Treatment of symptomatic convergence insufficiency with a home-based computer orthoptic exercise program

Angela Serna, BAppSc(Orthoptics), MPH, David L. Rogers, MD, Mary Lou McGregor, MD, Richard P. Golden, MD, Don L. Bremer, MD, and Gary L. Rogers, MD

PURPOSE To determine the efficacy of a home-based computer orthoptic program to treat symptomatic convergence insufficiency.

METHODS A retrospective review of consecutive patients with symptomatic convergence insufficiency treated with a home-based computer orthoptic program was performed. Symptomatic convergence insufficiency was defined as: near point of convergence (NPC) >6 cm, decreased positive fusional vergence, exophoria at near at least 4^{Δ} greater than at far, and documented complaints of asthenopia, diplopia, or headaches with reading or near work. The Computer Orthoptics CVS program was used for this study. Before beginning the computer orthoptic program, patients with an NPC >50 cm were given 4 base-in prisms and push-up exercises (NPC exercises with an accommodative target) for 2 weeks.

RESULTS A total of 42 patients were included. Mean treatment duration was 12.6 weeks; mean follow-up, 8.5 months. Of the 42 patients, 35 were treated with the home-based computer orthoptic program and push-up exercises; the remaining 7 only used the computer orthoptic program. Because of a remote NPC, 5 patients were given base-in Fresnel prism before starting treatment. Baseline mean NPC was 24.2 cm; posttreatment mean NPC improved to 5.6 cm: 39 patients (92.8%) achieved an NPC of ≤6 cm ($p < 0.001$). Positive fusional vergence improved in 39 patients (92.8%). Fourteen patients reduced their near exophoria by $\geq 5^{\Delta}$. A total of 27 patients (64.2%) reported resolution of symptoms after treatment.

CONCLUSIONS In our study, home-based computer orthoptic exercises reduced symptoms and improved NPC and fusional amplitudes. The computer orthoptic program is an effective option for treating symptomatic convergence insufficiency. (J AAPOS 2011;15:140-143)

Convergence insufficiency is a disorder characterized by inability to comfortably maintain binocular eye alignment at near. Von Graefe[1] described this as early as 1855. The symptoms of convergence insufficiency are varied and can include headache, asthenopia, and blurred vision or diplopia with near work or while reading. Patients can be asymptomatic or severely affected, and symptoms do not necessarily correlate well to objective findings.[2] For example, patients with a small-angle exophoria at near can have severe symptoms whereas others with similar objective findings can be asymptomatic. Objective findings will typically include a receded near point of convergence (NPC), an exophoria or intermittent exotropia at near, and a reduced positive fusional convergence amplitude.[3] The reported incidence of convergence insufficiency is between 2.4% and 8.3%.[4,5]

Treatment for this condition can include both passive and active orthoptic therapy and, in rare circumstances, surgery. Passive treatment may include simple observation, a prescription for reading glasses, or the use of base-in prisms. Active orthoptic training can be either home or office based. It is not uncommon for a combination of these treatment options to be used simultaneously.[3] Numerous reports in the literature support the use of orthoptic treatment to improve fusional amplitudes and the NPC in convergence insufficiency[3,6-9]; however, there is no accepted standard of care in the treatment of these patients. The purpose of this retrospective study is to evaluate the effectiveness of home-based computer orthoptic exercises in the treatment of convergence insufficiency.

Methods

A retrospective chart review was performed on all newly diagnosed patients seen and treated for convergence insufficiency at Nationwide Children's Hospital between November 2007 and January 2009. The study was approved by the Institutional

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Author affiliations: Nationwide Children's Hospital, Department of Ophthalmology, Columbus, Ohio

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Reprint requests: David L. Rogers, MD, Nationwide Children's Hospital, 555 S. 18th St. Suite 4C, Columbus, OH 43205 (email: david.rogers@nationwidechildrens.org).

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Review Board of Nationwide Children's Hospital and was conducted in accordance with guidelines of the Health Insurance Portability and Accountability Act.

Children 5-18 years of age who were diagnosed with convergence insufficiency on the basis of the following clinical measures were eligible for the study: an NPC break ≥6 cm, insufficient positive fusional vergence at near (ie, failing Sheard's criterion—positive fusional vergence less than twice the near phoria or a minimum positive fusional vergence of 15^{Δ} base-out break)[10]; exophoria at near at least 4^{Δ} greater than at distance; and documented complaints of asthenopia, diplopia, headaches, or reading difficulty.[3] All clinical measures were required for a patient to be included in the study. Patients were excluded from the study if they had a history of previous treatment for convergence insufficiency, strabismus surgery, amblyopia, vertical strabismus, or >1.50 D of anisometropia by spherical equivalence.

All patients were treated with a Computer Orthoptic Home-based Vergence Exercise (CVS) program (HTS Inc; http://www.computerorthoptics.com), with or without NPC exercises with an accommodative target. Patients prescribed convergence exercises were given a tongue depressor with a 20/30 reduced Snellen letter and instructed to keep the letter "single and clear" as they moved it close to their nose. Patients were treated until their NPC measured ≤6 cm or for a total of at least 18 weeks if the NPC did not reduce to normal.

The medical records of eligible patients were reviewed, and the following clinical data were recorded: sex, age, diagnosis, refractive error, best-corrected visual acuity, stereoacuity, distance and near motility measurements, NPC, positive fusional vergence, accommodative amplitude, length of follow-up, number of visits, and documented symptoms. Patients' symptoms were recorded at the initial visit and at the visit when the patient achieved an NPC of ≤6 cm or had performed at least 18 weeks of treatment. Monocular accommodative amplitude was measured by Donder's push-up method with the use of a single 20/30 reduced Snellen target and the Astron International Accommodative rule.[11] Patients with accommodative insufficiency who also had convergence insufficiency were included in the study. They were treated with over-the-counter reading glasses or bifocals and both the CVS computer program and convergence exercises. In the patients found to have a reduced amplitude of accommodation, the power of the reading glasses or bifocal was subjectively and objectively determined by the use of the Donder's push-up method to determine the power that gave the patient a normal range of accommodation (+1.25 D and +1.50 D were the most commonly prescribed reading glasses).

Patients were diagnosed with convergence insufficiency after a complete eye examination was performed. Patients were then seen by an orthoptist for a baseline assessment and treatment administration. All patients in this study were evaluated by the same orthoptist (A.S.), who also performed all baseline and follow-up measurements.

Patients were given personal instruction in the office on how to use the CVS computer orthoptic program at home. Only 3 minutes of convergence and 3 minutes of divergence exercises were prescribed. We have found that patient compliance increases when the exercises are reduced to 6 minutes per day versus 14 minutes, as recommended by the manufacturer. The treatment period ranged from 3 to 30 weeks (mean 12.6 weeks; SD 6.6). Treatment duration was determined by the number of exercise sessions performed at home and not by the number of follow-up visits. Patients are expected to complete approximately 30 sessions of 6 minutes each during the 6-week period before their follow-up. Patient compliance was monitored and rated as good or poor on the basis of how often they did the exercises, as determined by their exercise session printout, which is a function available on the computer program.

Statistics were performed with Statistical Package for the Social Sciences, version 17 (SPSS, Chicago, IL). All tests involved 2-tailed probability levels and post hoc comparisons. Descriptive statistics included mean, standard deviations, and standard error of measurement. Analysis of variance was used to test the hypothesis that groups of means were equal. For pairwise differences, the Tukey honestly significant difference test was used to adjust for multiple comparisons. Two sample *t*-tests were performed to identify differences between individual means. Paired *t*-tests were performed to assess differences in repeated measurements within specific groups of subjects. Linear regression and Pearson correlations were performed to assess relations across variables.

Results

A total of 114 patients were identified, 42 of whom (17 males [40%]) met criteria for inclusion in the study. Of these, 35 were treated with both the computer orthoptic program and push-up exercises; the remaining 7 patients used only the computer orthoptic program. Patient ages ranged from 5 to 16 years (mean, 9 years). The treatment period for all patients ranged from 3 to 30 weeks (mean, 12.6 weeks; SD 6.6), with a mean follow-up period of 8.5 months.

Near Point of Convergence

The mean pretreatment NPC was 24.2 cm (SD 15.3); the mean posttreatment NPC was 5.6 cm (SD 1.14; Figure 1). The effect of treatment on improvement of the NPC was highly significant ($t = 8.06$, $p < 0.001$). The NPC improved to ≤6 cm in 39 patients (92.8%). Of the remaining 3 patients who had a NPC >6 cm after at least 18 weeks of treatment, pretreatment mean NPC was 41.6 cm, and posttreatment NPC was 8.6 cm.

A subset of 35 patients had an NPC >20 cm at the initial visit. Adjunctive treatment with push-up exercises was initiated at the same time as the computer orthoptic program. Very poor convergence did not prevent the NPC from improving to ≤6 cm. Twelve of 15 patients (80%) who had a NPC of ≥25 cm before treatment achieved an NPC of ≤6 cm after treatment, with a mean treatment duration of 12 weeks.

Five patients in the study had a pretreatment NPC of ≥50 cm. Of these, 2 patients had <200 arcsec of stereoacuity. During the in-office computer orthoptic program instruction, these patients were not able to perceive the 3-dimensional images in the program because of their

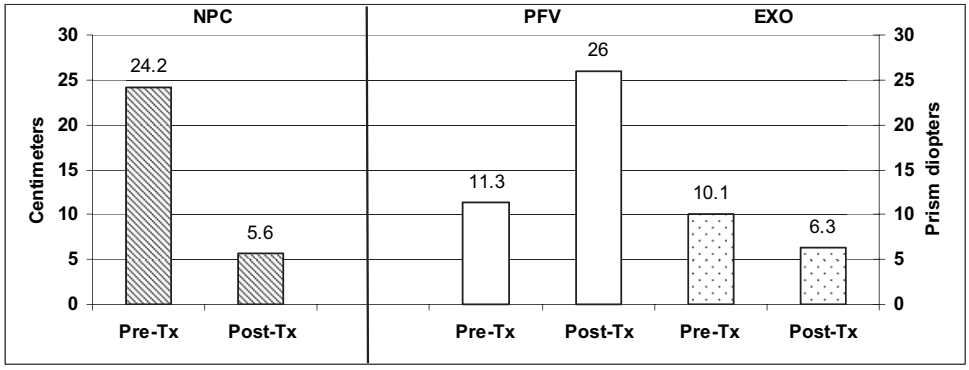

FIG 1. Mean objective outcome measures before and after treatment. *NPC*, near point of convergence; *PFV*, positive fusional vergence; *EXO*, near exodeviation; Tx, treatment.

poor fusion at near. They were prescribed a 4 base-in Fresnel prism plus push-up exercises for 2 weeks before starting the CVS computer orthoptic program in order to improve their NPC to a point where the stereo images on the computer were visible. Once their remote NPC had improved to a more workable distance, both patients were able to get started with the computer orthoptic program exercises.

Positive Fusional Vergence: Convergence Amplitudes at Near

A total of 39 patients (92.8%) achieved a normal positive fusional vergence according to Sheard's criterion after treatment. The pretreatment mean positive fusional vergence was 11.3^{Δ} (SD 4.71); posttreatment mean was 26^{Δ} base-out (SD 5.08; Figure 1). The effect of treatment on positive fusional vergence improvement was highly significant ($t = -14.406$, $p = < 0.001$).

Angle of Deviation at Near

Patients had either a near exophoria or an intermittent exotropia with good, fair, or poor control. The pretreatment mean exodeviation was 10.1^{Δ} (SD 4.54); posttreatment mean was 6.3^{Δ} (SD 2.96) (Figure 1). After treatment, 14 patients (33%) had a reduction of the near exodeviation $\geq 5^{\Delta}$; 1 patient developed an esodeviation. The effect of treatment on the overall reduction in near deviation was statistically significant ($t = 7.007$, $p < 0.001$).

Symptoms

All patients in the study reported asthenopic symptoms before treatment. Many patients complained of more than one visual symptom. The most common complaints were difficulty reading, diplopia, and headaches. Other symptoms reported were frequently losing one's place while reading, loss of concentration, words running into one another, and eye strain. Objective symptoms noted by parents were closure of one eye when reading or doing near work, excessive blinking, and rubbing of eyes. Complete resolution of symptoms after treatment was reported by 27 patients (64.2%); all 42 patients (100%) reported improvement of symptoms. The 15 patients who did not have complete resolution of symptoms did demonstrate normalization of their NPC and positive fusional vergence measurements.

Those patients who reported improvement but not complete resolution of symptoms were found to have issues with compliance. This included both lost computer glasses and computer break-down during the course of treatment. Overall, 7 patients demonstrated poor compliance with treatment whereas 35 had good compliance. All 7 patients who had poor compliance still had improvement of symptoms (4 had improvement of symptoms and 3 had resolution of symptoms) and objective clinical measures.

Accommodative Insufficiency

Accommodative insufficiency was found in 13 patients (30.9%) with convergence insufficiency. The average NPC in this group of patients with both accommodative insufficiency and convergence insufficiency was 26.2 cm pretreatment (range, 8–50 cm), the posttreatment NPC was 6.07 cm. When we compare these NPC values to patients with convergence insufficiency only, the pretreatment and posttreatment NPC values are only slightly better in the convergence insufficiency only group of patients.

Discussion

A recent report by the Convergence Insufficiency Treatment Trial (CITT) Study Group demonstrated that office-based therapy with home reinforcement is superior to other treatments for convergence insufficiency.[3] The CITT study used 3 additional treatment arms: (1) sham treatment in the office with home reinforcement, (2) home-based computer therapy plus pencil push-ups, and (3) home-based pencil push-ups alone. The main outcome measure was the change in symptoms on the basis of the Convergence Insufficiency Symptom Survey. This survey allows the patient to subjectively rate his or her responses to a 15-question symptom survey by using a 5-point scale. The sham-treatment group showed the least improvement

in their NPC and positive fusional vergence measurements; however, based on the symptom survey results, sham treatment was found to be the second most effective treatment modality after office-based therapy with home reinforcement. We believe this can be explained by a bias resulting from the significant one-on-one time the patient had with a study investigator during sham treatment in the office. Additionally, the study was designed to use subjective symptom measures as the primary outcome as opposed to objective signs of the disease. The CITT authors reported that when objective measures are considered, the home-based computer therapy plus pencil push-ups group was found to be the second most effective treatment modality. Many clinicians, including our group, use home-based therapy for convergence insufficiency. Our study demonstrates that a home-based computer orthoptic program can reduce the magnitude of symptomatic convergence insufficiency. We found that both objective and subjective measures improved or resolved with treatment. The fact that not all patients who had normalization of their NPC and positive fusional vergence measures had resolution of symptoms may be explained by the nonspecific nature of the symptoms themselves. For example, up to 30% of all children >7 years of age and as many as one-half of adolescents older than 15 years of age have headaches.[12] It would be reasonable to conclude that a similar number of children with convergence insufficiency could also have headaches unrelated to convergence insufficiency, which may continue to cause headache symptoms after successful convergence insufficiency treatment.

Accommodative insufficiency and convergence insufficiency frequently present at the same time. The rate of comorbidity has been shown to increase with the severity of the convergence insufficiency.[5,13] In 2 population-based studies,[5,12] the comorbidity of accommodative insufficiency and clinically significant convergence insufficiency was found to be 37.5% in patients with one clinical sign (ie, exophoria), 26% for convergence insufficiency with 2 signs (either a receded NPC or a reduced positive fusional vergence), and the comorbidity of 78% in children with all 3 signs of convergence insufficiency (exophoria at near, receded NPC ≥6 cm and a reduced positive fusional vergence failing Sheard's criteria). In our study, all patients presenting with accommodative insufficiency had convergence insufficiency with all three signs.

In conclusion, we found that the patients in our study responded well to treatment in which they used the Computer Orthoptics Home-based Vergence Exercise program. Our results show successful normalization of NPC and improvement in both PFV and near exodeviation. Although symptoms were not formally assessed with a symptom survey, the majority of patients subjectively reported resolution of their symptoms.

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