Treatment of convergence insufficiency

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Introduction

Convergence insufficiency (CI) is a common binocular vision disorder affecting 4-6% of the population.[1,2,3,4] Some have estimated its prevalence to be as high as 8.3% in school-age children and university students.[5,6] In addition to causing discomfort with reading, CI has been shown to have a negative impact on the quality of life and school performance in school-age children.[7] In fact, parents of children with CI are more likely than those of children with normal binocular vision to report difficulty completing schoolwork, avoidance of reading and studying, and distraction during reading.[8] A correlation between CI and attention deficit hyperactivity disorder (ADHD), inattentive type has also been suggested,[9] as a high prevalence of ADHD appears to exist in children diagnosed with CI.[10] Gronlund et al., found a receded near point of convergence in 24% of a group of children with ADHD, but only 6% in the reference group.[11]

First described by von Graefe in 1855, CI was previously thought to be myogenic or even psychogenic in origin, with the asthenopic symptoms manageable by orthoptics treatment, but ultimately incurable.[12] It is currently believed to have an innervational etiology; and only recently has vision therapy been established as an effective treatment.[13] Heretofore, management of CI has comprised of a variety of treatments with little consensus or standard. Treatment modalities have included pencil pushups, in-office orthoptics training, base-in prism reading glasses and computer-based training exercises.[14] As a result of findings from clinical studies conducted by the Convergence Insufficiency Treatment Trial (CITT) Investigator Group, in-office vision therapy supplemented by home reinforcement has now been established as the most effective treatment for primary CI, showing a significant reduction in symptoms in 73% of those treated.[15]

Diagnosing convergence insufficiency

Symptoms: Patients with symptomatic convergence insufficiency will often complain of headaches, blurred vision, diplopia, loss of concentration and sleepiness when reading. They often lose their place when reading, feel that the words move around on the page and need to re-read frequently.[5,16,17,18] In order to determine if these symptoms were significant for CI, the CITT group developed a valid and reliable questionnaire.[19] (Table 1) Patients are asked to rank their responses to the 15 questions on a scale from "never" (0) to "always" (4). The responses are then tallied and multiplied by the set multiplier. A score ≥16 is considered significant.

Underlying Causes: Convergence insufficiency can be either primary or secondary to an underlying etiology. In primary CI, the deviation is comitant and the patient reports long-standing symptoms with a negative health history. Whereas, a secondary CI (or, potentially, a convergence paralysis) may be associated with precipitating factors such as a mild traumatic brain injury, neuro-degenerative disease such as Parkinson's disease, micro-vascular event or secondary to accommodative insufficiency, also known as a pseudo-convergence insufficiency. For the purposes of this article, we will mainly focus on primary CI.

Signs: Primary CI consists of:

1. A receded near point of convergence (NPC) breakpoint

Additional inclusion criteria used by the CITT Investigator group included:

2. Exophoria greater at near than at distance by at least 4 prism diopters, and
3. Positive fusional vergence that is insufficient to meet demands.

Clinical testing: In a younger patient with normal accommodation, NPC can be measured using an accommodative target (2 lines above their threshold near visual acuity, often a 20/30

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Table 1: A copy of the CI Symptom Survey used in the CITT studies. Patients are asked to check their responses in the appropriate column. The responses are then tallied and multiplied by the multiplier shown at the bottom of the questionnaire. A score ≥16 is considered significant for symptoms of CI.

	Never	Infre-quently	Some-times	Fairly often	Always
1. Do your eyes feel tired when reading or doing close work?					
2. Do your eyes feel uncomfortable when reading or doing close work?					
3. Do you have headaches when reading or doing close work?					
4. Do you feel sleepy when reading or doing close work?					
5. Do you lose concentration when reading or doing close work?					
6. Do you have trouble remembering what you have read?					
7. Do you have double vision when reading or doing close work?					
8. Do you see the words move, jump, swim or appear to float on the page when reading or doing close work?					
9. Do you feel like you read slowly?					
10. Do your eyes ever hurt when reading or doing close work?					
11. Do your eyes ever feel sore when reading or doing close work?					
12. Do you feel a "pulling" feeling around your eyes when reading or doing close work?					
13. Do you notice the words blurring or coming in and out of focus when reading or doing close work?					
14. Do you lose your place while reading or doing close work?					
15. Do you have to re-read the same line of words when reading?					
	___x0	___x1	___x2	___x3	___x4
Total Score _____					

target). Use of an accommodative target makes the most of the accommodative demand as well as the accommodative component of convergence, and thus provides the best precision.[20] Maples and Hoenes found that a 5-centimeter breakpoint served as the best predictor for symptomatic children; the CITT group also used a NPC breakpoint of ≥6 cm.[21] Scheiman et al., also found that 85% of adults and children symptomatic for CI possessed a clinical breakpoint of 5 cm and a clinical recovery of 7 cm. In order to evaluate for fatigue, it is recommended to repeat NPC measurements five times, as most of the change occurs between the first and fifth measurement.[20]

A modification of this procedure includes the use of a penlight and glasses with red/green lenses. In patients with normal binocular vision, the NPC should be the same using either an accommodative target or a penlight. However, patients with symptomatic CI, there is a statistically significant difference in both breakpoint and recovery.[20] Patients who, therefore, show borderline measurements using an accommodative target may benefit from being re-evaluated using a penlight and red/green glasses.

Positive fusional vergence can be measured using two methods: using the phoropter for evaluation of smooth vergences or using a prism bar in free-space and an accommodative (20/30) target for evaluation of step vergences. The advantage of step vergence testing is that it can be administered outside the phoropter, which may be beneficial when examining young children. Expected findings are different for smooth versus step vergences. For smooth vergences, Morgan's phoropter expected minimum norms for positive fusional vergence are 17/21/11; for step vergences, norms are 35-prism diopters base out.[22] When considering if the amount of compensating positive fusional vergence is sufficient, one may refer to Sheard's criterion, which states that the fusional reserve to blur point or break point if the patient does not report blur, should be twice the amount of heterophoria. For reference, the CITT study protocol used both Sheard's criterion as well as a minimum PFV of 15 prism diopters base out blur or breakpoint.

Treatment of convergence insufficiency

The CITT Investigator Group is the first to compare treatments for CI in children and young adults using a prospective, multi-center, placebo-controlled, masked randomized clinical trial design. Studied over a period of 12 weeks, their findings determined that the most efficacious form of treatment for CI in school-age children was in-office vision therapy with home reinforcement. In young adults, treatment is still effective, although less so.[23]

In-office Vision Therapy

The studies conducted by the CITT Investigator Group have shown that in-office vision therapy is the only treatment for CI more effective than placebo vision therapy.[24] In-office therapy is typically comprised of a 45 or 60-minute session conducted once or twice a week, with 15-30 minutes of home therapy performed during the week. For reference, the CITT protocol was comprised of 12 weeks of 60-minute weekly sessions in-office, with 15 minutes of home reinforcement on weekdays.

Prior to commencing vision therapy, there are a few general guidelines that help ensure success. Factors that may aid in patient motivation include positive reinforcement and determining a level on which the patient can perform without frustration. Each training session should progress in level of difficulty while remaining sensitive to the patient's frustration levels and engagement.[22]

In addition, it is prudent to consider any prior amblyopia and suppression present prior to starting therapy. It is ideal for the appropriate refractive correction to be in place. While this should not be the case for a patient with symptomatic CI exophoria, the presence of an intermittent or constant strabismus would provide additional barriers that would compromise success. Please note that patients with pre-existing strabismus and amblyopia were excluded from the CITT studies.

In general, the sequence of vision therapy is as follows:

1. Anti-suppression activities and development of physiologic diplopia awareness
2. Monocular activities to normalize accommodative amplitude and facility
3. Activities utilizing monocular fixation in a binocular field, as a precursor to fusional activities
4. Fusional vergence training – both positive and negative
5. Integration of fusional vergence training with binocular accommodation, as well as free space fusion activities

Please refer to Table 2 for a sample list of vision therapy activities.

Table 2: This table illustrates sample vision therapy techniques and the corresponding skills they train.

Skill	Sample activities	Considerations
Anti-suppression	Red-lens activities, e.g., drawing	
	Polarized bar reading	
Gross convergence	Brock String	Also helpful for physiological diplopia awareness
	Barrel Card	
Monocular accommodation	Monocular accommodative rock	Start with +/-2.00 for children, if they are able
	Monocular near-far HART chart	Requires accurate saccades
Fusional Vergence — train positive and negative	Computer Orthoptics	Patient needs to be able to appreciate random dot stereopsis
	Vectograms (Quoits/ Clown) and Tranaglyphs	Smooth or ramp, followed by step or jump therapy
	Bernell-o-Scope	Morgenstern series cards are pediatric-friendly
	Loose prism facility	Available as "prism on a stick"
Binocular Accommodation with fusional vergence	Binocular accommodative rock	Work up to +/-2.50
	Single and Double Aperture Rule	
	Eccentric Circles	ABBA – convergence BAAB – divergence
	Lifesaver Rings	

Although deep suppression is uncommon in an exophoric patient with symptomatic CI, shallow, central, facultative suppression may still be present.[22] Thus, anti-suppression activities are still advisable during the earlier sessions of vision therapy. Anti-suppression activities often utilize red/ green glasses, red lenses, and polarized filters to provide the patient with visual cues regarding suppression. The Wheatstone and Brewster-style stereoscopes (e.g., the cheiroscope) are other in-office tools that can be used to train anti-suppression. The Brock String is also a common and convenient tool used during these beginning stages of vision therapy. There are a variety of techniques to break through suppression, including changing the target contrast or illumination, moving the target or flashing the target. Instruments, such as the stereoscopes mentioned previously, can also provide an artificial environment in which the patient can be more easily anti-suppressed. Once suppression is broken, the patient can be made aware of physiological diplopia.

The next step in vision therapy includes training of monocular accommodative amplitude and facility. These monocular activities often involve the use of lens flippers, as well as varying distances of targets. Some examples of these include monocular distance-to-near Hart chart rock, monocular lens sorting and monocular loose lens rock.[21]

Once suppression has been appropriately broken and accommodative functions strengthened, fusional vergence training can begin. In general, all activities begin where fusion is strongest; in the case of a patient with symptomatic CI, these activities would be at a greater distance. The targets and tools would then be brought closer as the patient's convergence strengthens. The goals of fusional vergence training are to expand both the positive and negative fusional vergence ranges utilizing both the slow, smooth vergence system as well as the step or jump vergence system. Eventually, asymmetric fusional vergences would be trained in lateral gazes.

There are a number of tools used during fusional vergence procedures. For example, one could use vectograms or tranaglyphs, which are available in either variable or nonvariable forms. The variable forms have an adjustable demand, while the nonvariable forms are fixed. Loose prisms can also be flipped or "dipped" to strengthen jump vergences and vergence facility. Other types of stereoscopes that can be used for vergence training in-office include the Bernell-o-Scope and the Aperture Rule trainer. A variety of computer vision therapy software exists for vergence training, including the HTS iNet Computerized Home Vision Therapy program and the Computer Aided Vision Therapy (CAVT) Computer Vergences software package. Regarding free-space tools, one can utilize the Eccentric Circles, Lifesaver Cards or Free Space Fusion Card series.[22]

Home-based pencil pushups

Although less effective as in-office vision therapy, the most common treatment for convergence insufficiency to date has been home-based pencil pushups (HBPP) and base-in prism reading glasses: 87% of doctors of optometry and ophthalmologists prescribe one or both of these treatment modalities "often, fairly often, or always" in children with symptomatic CI.[25] While the outcome of performing HBPP indicates that there are some improvement in symptoms as well as in NPC and PFV, compliance is often poor.[26]

To perform this technique, the patient is asked to place an index card or other object on the wall in front of them to be used as a visual check for suppression. The patient then holds a pencil approximately 40 cm in front of his or her face, and brings the pencil towards the tip of the nose while trying to maintain fusion. The pencil is only pushed away if the patient is unable to fuse the diplopic images. The goal of this exercise is for the patient to be able to appropriately view the pencil on the tip of his or her nose and sustain fusion for about five seconds.

While in-office vision therapy is the ideal treatment of choice for symptomatic CI, some patients lack the resources to do so — including lacking convenient access to a nearby clinic that offers these services. In addition, local clinics may lack the specialized equipment necessary for a full course of in-office vision therapy. In these instances, a viable alternative would be to prescribe HBPP in addition to computer vision therapy software that can be administered at home, such as the HTS iNet. When a patient completes an activity using the HTS iNet, their results are uploaded to a remote server, allowing the eye care provider to monitor progress remotely. The CITT Investigator Group found that this combination of home-based exercises was more effective than HBPP alone.[24]

Base-in prism reading glasses

Of course, not all patients are a good fit for active treatment measures such as vision therapy or HBPP. Thus, for this subset of patients with symptomatic CI, would base-in prism reading glasses be a viable treatment option? On one hand, Scheiman et al., found that base-in prism reading glasses were no more effective than placebo lenses and thus were not an effective treatment for children with symptomatic CI.[27] The amount of prism prescribed was based on Sheard's criterion, with the average amount of prism prescribed being approximately 4 prism diopters of base in prism. Compliance to treatment was excellent, and both groups — those with base-in prism reading glasses and those wearing placebo glasses — showed statistically significant decreases in symptoms.

On the other hand, Pang et al., used base-in prism reading glasses to treat presbyopic patients symptomatic for CI.[28] Their results indicated that glasses were successful in managing symptoms in this patient population, particularly if those with greater near heterophorias and receded near points of convergence. Overall, it appears that base-in prism glasses for managing symptomatic CI offers passive, rather than active treatment.

How effective is vision therapy?

One common concern is the long-term effectiveness of convergence insufficiency treatment. If a patient successfully completes a course of vision therapy, how long do the results last? The CITT Investigator Group examined their treatment group one year after successful completion of the 12-week vision therapy program.[29] Symptoms via the CISS questionnaire as well as NPC and PFV were measured at six months and again at a year after completion of therapy. For the first six months, the subjects were given a maintenance protocol corresponding to their treatment group. Those in the in-office group were assigned one convergence technique (Brock String or Barrel Card) and one fusional vergence technique (Eccentric Circles or Lifesaver Rings) to be performed for 15 minutes once a week. Subjects in the HBPP group were assigned pencil pushups for the same frequency and those previously performing HBPP and computer vision therapy were assigned 5 minutes of pencil pushups and 10 minutes of computer vergence therapy. It appeared that all groups maintained their improvement in signs and symptoms for at least one year after discontinuing treatment. Shin et al., also found that improved symptoms and positive clinical results lasted for at least one year after cessation of treatment.[14]

Conclusion

Overall, CI is a treatable binocular vision disorder that can be successfully managed with in-office vision therapy, ideally, as well as with pencil push-ups and computer orthoptics software. It appears that patients continue to experience symptomatic relief as well as improvement in positive fusional vergence and the near point of convergence up to a year post-treatment. While base-in prism reading glasses offer the same amount of symptomatic relief as placebo lenses in children, they may have a place in management for symptomatic presbyopes. Symptoms of CI may hamper a patient's ability to read comfortably as well as their academic performance. To manage this condition, doctors of optometry may consider expanding the treatment options offered at their practice, or referring these patients to an eye care provider who offers these services.

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