

Virtual reality therapy in Convergence Insufficiency patients (Case Series)



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Virtual reality therapy in Convergence Insufficiency patients (Case Series)



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By

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Under the guidance of

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DECLARATION

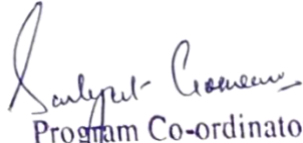


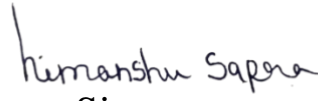
I hereby declare that this work “**Virtual Reality Therapy in Convergence Insufficiency Patients (Case Series)**” has been carried out by me under the guidance and supervision of **Mr. Himanshu Sapra**, Consultant Optometrist, CL Gupta Eye Institute Moradabad, Uttar Pradesh, and **Mr. Sarbojeet Goswami**, Head of Department, School of Health and Allied Science, Arka Jain University, Jamshedpur, Jharkhand, and this work has not been submitted earlier to any university for the award of any degree or diploma. This dissertation does not contain any part/chapter plagiarized from other sources including books, journals, and student projects.

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BONAFIDE CERTIFICATE

This is to certify that this research project entitled “**Virtual reality therapy in convergence insufficiency patients (Case series)**” is the bonafide work done by **Ms. K. Kritika Rao, Enrollment no. AJU/181128**. In partial fulfillment of the requirement of the Bachelor of Optometry (B. Optom) degree program in Arka Jain University, School of Health and Allied Science during the Academic year 2018-2022.

The project report is an independent and original work of the student under my supervision and guidance.

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ABSTRACT

TITLE: Virtual reality therapy in Convergence insufficiency patients.

AIM: To assess the efficacy of VR therapy in Convergence Insufficiency patients.

OBJECTIVE:

- To assess the improvement of Convergence Insufficiency parameters after Virtual Reality therapy given through VR box with anaglyph glasses.

METHOD: Parameters of the subjects were measured before and after VR therapy. The parameters measured in the study were: Near point of Accommodation, near the point of Convergence, and Cover test (Distance and near), Patient diagnosed with Convergence Insufficiency was advised to use a VR box with anaglyphs to see the improvement.

HYPOTHESIS: The VR therapy will be effective in managing the symptoms of convergence insufficiency patients as it will promote the fusional vergence as it uses anaglyph glasses which causes two separate images to fall on each eye which creates an illusion of a 3-D image, as a result, the eyes get engaged and converged to see and identify the image and the VR videos is created in such a way that the eyes keep on changing the focus to see the clear image of the moving objects at different points.

INTRODUCTION

Convergence insufficiency (CI) is a decrease in the ability to converge the eyes smoothly and effectively and maintain binocular fusion while looking at near objects¹. This ineffective muscular action results in loss of proper binocular alignment which causes exophoria or intermittent exotropia near⁵. This binocular vision disorder is characterized mainly by near point of convergence (NPC) (≥ 6 cm)², Exophoria ≥ 4 prism dioptres (PD) for near larger than far², insufficient positive fusional reserves (PFR) at near according to Sheard's criteria³ (PFR break or blur $< 2 \times$ near phoria) and normal values (for example, PFR break ≤ 15 PD)^{2,4}. CI can also be associated with symptoms including eye strain, headaches, blurred vision, diplopia, sleepiness, difficulty in concentrating, movement of print while reading, and loss of comprehension after short periods of reading or performing close activities, asthenopia². Suppression may also occur⁶. Thus, CI can negatively impact health-related quality of life, interfering with reading and near work performed in school, work, and leisure⁴.

Most of the symptoms of convergence insufficiency are directly related to reading or while doing near tasks. It occurs when there is a presence of binocularity still an attempt at fusion is done. Patients with monocular fixation syndrome have fewer chances of getting symptoms of CI. Similar to most strabismic conditions, the symptoms of convergence insufficiency can be triggered by stress, illness, or lack of sleep. The patients can be present with one or more of the following symptoms⁵:

Headaches – The headache may occur while reading or for a long period of reading or while doing specifically near tasks. The headaches are frequently located in the frontal or periocular area. It results due to sustained effort put to increase fusional convergence. This resultant headache due to convergence insufficiency can trigger other underlying headaches such as migraines⁵.

Asthenopia – This complaint results due to increased convergence or accommodative effort induced to maintain convergence. This manifests as tired, strained eyes or eyes that hurt or feel sore near work. Some patients mostly indicate about something wrong is going on with their eyes

but are unable to describe the exact problem. Patients also describe a pulling sensation or sensation of pressure around the eyes⁵.

Difficulty with reading or near tasks – Difficulty while reading for longer periods is common as the symptoms worsen with increasing time at the near task. Patients will describe occasional/intermittent blurring of words, words/print moving on the page, frequently, poor concentration, or difficulty with comprehension while reading. Sometimes patients do not describe symptoms at near because of their strong avoidance of near vision tasks⁵.

Diplopia – Diplopia results from related exodeviation at near seen in convergence insufficiency, it presents as two separate images or overlap of images. In convergence insufficiency, horizontal displacement of the images takes place, as a result, many patients face problems with the double images and complain of blurring of their vision⁵.

Treatment for convergence insufficiency includes base-in prism reading glasses, home-based pencil push-ups, home-based vision therapy/orthoptics, and office-based vergence/accommodative therapy⁴. Out of these treatments, the study showed that office-based orthoptic therapy is more effective than home-based pencil push-ups and placebo therapies. 12 weeks of office-based orthoptic therapy with home reinforcement resulted in greater improvement in symptoms of CI and clinical measurements when compared with home-based pencil push-ups⁵.

The Convergence Insufficiency Treatment Trial (CITT)⁷ treatment includes a 12week treatment including (i) in-office fusional vergence training plus home-based activities (ii) home-based computer vergence training (iii) office-based placebo therapy and (iv) home-based pencil push-ups. Out of these four methods, only the in-office fusional vergence training plus home-based activities, improved signs (NPC and PFR) and successfully reduced symptoms of CI. The rate of success of the in-office training, at 73 percent, was higher than in the other groups, where the range of success was only 33 to 43 percent. In a study including 19 to 30yearold people with CI⁷, the in-office vision training group showed more improvement in PFR compared to pencil push-up or placebo groups, yet 58 percent remained symptomatic. Scheiman et al. also compared three home-based treatments over 12 weeks of therapy⁸: (i) computerized vergence/ accommodation training (ii) pencil pushups and (iii) placebo therapy, which resulted in poor success rates, ranging 16–23

percent. There was a loss to follow-up in that study, with eight percent loss in the computer-based group, 19 percent loss in the pencil push-up group, and 30 percent in the placebo group. This shows that the treatment method affects continuation with treatment and therefore, any method of home-based treatment has a less success rate. The poor success rate of home-based vision therapy may be related to difficulties in setting up the resources and activities required of placing the setup at the correct level of difficulty or lack of motivation and compliance. Clinicians also play an important role in encouraging patients to persist with the therapy and also to assign tasks that should be challenging for the patients but not discouraging^{2,9}. Although research showed that in-office treatment is the best treatment option for CI¹⁰, the burden of resources for in-office vision training and the low success rate of home-based vision training results in the need for a simple-to-use home-based therapy that is interesting enough to provide the motivation and encouragement of the patient.

Virtual reality (VR) is the digital process of three-dimensional (3-D) worlds. By using anaglyph glasses two separate images are presented to each eye including head movement tracking, vergence, and parallax cues which may be created that give the illusion of the 3-D image. As a result, both the eyes get engaged and converged to perceive the image as one, and thus diplopia or suppression can also be easily diagnosed. Further, the VR video allows the alignment of the image presented to each eye to be varied. This allows the difficulty of the treatment to be varied so that patients start their training at a level equal to their capability before increasing the level of difficulty. Thus, VR training for fusional vergences is accepted as well as an effective treatment for CI¹¹.



Fig 1: VR box

AIM: To assess the efficacy of VR therapy in Convergence Insufficiency patients.

OBJECTIVE:

- To assess the improvement of Convergence Insufficiency in response after Virtual Reality therapy given from a VR box with anaglyph glasses.

LITERATURE REVIEW

Year/Place of publication	Author/s	Title	Methodology	Summary/ Result
2020 in Clinical and Experimental Optometry	Mei Ying Boon, Lisa J Asper, Peiting Chik, Piranaa Alagiah, Malcolm Ryan.	Treatment and compliance with virtual reality and anaglyph- based training programs for convergence insufficiency.	Longitudinal study design in which virtual game based therapy and conventional anaglyph based therapy was used.	Some of the patients still had the symptoms of CI so further study was required to rule out the differences.
2005 in Optometry and Vision Science	Mitchell <u>Scheiman</u> and others.	A randomized clinical trial of vision therapy/orthoptics versus pencil <u>pushups</u> for the treatment of convergence insufficiency in young Adults	Randomized <u>multicenter</u> clinical trial with symptomatic convergence insufficiency were randomly assessed.	Out of all the treatment modalities, only vision therapy was effective.

Mei Ying Boon conducted a study titled “treatment and compliance with virtual reality and anaglyph- based training programs for convergence insufficiency” in which Two interventions, anaglyphs and a virtual reality game of Snakes, were evaluated for their effectiveness in treating adults with convergence insufficiency. The prescribed training regimen was 20 minutes, three times per week for six weeks. The vision was assessed before and after the treatment period. Eighteen participants (mean age 20.8 _ 1.8 years) met the inclusion criteria for convergence insufficiency and nine participants were randomly assigned to each intervention. Gamification of vision training in a virtual reality environment is feasible and associated with increased compliance, hence may be a useful strategy to treat convergence insufficiency.

Mitchell Scheiman conducted a titled “A randomized clinical trial of vision therapy/orthoptics versus pencil pushups for the treatment of convergence insufficiency in young adults” study using a randomized, multicentre clinical trial in which 47 children 9 to 18 years of age with symptomatic convergence insufficiency were randomly assigned to receive 12 weeks of office-based vision therapy/orthoptics, office-based placebo vision therapy/orthoptics, or home-based pencil push-ups therapy, as a result, vision therapy/ orthoptics was more effective than pencil push-ups or placebo vision therapy/orthoptics in reducing symptoms and improving signs of convergence insufficiency

in children 9 to 18 years of age. Neither pencil push-ups nor placebo vision therapy/orthoptics was effective in improving either symptoms or signs associated with convergence insufficiency.

METHODOLOGY

Study design: Case series

Study duration: November 2021 to May 2022.

Study place: CL Gupta Eye Institute, Moradabad, Uttar Pradesh

Inclusion criteria:

- Aged 14 years or above.
- Visual acuity of at least 0.1 Log mar.
- Patient diagnosed with convergence insufficiency.

Exclusion criteria:

- Patient having a history of any extraocular muscle surgery, strabismus, or amblyopia.

Tools required:

- Smartphone.
- VR box.
- Anaglyph glasses.

Materials and methods:

In each patient, all optometric examinations including initial screening followed by comprehensive binocular vision assessment were done. Initial screening includes history i.e., ocular and systemic, Hirschberg's Test and EOM test to rule out the presence of strabismus, Cover test (distance and near) to rule out exophoria at near (characteristic of CI), and Vision screening. After the initial examination, a binocular vision assessment will be done and the patient having any anomalies or any other ocular pathology was excluded from the study and sent to the clinic for further

management regarding ocular/systemic associated disease whereas those who have normal retinal pathology were included in this study. All the binocular parameters include the Cover test, Near Point of Accommodation, and Near Point of Convergence. Patients diagnosed with CI were advised to use a VR box with anaglyph glasses 2 hours per day for 1 month to see any improvements regarding the symptoms of CI.

Test Procedures:

Near Point of accommodation:

Both binoculars, near the point of accommodation, were measured by RAF Rule (Royal Air Force Rule).one line above the best-corrected visual acuity is used as the target on the RAF rule. The target was moved closer from 50 cm from the subject toward the subject until the subject reported that the target begins to blur. We stopped when the first sustained blur was reported.

Near Point of convergence: Near the point of convergence was evaluated by the RAF rule. The single line on the RAF rule was used as a target. The target was moved closer until the subject experience constant diplopia on the stick.

Negative and positive Relative accommodation:

Negative relative accommodation (NRA) and positive relative accommodation (PRA) values will be determined by adding lenses in front of the patient's eyes (plus and minus lenses, respectively). The objective of the test will be to keep the letters as clear and single as possible and to indicate when the letters become blurry or double. The test will be done at 40 cm.

Negative and Positive fusional vergence:

For the measurement of Fusional vergence, we used the Prism bar. Both positive & negative fusional vergence was measured for distance (at 6m) as well as near (at 33cm). For positive fusional vergence (PFV) base out prism & for negative fusional vergence (NFV) base in the prism is used. The subject has reported blur, diplopia & recovery i.e., at what point subject report the single after reporting double.

Cover Test:

First of all, we performed the Hirschberg test with torchlight at a distance of 40 cm in front of both eyes and observed the corneal reflex then did a cover test for distance testing by isolating a 20/30 letter on the distance visual acuity chart, for near testing, we used Gulden fixation stick at 40 cm from patient's face and directed the patient's attention to the isolated 20/30 letter, instructing the patient to fixate the letter and to "keep it clear" throughout testing.

"The above-mentioned test procedures are the standard procedure to diagnose the Convergence Insufficiency. In our study, we have considered two parameters i.e., Near point of Convergence and Cover Test".



Fig 2: RAF



Fig 3: Prism bar

Case 1:

A 14-year female patient came to the hospital with the complaint of both eye pain, watering, and blurring of vision for 1 month. She was having no history of using any glasses previously and no history of any ocular and head injury. She had a history of recent ophthalmic consultation at Karalpur, where the patient was prescribed some eye drops but she was not satisfied with the treatment so the patient came here for further management. There was no other specific history that correlates with the patient's complaint as the patient's distance vision was 20/20 in both eyes with N06 near vision. On performing Objective refraction through retinoscopy, we got +0.50D spherical in the Right eye and +0.75D spherical in the Left eye. On cyclo refraction (Cyclopentolate) we got +0.50D spherical in both eyes. On subjective refraction, we got 0.00 D in both eyes with N06 near vision for both distance and near. On Hirschberg corneal reflex test the reflex was central whereas in the Cover test we got exophoria for both distance and near (near > distance). Slit-lamp examination including eyelids, conjunctiva, sclera, cornea, anterior chamber, iris, and pupil was within normal limits. The intraocular pressure was 12 mm of Hg in both eyes checked with an applanation tonometer. The post dilated (8mm) examination showed no other specific symptoms in the posterior chamber.

In fundus examination, both eye media was clear. The optic disc was within normal limits with a 0.3 cup disc ratio and medium optic disc size. Blood vessels and macula were within normal limits.

In motor evaluation, head posture including head tilt, face turn, chin elevation, and depression was normal. In nine gaze (prism) evaluation showed 5 prism diopter exophoria at distance and 8 prism diopter exophoria at near. There was no limitation in ductions and other findings showed positive large angle kappa.

In orthoptic evaluation, the near point of convergence done with the RAF ruler was 35cm for both eyes.

As the patient was evaluated with exophoria for near along with the near point of convergence more than normal limits which correlate to the characteristics of convergence insufficiency, so the patient was diagnosed with both eyes Convergence insufficiency.

Given Convergence Insufficiency, the patient was advised Virtual reality therapy through a VR box with anaglyph glasses for 2 hours per day for 1 month and was asked to come for follow up after 1 month

Case 2:

A 22- year female came to the hospital with the complaint of frontal headache for 15 days and no other complaints regarding vision. She was having no history of using glasses, no history of any recent ophthalmic consultation, no history of any head or ocular injury, and no other significant history was there. The patient's vision was 20/20 in both eyes with N06 near vision. On Objective refraction, we got 0.00 D in both eyes. On the Hirschberg test, we got the central glow and the rest external symmetry of the face was within normal limits whereas in the Cover test we got exophoria for near. Slit-lamp examination including eyelids, conjunctiva, sclera, cornea, anterior chamber, iris, and pupil was within normal limits. The intraocular pressure was 15 mm of Hg in the Right eye and 16mm of Hg in the Left Eye checked with an applanation tonometer. The pre dilated (3mm) examination showed no other specific symptoms in the posterior chamber.

In fundus examination, both eye media was clear. The optic disc was within normal limits with a 0.3 cup disc ratio and medium optic disc size. Blood vessels and macula were within normal limits.

In motor evaluation, head posture including head tilt, face turn, chin elevation, and depression was normal. We got ortho for distance and 8 Prism Diopter exophoria for near in the cover test.

In orthoptic evaluation, the near point of convergence done with the RAF ruler was 12cm for both eyes.

The patient was diagnosed with Convergence Insufficiency and advised Virtual reality therapy through a VR box with anaglyph glasses for 2 hours per day for 1 month and was asked to come for follow-up after 1 month.

Case 3:

A 17- year female came to the hospital with the complaint of occasional mild frontal headache associated with both eye ocular pain and watering for 1 year and no other visual-related complaints. She was having a history of using glasses for 6 months with a prescription of -1.00 D in both eyes. She had no history of recent ophthalmic consultation and no history of head or ocular injury. She had no family history of myopia or glaucoma. And rest of other history was within normal limits.

The patient's distance visual acuity was 20/20 for both eyes and near visual acuity was N06 in both eyes. On objective retinoscopy, we got a neutral glow with 0.00D in both eyes.

In orthoptic evaluation, the near point of convergence done with the RAF ruler was 12cm for both eyes.

On the Hirschberg test, it was orthophoria whereas in the cover test it showed flick exophoria for near about 2 prism dioptres. Ocular motility was full and free in all directions.

On slit-lamp examination eyelids were flat, conjunctiva and sclera were normal, the cornea was clear, the anterior chamber was normal in contents and depth PACD= 1 CT, Iris was in normal color and pattern and pupil was round, regular, and reacting. The intraocular pressure was within normal limits i.e., 18mm of Hg in the right eye and 16mm of Hg in the left eye.

In post dilated examination the lens was clear. The lacrimal patency showed ROPLAS negative in both eyes.

In fundus examination, both eye media was clear. The optic disc was within normal limits with a 0.3 cup disc ratio and medium optic disc size. Blood vessels and macula were within normal limits.

The patient was diagnosed with Convergence Insufficiency and advised Virtual reality therapy through a VR box with anaglyph glasses for 2 hours per day for 1 month and was asked to come for follow-up after 1 month.

DISCUSSION

In this case series, we have included 3 patients diagnosed with Convergence Insufficiency in which we checked two parameters like Near Point of Convergence and Cover Test and asked the patient to come after 1 month for follow-up.

Mei Ying Boon et al.¹ conducted a study in which Two interventions, anaglyphs and a virtual reality game of Snakes using gamification techniques were used in treating adults with convergence insufficiency. Gamification of vision training in a virtual reality environment is feasible and is associated with increased compliance, hence it was considered a useful strategy to treat convergence insufficiency¹ In this study, it has been mentioned that through this technique there is an improvement in the symptoms of convergence insufficiency. Similarly, we used virtual reality therapy with anaglyph glasses to treat the symptoms of convergence insufficiency and it has been seen that there is an improvement in both the considered parameters.

Mitchell Scheiman⁷ conducted a study in which 47 children 9 to 18 years of age with symptomatic convergence insufficiency were randomly assigned to receive 12 weeks of office-based vision therapy/orthoptics, office-based placebo vision therapy/orthoptics, or home-based pencil push-ups therapy, as a result, vision therapy/ orthoptics was more effective than pencil push-ups or placebo vision therapy in reducing symptoms and improving signs of convergence insufficiency⁷.

Similarly, we choose to give vision therapy through virtual reality therapy and it has been observed that there has been an improved symptom in the patient of convergence insufficiency.

Parameters	Case 1	Case 2	Case 3
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	Pre		Post		Pre		Post		Pre		Post	
	OD	OS	OD	OS	OD	OS	OD	OS	OD	OS	OD	OS
Visual acuity	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dry Refraction	0.5	0.75	0.0	0.0								
BCVA	0	0	0	0	0	0	0	0	0	0	0	0
NPC (in cm)	35		18		12		8		8		5	
Cover Test (in PD X')	8		2		8		4		5		2	

Table 1: Parameters before and after Virtual Reality therapy.

LIMITATIONS: There are some limitations to our study.

- Small sample size.
- Follow-up criteria should be strong enough to carry out the study effectively.

RECOMMENDATIONS: Virtual reality therapy can be a treatment modality for treating Convergence Insufficiency but we cannot comment on that as the sample size is small.

CONCLUSION: Virtual reality therapy is effective in treating the signs and symptoms of convergence insufficiency. As there were fewer patients, this study has been done in the form of case series. Therefore, it requires more subjects further to evaluate more effectiveness of Virtual reality therapy in treating the signs and symptoms of convergence insufficiency.

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