The Treatment
Of
Convergence Insufficiency
A HISTORICAL OVERVIEW OF THE LITERATURE

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Abstract

Convergence Insufficiency (CI) is a common non-strabismic binocular vision disorder in children and adults. Optometrists and ophthalmologists diagnose this condition but approach the treatment options differently. Surveys have been conducted and the general consensus even among the two professions, varies. Behavioral optometrists evaluate the patient and prescribe lenses, prisms and vision therapy as their treatment options for these patients. Other optometrists may also prescribe treatments such as pencil push-ups, home-based vision therapy, lenses or prisms. Ophthalmologists generally prescribe differently and chose from a list including pencil push-ups, orthoptics, prism glasses or ocular surgery. The Convergence Insufficiency Treatment Trial investigators, consisting of both optometrists and ophthalmologists, have conducted a series of clinical treatment trials, to determine the optimal treatment for patients with convergence insufficiency. This article reviews some of the historical studies conducted, and describe the most recent research on convergence insufficiency. The impact of this new research and its effects on how these patients are therapeutically managed will be discussed.

Key Words

convergence insufficiency, Convergence Insufficiency Treatment Trial (CITT), Convergence Insufficiency Reading Study (CIRS), Convergence Insufficiency Symptoms Survey (CISS), home vision therapy, pencil push-ups, vision therapy

INTRODUCTION

Convergence insufficiency (CI) was first described by von Graefe in 1855.[1] This non-strabismic, binocular vision disorder is a common condition that usually presents with asthenopia and performance problems. Clinical signs are: exophoria greater at near than at distance, a receded near point of convergence (NPC), reduced positive fusional vergence (PFV) and low a accommodation convergence/accommodation ratio (AC/A ratio).[2] Depending on the study, the prevalence of CI is between 3% and 7.7%.[2-9]

One of several treatment options for this condition is vision therapy (VT). VT has been used for over a century and was originally called orthoptics. Orthoptics was founded in 1858 by a French ophthalmologist, Javel. The word orthoptics literally means "straight sight".[10] Orthoptics includes vergence-based tasks, such as pencil push-ups, physiological diplopia, stereograms and prism therapy to enhance the vergence ability.[11] Orthoptics does not generally include accommodative, sensory, perceptual or cognitive tasks.

VT has a more global model and is designed to address many aspects of vision. VT can be passive or active. Passive therapy might consist of lenses, prisms, occlusion and pharmaceutical treatment. Active VT, includes: orthoptics (vergence tasks), pleoptics (amblyopia specific tasks, including fixation), ocular motor, accommodative and visual perceptual/cognitive techniques.[12]

The Convergence Insufficiency Treatment Trial (CITT) investigators set out to systemically investigate the symptoms, signs and optimum therapies for CI. They carefully designed a sequential number of randomized clinical trials to determine the most effective treatment option for patients with CI. Previous studies had contained flaws and biases. Consequently, the CITT investigators rigorously designed a detailed protocol for every aspect of these studies. They created a quality of life symptom survey, known as Convergence Insufficiency Symptom Survey (CISS). This survey documents symptoms a patient might experience and how often the symptom presents. The score becomes a measure of the morbidity of CI. The CISS also serves to educate the patient to common symptoms associated with CI. It is an effective tool to document the patient's symptoms, before and after treatment.[13]

Characteristics of Convergence Insufficiency Symptoms

Many papers have defined characteristics of CI.[4-10] CI patients may complain of: frequent loss of place, loss of concentration, re-reading text often, reading text slowly, poor memory of what has been read, sleepiness, blurred vision, diplopia, headaches, and/or eye strain during reading or other near work.[14] In 1999, The Convergence Insufficiency and Reading Study (CIRS) group determined that the CISS was a valid instrument to define symptomatic CI subjects among school-aged children (ages 8 to 13 years).[15] This survey was further refined in 2003 (Appendix 1).[16] This study determined an acceptable validity and reliability of the CISS survey. Symptomatic CI patients correlated with a score of ≥ 16, for sub-

jects ages 9 to 18 years old. In 2004, another study was reported by the CITT group with subjects aged 19 to 30 years.[17] Again, it was found that the CISS was valid and reliable. The symptomatic CI subjects in this study were found to have a score of 21 or higher.

Signs

A 1997 survey investigated how practitioners diagnosed CI patients.[18] The three most common findings used to diagnosis CI were near point of convergence (NPC), low positive fusional vergence (PFV) and high relative amounts of exophoria at near. This research helped to illustrate the lack of consensus among the practitioners, when deciding the tests results to best diagnosis CI. Early studies conducted by Rouse et al described children with a CI as presenting with an exophoria at near of 4 prism diopters greater than at distance, a receded NPC and insufficient PFV.[8,18] In another study, Porcar and Martinez-Palomera defined adults with CI as presenting with a near exophoria of 6 prism diopter or more than distance, with receded NPC and reduced PFV.[6] The NPC was evaluated independantly and in children with CI, Hayes et al found the break to be 6 to 10 cm,[19] while Maples and Hoenes reported a break of 5 cm or less to be the norm.[20] Lastly, Scheiman et al evaluated young adults and suggested a break of 5 to 7 cm or more was appropriate to diagnosis a CI.[21] Furthermore, a patient with CI having insufficient PFV, was defined as being less than 15 prism diopters on the blur/break finding (based on Morgan norms) and did not meet Sheard's criterion (twice the phoria amount was not in reserve).[13]

In 2002, the Convergence Insufficiency and Reading Study (CIRS) group reported the inter-examiner reliability of binocular vision tests to classify CI. The most reliable tests were the near heterophoria, nearpoint of convergence and accommodative amplitude. The break on the positive fusional vergence tests was not as repeatable among the examiners and not as reliable in making the diagnosis.[22] The Maples and Hoenes study also evaluated the repeatability of the near point of convergence (NPC) of 539 elementary school children over a course of three years.[20] The study reported good clinical reliability.

Historical Treatment Modalities for Convergence Insufficiency

CI can be treated in a number of ways.[14] Practitioners chose from various treatment options including surgery, in-office/home based vision therapy and base-in prism reading glasses. A popular home based therapy is pencil push-ups.

Surgery

Although surgery is not the first line of treatment for the patient with CI, it is noted in the literature.[23-25] Surgery is invasive, costly and with side effects.[11] Documented cases with organic convergence insufficiency were treated with a resection of the medial rectus muscles.[25] Some cases resulted in consecutive esotropia. These consecutive esotropes were then treated with a prism correction. It is reported that, over time, near exophoria after surgery reappears and symptoms return as well. Surgery does not appear to be a viable treatment option for patients with CI. Unfortunately, this continues to be an option considered by some ophthalmologists for a patient with persistent CI before considering other more effective and less invasive forms of treatment.[26]

Vision Therapy

The American Optometric Association created the 1986/1987 AOA Future of Vision Development/Performance Task Force to document the efficacy of vision therapy in many binocular vision conditions, including convergence insufficiency.[27] Wick, in 1994, reported on the efficacy of orthoptics therapy for patients with CI and illustrated the need for a well-controlled clinical trials with long term follow up.[28] The main focus of these early studies was based on evaluating children and vision therapy, not older patients with the same condition.[27,28] Cohen and Soden (1984) conducted a small study where vision therapy was used to treat 28 symptomatic adult patients with CI during their in-hospital stay.[29] Each patient received 12 sessions of vision therapy. Symptoms and examinations findings were evaluated pre and post VT. The study found that 96% of the patients showed improved findings and fewer symptoms after treatment. In addition, 12 out of 28 patients were re-examined nine months or more after the VT was ended. Eighty three percent of these patients were still asymptomatic and retained adequate objective findings during the re-examination. There was, however, no specific form of randomization during the study and actual VT procedures were also not described.

A more controlled study (1999) of adult subjects with symptomatic CI was reported.[30] This study had a more detailed description of specific treatment groups:

office-based vision therapy with supplemental home therapy, home-based vision therapy only and a control group. These patients were treated for 24 weeks. This study found a success rate of 61.9% for the office-based vision therapy/supplemental home therapy group. This compared to 30% for the home-based vision therapy only group and only 10.5% for the control group. The control group was defined as a no treatment group (not a valid placebo group), as is found in a well-designed clinical trial. This study failed to utilize masked examiners and did not define any systematic form of randomization.

Home-based Pencil Push-ups

A survey was conducted in 2002 to determine the most common treatment modality prescribed for CI.[31] The survey found that optometrists would first prescribe pencil push-ups (36%), followed by home-based vision therapy (22%) followed by office-based vision therapy (16%). Ophthalmologists also frequently prescribed pencil push-ups (50%) as well as home based vision therapy (21%) and base-in prism (10%). This report supported the belief that the pencil push-ups procedure was an effective treatment since it was so frequently prescribed.

The first documentation of pencil push-ups was presented in 1973 by Duke-Elder and Wybar and was described it as follows:

> *Exercises to improve the nearpoint of convergence are carried out simply by the patient holding a target at arm's length and then gradually bringing it towards the eye, all the time maintaining bifoveal fixation. These exercises should be carried out several times each day for a few minutes.[32 (p. 547-51)]*

It should be noted that this is a general description and few specific details are given, relating to the target chosen, length of time for this therapy and number of repetitions. Patients tend to lose interest in this therapy and will most likely stop the exercises prematurely.[13] This possibility tends to make pencil pushups an ineffective form of treatment for these patients, even though it is the least expensive intervention.

In 2002, a pilot study was conducted to evaluate the effectiveness of home-based pencil push-ups for patients with CI.[33] The study involved 25 adult patients with symptomatic CI. All of the patient's symptoms were evaluated with CISS prior to the treatment. The patients were given

specific instructions on how to perform the pencil push-ups during the study. Each patient was required to perform the therapy for 15 minutes a day, five days a week for six weeks. The patients were then re-evaluated and the results showed some improvements in NPC, positive fusional vergence and symptoms; however, there was poor compliance with this home based treatment. Additionally, only 12 out of 25 patients returned for post therapy testing.

Base-in Prism

A randomized clinical trial evaluated the effectiveness of base-in prism reading glasses against placebo reading glasses in symptomatic patients.[34] Of 72 children evaluated, the study found that base-in reading glasses did not reduce the patient's symptoms any better than the placebo group. The prism reading prescription also did not show significant improvements in the NPC or positive fusional vergences after six weeks of treatment, compared to the placebo group. The investigators concluded that base-in prism glasses are not an effective treatment option for children with CI.

Convergence Insufficiency Treatment Trials (CITT)

Researchers conducted two important randomized clinical trials to further evaluate the most effective treatment for patients with convergence insufficiency.[35,36] In 2005, a clinical trial on young adults compared the effectiveness of VT versus pencil push-ups.[35] The 46 patients, aged 19 to 30 years, were divided among three groups: office-based vision therapy/ orthoptics, office based placebo therapy / orthoptics and home-based pencil push-ups. This trial found that the patients who received office based vision therapy showed the most significant improvements in their NPC and positive fusional vergence. A reduction in symptoms was noted in comparison to the group receiving home-based pencil push-ups. That same year, a similar clinical trial evaluated 47 children aged 9 to 18 years old.[36] They reported the office-based VT group was the only group that became asymptomatic, showed significant improvements in the NPC and better positive fusional vergences. These two clinical trials paved the way for the larger CITT study.

Recently, the CITT group, led by Scheiman, has completed a randomized, multi-centered, National Eye Institute-funded clinical trial, to further evaluate the most effective treatment for children with symptomatic CI.[14] The CITT investigators followed strict protocol that was documented in their manual of operations. This manual was very specific. It illustrated specific protocols, including exact criteria for eligibility, detailed description of the tasks used for each therapy group to insure that outcome measures would be determined accurately. This clinical trial evaluated 221 children, aged 9 to 17 years, at nine different sites (Table 1), including three ophthalmology-based sites and six optometry-based sites.

The children were divided into four treatment groups:
1. office-based vergence/accommodative therapy with home reinforcement,
2. office-based placebo therapy,
3. home-based pencil push-ups and home-based computer vergence/accommodative therapy and
4. pencil push-ups.[14]

Treatment was conducted for 12 weeks and subjects were re-examined at four, eight, and at 12 weeks. The primary outcome measure was the CI symptom survey score. The secondary outcome measures were the NPC and positive fusional vergence. The subjects were administered the CI symptom survey at every visit and re-examined by a masked examiner. The results concluded that the group receiving office-based vergence /accommodative therapy with home reinforcement had clinically significant improvements in both the primary and secondary outcome measures over any of the other three groups. The CITT group had previously determined that the placebo therapy program created for this study was an "effective program in maintaining the masking of the subjects."[37] More outcome results of this and future CITT studies are forthcoming in the near future.

DISCUSSION

VT has specific goals for the patient. These include maximizing the flexibility and function of the patient's vergence system. By assisting the patient to function more efficiently, fewer visual symptoms should be present.[38] Every patient has his or her unique presentation of visual conditions but a systematic approach to determine the most appropriate diagnosis is warranted. Optometrists should be able to apply the findings from these studies in a number of ways.

A more consistent diagnostic criterion of CI is one result of these studies. More

than one test result is required to make the complete diagnosis of CI. Based on the recent Convergence Insufficiency Treatment Trial,[39] a patient with CI has some of the following four examination findings:
1. Receded nearpoint of convergence with a break of 6 cm or more
2. Exophoria at near at least 4 prism diopters greater than at far
3. Insufficient positive fusional vergence
   a. failing Sheard's criterion[40]
   b. or less than 15 prism diopters base out blur or break finding
4. Appreciation of a minimum of 500 seconds of arc of random dot stereopsis

Quality of life factors and symptoms associated with CI is another pertinent result of these studies. The patient's symptoms can be assessed using CISS (Appendix 1). A child with a score greater than or equal to 16 is considered symptomatic. Symptom scores can help quantify the patient's symptoms, while educating the patient about those symptoms. In addition, some studies have found a high correlation of accommodative insufficiency with convergence insufficiency. In particular, children who presented with many symptoms were categorized as both CI and accommodative insufficiency.[41,42] This is logical since the accommodative and vergence system are linked and when one system malfunctions, the other attempts to compensate. Another study has noted that children with Attention Deficit Hyperactivity Disorder (ADHD) may also have a high incidence of CI.[43]

Lastly, these recent findings from randomized clinical trials have now dictated that the most effective treatment for children with CI is office-based vergence/accommodative therapy with home reinforcement. This is important since most eye

care professionals have traditionally prescribed other forms of treatment that have now been shown to be ineffective.

It is imperative to discuss all treatment options with your patient, with an emphasis on the most effective forms of treatment. The most efficacious treatment regimen should always be the first option offered to the individual patient who is diagnosed with CI. It is understandable that many factors must be taken into consideration in determining the most acceptable treatment for your patient. Factors influencing the doctor/patient decision include cost, commitments of time, follow up care and motivation to complete the treatment. It is the eye care professional's responsibility to not only educate the patient to all the treatments available, but also to play the role as a knowledgeable mediator who can guide the patient to the most effective treatment option. The eye care professional should modify her treatment plan for CI based upon the facts revealed in this new data.

CONCLUSION

CI continues to be an area of strong interest for many eye care professionals. Despite all the recent studies published, it is obvious that more research is warranted in this area, as well as for other binocular vision disorders. Eye care professionals can now discuss with their patient all the available treatments for children with CI, with emphasis on the most effective treatment, VT. This new information can help the practitioner better educate the patient, parent and other eye care professionals, thus insuring that the patient receives the most effective treatment for CI.

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Appendix 1. CISS

Convergence Insufficiency - Symptom Questionnaire

Name _____   DATE __/__/__

Clinician instructions: Read the following subject instructions and then each item exactly as written. If subject responds with "yes" - please qualify with frequency choices. **Do not give examples.**
Subject instructions: Please answer the following questions about how your eyes feel when reading or doing close work.

		Never	(not very often) Infrequently	Sometimes	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?					
		__ x 0	__ x 1	__ x 2	__ x 3	__ x 4

Total Score: ____