Using liquid crystal glasses to treat ambyopia in children

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PURPOSE To evaluate the effectiveness of liquid crystal glasses (LCG) in the treatment of children with monocular amblyopia.

METHODS A total of 14 amblyopic eyes of 14 children with monocular amblyopia were enrolled in the study. LCG with appropriate refractive correction were ordered for each patient. Each patient was examined with the new LCG before treatment and monthly thereafter. The parents were informed about the use, care, and charging of the glasses. Best-corrected visual acuity was measured as Snellen decimal notation and converted to logarithm of the minimum angle of resolution (logMAR) for statistical analyses.

RESULTS The mean age of the study population was 7.4 ± 1.4 years. Ten patients (71%) had anisometropic amblyopia; 2 (14%), strabismic amblyopia; and 2 (14%), mixed amblyopia. The mean follow-up period was 4.0 ± 1.2 months (range, 3-7 months). The mean duration of using LCG was 8.2 ± 2.5 hours daily (range, 4-12 hours). All of 14 patients used the LCG as suggested. The mean logMAR best-corrected visual acuity of the amblyopic eyes was 0.6 ± 0.3 at baseline, improving to 0.3 ± 0.2 at final follow-up ($P < 0.001$). No side effects were observed.

CONCLUSIONS The current study demonstrated that LCG wear improved visual acuity in children with monocular amblyopia. Additional studies are needed to determine whether this effect is due to the LCG on/off feature or to refractive correction alone. (J AAPOS 2015;19: 257-259)

Amblyopia is a major cause of acquired monocular visual impairment.[1] Decreased vision in amblyopia is thought to be caused by an abnormal neuronal network within the primary visual cortex, which can result from refractive errors, strabismus, and stimulus deprivation.[2] It is estimated to affect 1% to 4% of children.[3]

Treatment of amblyopia is based on refractive correction, a period of refractive adaptation, and occlusion of the fellow eye. Patching is commonly used to treat amblyopia.[4-6] One of the main limiting factors in the therapeutic effectiveness of occlusion therapy is compliance. Compliance with patching is difficult because of various factors, such as skin irritation, cosmetic problems, and resistance of the child due to visual, social, and psychological problems.[7,8] Pharmacologic penalization is alternative treatment[8]; however, concern for potential toxicity limits its use in the treatment of amblyopia.

Recently liquid crystal glasses (LCG) have been developed for the treatment of amblyopia. To our knowledge, only 2 studies investigating the effectiveness of these devices in the treatment of amblyopia have appeared.[9,10] These studies investigated the effectiveness of LCG in children with a mean age of approximately 6 years. The present study aimed to evaluate the effectiveness of LCG in the treatment of slightly older children with monocular amblyopia.

Materials and Methods

The study was in accordance with the tenets of the Declaration of Helsinki and was approved by the Ethics Committee of Gaziantep University Medical School. A total of 14 consecutive amblyopic eyes of 14 children with monocular amblyopia were enrolled in this study. Subjects who received treatment for amblyopia during the previous month and who had a history of intraocular surgery, an organic cause of reduced visual acuity, or a history of epilepsy were excluded. All parents were informed about the study and consented to participate.

Each patient underwent a complete ophthalmic examination, including determination of refractive error and best-corrected visual acuity (by Snellen charts), ocular motility examination, slit-lamp examination, and dilated fundus examination at baseline and at each follow-up visit. Best-corrected visual acuity was measured as Snellen decimal notation and converted to logarithm of the minimum angle of resolution (logMAR) for statistical

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Submitted December 8, 2014.
Revision accepted April 3, 2015.
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1091-8531/$36.00
http://dx.doi.org/10.1016/j.jaapos.2015.04.001

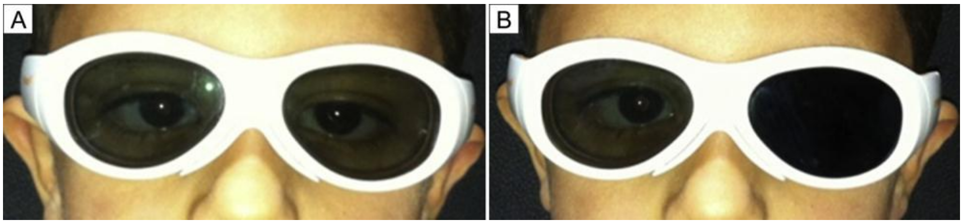

FIG 1. A patient with right eye amblyopia wearing liquid crystal glasses. A, Clear view for the fellow eye with the “off” state. B, Occlusion of the fellow eye with the “on” state.

analyses. Cycloplegia was achieved by administration of 3 drops of cyclopentolate 1%, 1 drop every ten minutes. Refractive error was measured by an autokeratorefractometer, at least 30 minutes after the last drop. Each patient received LCG (Amblyz; Xpand 3D Group, Limassol, Cyprus) with appropriate refractive correction and was examined with the glasses in place at baseline and monthly thereafter. Parents were informed about the use, care, and charging of the LCG. Figure 1 shows a patient wearing LCG.

The working principles of LCG have been described in detail elsewhere.[9] In the present study, the glasses were arranged by the manufacturer to make occlusion for 50% of the time of glasses wear. The “On (occlusion)” time was 30 continuous seconds and the “Off (open)” time was 30 continuous seconds of each minute. The prescription of occlusion time was based on the level of visual deficit and the age of the child. Longer durations were suggested for patients with best-corrected visual acuity worse than 0.4 Snellen decimals and with ages . 6 years. Children were suggested to wear their non-LCG prescription during the time when they were not wearing the LCG. Compliance was assessed according to parents’ declarations about whether the patient used the LCG for suggested time.

Software SPSS version 16.00 (SPSS for Windows software; SPSS Inc, Chicago, IL) was used for statistical analyses. The Wilcoxon test was used to assess visual acuity changes. A *P* value of \0.05 was considered statistically significant. Continuous variables are expressed as mean with standard deviation; categorical variables, as percentages.

Results

The mean age of the study population was 7.4 ± 1.4 years (range, 4.5-10 years). Of the 14 patients included in the study, 9 (64%) were male. Five patients (36%) had amblyopia in the right eye; 9 (64%), in left eye. 10 patients (71%) had anisometropic amblyopia; 2 (14%), strabismic amblyopia; and 2 (14%), mixed amblyopia. The mean follow-up period was 4.0 ± 1.2 months (range, 3-7 months). The mean duration of LCG use was 8.2 ± 2.5 hours daily (range, 4-12 hours).

Descriptive and clinical parameters of the patients are provided in Table 1. The mean logMAR best-corrected visual acuity of the amblyopic eyes was 0.6 ± 0.3 (range, 1.0-0.2) at baseline, improving to 0.3 ± 0.2 (range, 0.8-0.0) at final follow-up. The difference was statistically significant (*P* \ 0.001). All fellow eyes had logMAR best-corrected visual acuity of 0.0, which remained unchanged during the follow-up period. All of 14 patients used LCG as suggested. No side effects were observed.

Table 1. Descriptive and clinical parameters of the patients

Patient	Age, years	BCVA, logMAR		Daily LCG, hours		Follow-up, months
		Initial	Final	Prescribed	Reported	
1	7	1.0	0.3	10	10	4
2	7	1.0	0.3	12	12	3
3	7	0.7	0.5	10	10	4
4	4.5	1.0	0.4	8	8	4
5	10	1.0	0.8	10	10	3
6	10	0.7	0.4	10	10	5
7	7	0.3	0.1	4	4	4
8	9	0.7	0.4	8	8	6
9	8	0.4	0.2	6	6	4
10	7	0.7	0.4	8	8	4
11	6	1.0	0.0	10	10	7
12	7	0.2	0.0	4	4	3
13	8	0.7	0.4	8	8	3
14	7	0.2	0.1	6	6	3

BCVA, best-corrected visual acuity; *LCG*, liquid crystal glasses; *logMAR*, logarithm of the minimum angle of resolution.

Discussion

In the current study, use of LCG improved visual acuity of children with monocular amblyopia caused by anisometropia, strabismus, or both. The glasses were well tolerated by patients and accepted by parents.

Occlusion therapy has been demonstrated to be an effective treatment for amblyopia.[11] However, it has also been reported that compliance with patching was low, and the success rates of treatment were associated with the compliance.[7,12,13] Wallace and colleauges[7] evaluated compliance with occlusion treatment of amblyopia in 152 patients in the Monitored and Randomized Occlusion Treatment of Amblyopia Studies (MOTAS and ROTAS), using objective monitoring, and found that compliance with patching treatment was \50%. Lithander and colleauges[14] reported patching therapy outcomes of 44 children with strabismic and anisometropic amblyopia and found that adherence with the treatment was the most important factor affecting treatment success rate. Although the success rate of the treatment was 97% (35/36) among the compliant children, it was 50% (4/8) among noncompliant children. In addition, long treatment periods were needed for noncompliant children.

Occlusion therapy for amblyopia is also achieved by means of pharmacological penalization with cycloplegic eyedrops (atropine or another long-acting agent) to the fellow eye. The advantage of pharmacologic penalization is its simplicity of application and low cost. Nevertheless, pharmacologic penalization has potential toxicity.[8] Owing to the aforementioned limitations of both patching and atropine, alternative penalization methods are desirable.

LCG have been introduced to provide a new approach for the treatment of amblyopic patients. LCG have an electronic shutter in the refractive lens. When an electrical input affects this shutter, the spatial orientation of the suspended molecules within the spectacles changes. As a result, the rotated light is obstructed by the outer polarizing film and an "opaque" lens occurs. The shutter interchanges between transparent (off/open) and opaque (on/close) states. The on/off durations can be adjusted according to the suggestion of ophthalmologist.[9]

To our knowledge, only 2 previous studies reported treatment outcomes of LCG therapy for amblyopia.[9,10] BenEzra and colleauges[10] used LCG in 10 children with amblyopia. They stated that liquid crystal technology could be used for spectacles to perform an electronic, controlled, intermittent occlusion of the sound eye to provide visual stimuli input to the amblyopic eye. Spierer and colleauges[9] assessed the use of LCG in the treatment of 24 children with anisometropic, strabismic, and mixed amblyopia. They reported that use of LCG to treat amblyopia was successful and well accepted by children and parents. Our results accord with the results of these previous studies. Our study added 14 patient outcomes to the limited literature about LCG. The "on" state of these devices acts as penalization and diminishes patient's vision to 0.2-0.3 levels. This working principle and consecutive on/off periods within a minute might provide high patient compliance.

The present study had several limitations. First, we did not have binocular vision measurements. Second, all patients had monocular amblyopia. Therefore, we programmed the LCG for monocular occlusion. (These devices can be programmed for alternate occlusion.) Third, a refractive adaptation period was not established before starting LCG. Accordingly, it is possible that the improvement of best-corrected visual acuity might be attributed to refractive correction. Finally, the source of the data for evaluating the compliance was the parents of the subjects.

In conclusion, in the current study visual acuity in children with monocular amblyopia improved following LCG treatment. Additional studies are needed to determine whether this effect is due to the LCG on/off feature or to refractive correction alone.

References

1. Leon A, Donahue SP, Morrison DG, Estes RL, Li C. The age-dependent effect of anisometropia magnitude on anisometropic amblyopia severity. J AAPOS 2008;12:150-56.
2. DeSantis D. Amblyopia. Pediatr Clin North Am 2014;61:505-18.
3. Simons K. Amblyopia characterization, treatment, and prophylaxis. Surv Ophthalmol 2005;50:123-66.
4. Pradeep A, Proudlock FA, Awan M, Bush G, Collier J, Gottlob I. An educational intervention to improve adherence to high-dosage patching regimen for amblyopia: a randomised controlled trial. Br J Ophthalmol 2014;98:865-70.
5. Tang EW, Li BC, Yeung IY, Li KK. Occlusion therapy in amblyopia: an experience from Hong Kong. Hong Kong Med J 2014;20:32-6.
6. Matta NS, Silbert DI. Part-time vs. full-time occlusion for amblyopia: evidence for part-time patching. Am Orthopt J 2013;63:14-18.
7. Wallace MP, Stewart CE, Moseley MJ, Stephens DA, Fielder AR. Monitored Occlusion Treatment Amblyopia Study (MOTAS) Cooperatives; Randomized Occlusion Treatment Amblyopia Study (ROTAS) Cooperatives. Compliance with occlusion therapy for childhood amblyopia. Invest Ophthalmol Vis Sci 2013;54:6158-66.
8. Kaye SB, Chen SI, Price G, et al. Combined optical and atropine penalization for the treatment of strabismic and anisometropic amblyopia. J AAPOS 2002;6:289-93.
9. Spierer A, Raz J, Benezra O, et al. Treating amblyopia with liquid crystal glasses: a pilot study. Invest Ophthalmol Vis Sci 2010;51:3395-8.
10. BenEzra O, Herzog R, Cohen E, Karshai I, BenEzra D. Liquid crystal glasses: feasibility and safety of a new modality for treating amblyopia. Arch Ophthalmol 2007;125:580-81.
11. Taylor K, Powell C, Hatt SR, Stewart C. Interventions for unilateral and bilateral refractive amblyopia. Cochrane Database Syst Rev 2012;4:5137.
12. Awan M, Proudlock FA, Gottlob I. A randomized controlled trial of unilateral strabismic and mixed amblyopia using occlusion dose monitors to record compliance. Invest Ophthalmol Vis Sci 2005;46:1435-9.
13. Stewart CE, Fielder AR, Stephens DA, Moseley MJ. Treatment of unilateral amblyopia: factors influencing visual outcome. Invest Ophthalmol Vis Sci 2005;46:3152-60.
14. Lithander J, Sjöstrand J. Anisometropic and strabismic amblyopia in the age group 2 years and above: a prospective study of the results of treatment. Br J Ophthalmol 1991;75:111-16.