viewing an apparatus on which any

one of a selection of high contrast square wave gratings having spatial frequencies of 0.5, 1, 2, 4, 8 or 16 cpd were rotated slowly at 1 rpm underneath a clear plastic cover. In order to ensure concentration on the stimulus the child played games or drew pictures on the transparent plate in front of the gratings using the amblyopic eye. If possible, two children matched for age and intelligence were seated in front of the apparatus as they tended to concentrate better in such circumstances. The length of the treatment was standardized at seven minutes. Depending on the contrast threshold either the same grating was used during the entire session or a finer grating was introduced (7-9).

No occlusion was pescribed between treatments. Treatment was concluded when three consecutive sessions showed no improvements in visual acuity. The orthoptic assessment was repeated at the end in order to determine the next stage of the patient's care (7-9).

3. Results

The preliminary findings suggested that this new form of therapy improved vision in the amblyopic eye much faster and more completely than any current method. 48 out of 50 amblyopic children showed improved acuity of the amblyopic eye both for distance and for near, 73% achieving 20/40 or better (8). Significant improvements were obtained after only three seven minute treatment sessions. The number of treatments required to produce a maximal acuity varied

considerably, however, the average being five sessions. Contrast threshold measurements also improved for both low and medium spatial frequencies. Patients with no previous treatment for amblyopia improved marginally more than those previously treated (7). The regression in visual acuity after terminating treatment was at most one snellen line (7-9).

Campbell and his colleagues urged others to further assess the effectiveness of this new device- called the CAM vision stimulator- on a large number of children and adults. There have been many studies since. They ranged in scope from case studies of single patients (24-28) to controlled studies using a large number of subjects (29-32). Most patients were young amblyopic children but the device was studied in older patients as well (31,33). Many investigators followed the recommended procedure for CAM stimulation (7) but there were variations (34). The frequency and number of treatment sessions were not constant; short term or long term therapy was carried out daily, weekly or monthly. Some patients played games during the sessions (7) while others simply fixated at the rotating disc (33). The size and number of the gratings and the viewing distance were other variables.

The response to therapy also varied (31,35-37). Some patients improved significantly, others modestly and some not at all. Improvemnent was rapid and dramatic at times (9,38,39). Large improvements in vision were reported after a short exposure to CAM. It was called by some an important addition to amblyopia therapy (40-42). Others found no

significant improvement following short term or long term CAM stimulation (33,43) and did not consider it a useful method of treatment (37).

a. Improvements in visual acuity

Visual acuities of amblyopic children are usually unreliable findings (50). They represent a non-static function capable of variation (37). Contour interaction exhibited by amblyopes can complicate testing (51). Children can also learn and remember letter charts and their motivation, concentration and cooperation may vary (37). Conventional Snellen charts are not suited for testing of acuity in such children (37). An ideal visual acuity chart would minimize memorization. The acuity levels would be incremented in equal amounts and at each level there would be an equal number of test letters spaced equally apart - thus minimizing the effects of contour interaction (52). The multiple Landolt ring chart (32) and the Bailey-Lovie chart (29,52) utilized in some studies are such tests valuable for assessing amblyopic acuities. However, most investigators studying the CAM vision stimulator used the linear Snellen charts and the Sheridan-Gardiner single optotypes (49,53).

The initial good results of therapy were confirmed by a majority of the studies that followed (40,44-47). Improvement in acuity was reported in 50% (35) to over 90% of the patients (47,48) and case studies showed substantial gains after only a few therapy sessions (7,24,25). However, a

number of investigators reported little or no effects on visual acuity following CAM therapy (32,34,49). The unpredictable nature of the effects of treatment were reported by the original investigators (9) and others (30).

The greatest degree of improvement was in near vision (36,40,44,54,55) and in linear acuities (43). There was no correlation between visual acuity improvement and the type of amblyopia (29) or patient's history of treatment (29,49,53). Previously occluded patients, however, needed more therapy sessions to reach their maximum visual acuity (44). A lack of correlation was also reported between response to therapy and age (38,49,56) though some found younger children more likely to improve with treatment (45). Heterophoric patients showed improvements more often than heterotropes (36) and patients with lower initial acuities showed greater gains in visual acuity (29).

b. Improvements in contrast sensitivity

Improvement of the contrast threshold following CAM therapy has been reported in many patients (7,43,48,57,58). In some cases the contrast sensitivity function improved in the absence of gains in visual acuity indicating that vision can improve for low and middle spatial frequencies before high frequencies (7,23,57). As many as 50% of the patients who did not show any changes in visual acuity have shown improvemnts in contrast sensitivity (58). Snellen acuity is concerned with high spatial frequencies only; it is not

indicative of all changes. As an alternative, some investigators have used scores on the Arden gratings and reported significant improvement (48). The therapy improves visual function over the spatial frequency range of the gratings used. Contrast sensitivity normalization even for a restricted range of spatial frequencies is a valuable gain in the visual ability of the amblyopic eye (58).

c. The role of fixation

Patients with eccentric fixation and those with central fixation improved at different rates (7-9); eccentric fixators were considered poor responders to therapy by many investigators (45,53,59). Yet some have found no significant difference in the response of the two groups (32) and others have reported substantial improvements in the visual acuity of eccentric fixators following therapy (44). The treatment itself has improved fixation occasionally (9,27).

d. Maintenance of improvement

Varying amounts of visual acuity regression were observed in many patients once the treatment was completed (31,59-61), but spontaneous improvements after the completion of therapy were rarely reported (59,61). Maximum vision dropped in as many as 40% to 50% of the subjects (53,56). Poor maintenance of the contrast sensitivity improvements were also reported (57). Patients with nystagmoid fixation jerks and those who exhibited crowding or distortion were

more likely to show slippage (59,61). To retain the improvements in vision follow-up assessment and therapy were recommended (55-57).

e. Side effects

An initial concern with the CAM vision stimulator was the possibility that a rapid improvement in vision would induce intractable diplopia in a patient who had suppressed vision in the amblyopic eye (9,36). However, such a side effect was not reported in any of the studies.

4. CAM vs occlusion

The success rate for the CAM vision stimulator compared favorably with the conventional methods of occlusion(7,40,62) In strabismic amblyopes CAM was comparable to traditional occlusion; in anisometropic amblyopes it was more effective (42).CAM stimulation was useful where occlusion had failed (44,48,56); previously treated patients showed further improvements following therapy (7).CAM in conjunction with routine occlusion produced an even faster rate of visual improvement (26). Some investigators, however, considered such results as support, not for CAM stimulation but for the effectiveness of occlusion for short periods in association with concentrated visual tasks (42).

5. The role of the gratings

Controlled studies were carried out to determine the

contribution of the gratings in CAM therapy. The experimental groups were exposed to rotating gratings while the control groups observed homogeneous gray discs (29,31,43) or rotating black and white pictures (49). Other controlled studies introduced a variation of CAM therapy where the treatment group played video games with superimposed moving stripes on the screen while the control group played games without the superimposed stripes (30,31).

Experimental and control results were indistinguishable (29-31,34,43,61). There was no difference in the rates of response to treatment or in the tendency to maintain or improve vision once the treatment was completed (29). Grating stimulation did not contribute to the degree or the rate of improvement (29,34,39,43,49) and it did not affect the immediate or long term outcome of therapy (31).

Improvements in vision were attributed to other aspects of therapy. They included intensive use of the amblyopic eye performing detailed visual tasks and visuomotor activities and short term occlusion during the time required for testing and treatment (28,29,56,60,63). Patient attentiveness and cooperation may have improved (31,49,60) as well as the enthusiasm of the patient and his therapist (29,49). Furthermore, visual acuity changes could be credited to non-specific improvements that occur with any treatment (29) or to the training effects that occur during repeated acuity testing (28,29,49,60,64).

Conclusions

Many new forms of amblyopia treatment have been introduced since the pioneering work by deBuffon (6). CAM stimulation is similar to a form of therapy introduced by Arneson in the U.S. during 1930's. His "visual gyrations" used binocular stimulation, colored grating patterns and faster clockwise and counterclockwise rotation (65). CAM therapy generated much more interest, however, since it seemed to produce maximum results in minimum time.

Reported benefits of the CAM vision stimulator were numerous. It was easy and simple to administer (38,54) and worked rapidly (7,27,39,59). Therapy was more readily accepted and enjoyed by the patient minimizing frustration and improving cooperation (7,28,38,54,59). None of the educational, psychological or social side effects of occlusion were reported (7,26,38,39) since the treatment sessions were far less traumatic than a patch (54,59). It was also effective for patients who had failed to respond to conventional occlusion (39,48).

There was good reason from research on the normal visual function (15-20) to attribute improvements in vision to a short intensive stimulation of the spatial frequency and orientationally selective cells in the visual cortex by the rotating gratings (7-9). However, controlled studies have found the contribution of the gratings to the results of therapy insignificant. They support the claims for the

effectiveness of short term occlusion in conjunction with detailed visual tasks and visually guided motor activity (29,66).

The physiological aspects of the treatment remain conjectural and the etiology of amblyopia remains uncertain; yet the fact that the mechanisms are not understood does not detract from the observation that in many studies visual acuity and contrast sensitivity have been improved within a very short period of time (7-9). Undoubtedly amblyopic children and their parents would be spared much distress if alternatives to conventional occlusion could be developed. Therefore amblyopia therapy in the form of short term occlusion in association with intensive use of the amblyopic eye should be studied further along with other forms of treatment such as penalization, prism therapy, indirect occlusion, pleoptics and red lens therapy.

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