

## ABSTRACT

**Aim:** To compare conventional orthoptic exercises and modified dot cards in the management of primary convergence insufficiency.

**Study design:** Experimental hospital-based study

**Duration and Setting of the Study:** The study was conducted at Tawam Hospital United Arab Emarat (UAE) from March 2021 to April 2022.

**Method:** Patients diagnosed with primary convergence insufficiency were divided into two groups. One group was given conventional orthoptic exercises (conventional dot card) while the other group was given a modified dot card. All the patients were instructed to exercise 5 times a day, each time for 5 minutes and were reviewed after three weeks and a second review after two weeks. Consent was taken from every participant.

**Results:** A total of 27 patients were included in the study diagnosed with primary convergence insufficiency. The age limit of the patients was between 13-24 years, to rule out the non-compliance part of the study. Participants treated with conventional methods showed a 62% success, while those treated with modified dot card had success rate of 83%. Furthermore, patients who were having remote near point of convergence (NPC) and who showed no improvement at all with conventional exercise were given modified dot card for exercise. By switching to the modified card they showed a very good improvement in their symptoms and NPC.

**Conclusion:** The modified dot card is an effective test that can be used in patients with mild, moderate, and marked convergence insufficiency.

**Keywords:** Primary, Convergence insufficiency, Near point of convergence, Conventional

## INTRODUCTION

By definition, Primary Convergence Insufficiency (PCI) is present if the Near Point of Convergence (NPC) is less than 8-10 cm<sup>1,2</sup> or if it can be maintained at the level with a bit of effort. But the effort should not cause any symptoms of asthenopia or headache. Convergence insufficiency (CI) is a common binocular vision disorder characterized by exophoria greater at near than at distance, a receded NPC and reduced positive fusional vergence (convergence amplitudes) at near.<sup>3</sup>

CI is one of the most common binocular vision

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anomalies that cause difficulty in near activities. The condition leads to the discomfort of near vision, and functional difficulties such as reading, writing, and confused attention, resulting in impaired education, poor academic performance, and task achievements. CI is typically described as a group of clinical signs that appear at near fixation, such as exophoria, a receded point of convergence and reduced positive fusional vergence amplitude. Convergence is basically a measurement of binocular single vision. At any point in time, if Binocular Single Vision (BSV) is disrupted, the patient's convergence mechanism fails.<sup>4,5,6</sup>

Investigation of primary convergence insufficiency includes a detailed cover test that excludes other conditions causing convergence insufficiency. The near point of convergence is tested and will show a receding near point of convergence. While checking convergence, accommodation is also checked both

monocularly and binocularly. In case monocular accommodation is better than binocular accommodation, then the most likely diagnosis is PCI. Accommodative and fusional amplitude should also be measured. Accommodative amplitude is used with the lens bar while the fusional amplitude is measured with the prism bar. Fusional amplitude should always be measured with care, as most of the time patients fail to understand the instructions.

Management of these cases includes correction of all types of refractive errors, including a small amount of astigmatism, which can cause asthenopic symptoms especially oblique astigmatism. For this purpose, cycloplegic refraction gives an accurate estimation of the amount of refractive error and the full refractive state of the eye.

Orthoptic exercises are extremely helpful in managing CI. These exercises are more helpful and easy if the patient's general health is in good condition and they are motivated to do these stressful exercises regularly. In current busy clinical scenarios, it is hard to accommodate these patients on a regular basis in the clinic for the sole purpose of exercise. It is therefore recommended to teach these patients how to do these exercises at home and review them later in the clinic.

Orthoptic exercises are divided into:

1. **Anti suppression therapy:** This is the recognition of diplopic images when the patient's convergence mechanism fails. In case the patients fail to understand then dissociating filters can be used to teach them about diplopia.
2. **Physiological diplopia:** it is very necessary to show these patients this phenomenon. It can be demonstrated to them using their own fingers holding them one ahead of each other. Parallel diplopia is observed when the fixation finger is the near one while cross diplopia is seen when the fixation finger is the distant one.
3. **Timings of exercises:** Timing is an important

factor in managing these cases. It is important that patients do regular exercises and at the end of a session do some relaxing exercises. Relaxing exercises would be to look at a distant object as far as possible.

In teaching physiological diplopia, a dot card can be used in home-based therapy while stereograms can be added in clinic settings to the dot card.

The current study was carried out on home-based therapy, so therefore, we discuss dot card and modified dot card<sup>7</sup>.

Considerable uncertainty exists regarding the best treatment for CI. Prescribed treatments include: base-in prism reading glasses, home-based pencil push-ups, home-based vision therapy/orthoptics and office-based vergence/accommodative therapy. Recent studies surveying the eye care community regarding treatment patterns for persons with symptomatic CI suggest that home-based pencil push-ups is the most commonly prescribed treatment by both ophthalmologists and optometrists. The clinical popularity of the technique is most likely related to its simplicity and perceived cost effectiveness.<sup>8,9,10</sup>

Patients with CI commonly complain of asthenopia symptoms such as eyestrain, blurred vision, diplopia, headaches and reading difficulties.<sup>11</sup> In the United States, symptomatic CI is a prevalent binocular vision defect affecting approximately 5% of the population.<sup>12,13</sup> An early study showed that CI had been confirmed to be a prevalent binocular vision disorder among both children and adults and it is recommended that there is a critical need for studies to assess its prevalence among students who learn in a digital setting.<sup>14</sup> Among the studies conducted in various regions with different environments and ethnic backgrounds, the findings showed that the prevalence of CI varied between 1.7% and 33%. The prevalence of CI among school-aged children reported in the literature varies from 2% to 13%.

An earlier study showed that there was no significant

difference in the prevalence of CI with age up to 60 years. However, it increased significantly after 60 years. Furthermore, similar findings from a study conducted in Iran revealed that the prevalence of CI is affected by age, sex and refractive conditions. In the last decade, the literature has shown the CI Symptom Survey (CISS), which is a questionnaire used as an indicator for the treatment of CI. A study conducted in 2015 suggested that the CISS questionnaire is not specific for detecting convergence insufficiency.<sup>15</sup> Another study reported that the accurate prevalence of CI in the general population has not been investigated because of the different diagnostic criteria.<sup>16</sup>

There are several types and modalities for the treatment of CI that can be prescribed, such as base-out prism spectacles, pencil push-ups, vision therapy and home-based computer vergence/accommodative therapy. There is a lack of information and rareness of unanimity about the most convenient treatment.<sup>17, 18</sup>

The findings of a study performed in South Korea suggest that vision therapy is successful in reposing the symptoms of CI.<sup>19</sup> Amit, et al. reported that smartphone-based fusion exercises connected with modified glass prescriptions were more effective in the treatment of symptomatic CI.<sup>20</sup> Previous studies showed that improvements in reading performance were observed after office-based vergence/accommodative therapy. Most of the treatment studies on CI did not report any side effects for any of the earlier techniques; moreover, they showed great adherence to office-based vergence/accommodative therapy.

As mentioned above, there is a large gap in the information on its global prevalence and consensus on the treatment of CI. In current busy clinical scenarios, it is difficult to accommodate these patients regularly in the clinic for the sole purpose of exercise. Therefore, it is recommended that these patients be taught how to perform these exercises at home and reviewed later in the clinic.<sup>21</sup>

The modified card is basically a design to test all three grades of BSV. Patients look at two different sides of the paper, which is simultaneous perception. Then the patient tries to combine those two lines at a dot, which is basically fusion and at last patient tries to read the word written on two sides as shown in figure 1. Since the words lie within the panum's fusional area, the patient perceives it in a standout manner, which gives a stereoscopic view.

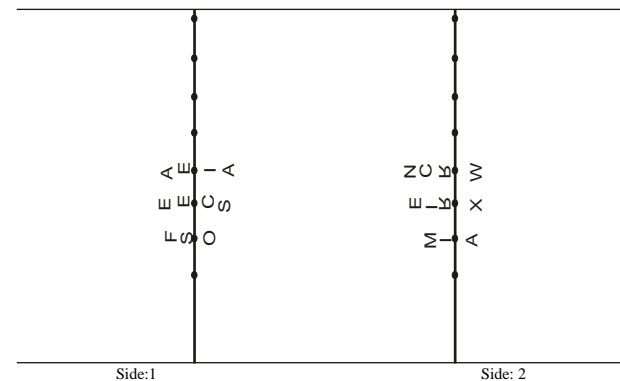


Figure 1: Showing two sides of a modified dot card

## METHODS

A convenient sample-size technique was used in this study. Patients who fulfilled the inclusion criteria were included in the study during the study period (March 2021 to April 2022). This Experimental hospital-based study was conducted at Tawam Hospital UAE. This study aimed to manage patients with primary CI more effectively by introducing new modalities to current practice. Patients who were diagnosed with convergence insufficiency were included in the study in the time span of one year. All of them were carefully examined and patients who had secondary convergence insufficiency were excluded. The patients were then divided into two groups of 13 and 14. The first group was given a conventional dot card and the other a modified dot card.

Both groups were trained and taught how to do exercises. Patients were trained till they recognized diplopia upon decompensation. All of the patients were given a four-week review and a reduction in maintained NPC without any asthenopic symptoms by 5cm or more, was considered a success.

**RESULTS**

A remarkable improvement was observed in patients who were given the modified card compared to those who were using the conventional card. The following results were obtained from this study: A close review showed that even for patients who showed improvement in group-1 having moderate CI still needed to do exercises as their NPC was still far from normal. More than 60% of patients remain treated with convergence exercises.

**Table 1: Improvement in NPC with conventional dot card vs modified dot card reviewed after 3 weeks**

| NPC         | Conventional dot card |                       | Modified dot card  |                       |
|-------------|-----------------------|-----------------------|--------------------|-----------------------|
|             | Number of patients    | Improved NPC patients | Number of patients | Improved NPC patients |
| 12 to <18cm | 6                     | 5                     | 5                  | 5                     |
| 18 to <24cm | 4                     | 2                     | 3                  | 3                     |
| 24 to <30cm | 3                     | 1                     | 6                  | 5                     |
| Total       | 13                    | 8                     | 14                 | 13                    |

NPC: Near point of convergence

Group 2 showed remarkable results. Only 37% of patients remained with convergence problem. These patients were quite motivated and those who were asked to stop the exercises were having almost no asthenopic symptoms when tested for their convergence. The distribution of remaining patients in group 1 and group 2 was as follows (Table 2).

**Table 2: Distribution of patients after two weeks of therapy**

| Near point of convergence | Number of Patients              |                             |
|---------------------------|---------------------------------|-----------------------------|
|                           | (Group 1) Conventional dot card | Group 2 (Modified dot card) |
| 12<18cm                   | 3                               | 1                           |
| 18<24cm                   | 3                               | 3                           |
| 24<30cm                   | 2                               | 1                           |

**Follow-up of Group 1**

Patients were reviewed after two weeks this time. A short review was given so that patients are kept motivated and compliant with exercises. The results are shown in table 3.

**Table 3: Success rate of patients with convergence problems.**

| Near point of convergence | Number of patients | Improved NPC patients | Success Percentage |
|---------------------------|--------------------|-----------------------|--------------------|
| 12 to <18cm               | 3                  | 2                     | 66%                |
| 18 to <24cm               | 3                  | 1                     | 33%                |
| 24 to <30cm               | 2                  | 1                     | 50%                |
| Total                     | 8                  | 4                     | 50%                |

After the second review only 2 patients managed to be in the normal range and hence were excluded from the third review. Overall success was 50% after 2 weeks.

**Table 4. The distribution of leftover patients with convergence problems.**

| Near point of convergence | Number of Patients |
|---------------------------|--------------------|
| 12<18cm                   | 2                  |
| 18<24cm                   | 3                  |
| 24<30cm                   | 1                  |

These patients were followed up till the fourth review. All the patients were brought in the normal range by dot exercises.

**Follow-up of Group 2**

This group, who were using modified dot card showed remarkable results again. The patients' convergence drastically improved to a normal level. Patients could feel the difference and control of fusion. The following results were calculated after 2 weeks of exercises with a modified dot card.

**Table 5. The distribution of leftover patients on follow-up visit.**

| NPC     | No: of Patients | Improved NPC Patients | Success Percentage |
|---------|-----------------|-----------------------|--------------------|
| 12<18cm | 1               | 1                     | 100%               |
| 18<24cm | 3               | 3                     | 100%               |
| 24<30cm | 1               | 1                     | 100%               |
| Total   | 5               | 5                     | 100%               |

Only one patient was left with a slightly reduced NPC of 14cm. The patient was asked to continue exercise for one week and consult an orthoptic clinic, in case the problem persists.

**DISCUSSION**

The reviewed studies in children and adults showed that vision therapy is more effective in eliminating the symptoms of CI. This could be because most patients with CI have weak positive fusional vergence, and most of the vision therapy techniques depend on improving positive fusional vergence amplitude and vergence accommodation relationship. Our findings

were similar to that of Scheiman, et al<sup>20</sup>. who reported that office-based vision therapy was a more effective treatment of CI in children. Scheiman et al. suggested that for young adults, outpatient vision therapy is the most effective treatment for CI, in improving positive fusional vergence at near fixation.<sup>21</sup> Moreover, previously published studies.<sup>20,21</sup> reported that office-based vergence-accommodative treatment with home enforcement was more effective than other procedures. Individuals who have stereopsis will have fusion and simultaneous perception positive but people who have simultaneous perception may not have fusion and hence stereopsis or those who have first two grades positive may not have stereopsis.

When the patients use the modified card initially, it is very difficult to do exercise with it, as it hampers the remaining fusional reservoir that the patient has. But slowly and gradually patients start building up on it. The newly built fusional reserve is very abrupt and well controlled. As the patient exercises with a septum, so when the patient starts working in normal condition, he/she feels the improvement right from the beginning. While a normal dot card works only on fusion as there is no septum between the two eyes. Patients feel improvement only when their NPC improves. The test by itself is not that much demanding as well. Patients usually want alternatives as they don't see much improvement in their condition.

### RECOMMENDATION

While conducting the study, it was learned immediately to make the card from thick design cards rather than simple paper as it maintains its position and shape when the patient is doing exercises on it. Plastic lamination is also of great help.

### CONCLUSION

The results and mechanism of the modified card show that convergence insufficiency can better be managed with a slight modification of the currently available dot card. This slight modification can easily be done and is a good alternative to other methods (Computer-based)

used for treating convergence insufficiency. The mechanism is far more similar to the computer-based method as both of them produce dissimilar images to the eyes. One with red green filters and the other uses septum. However, a study with a larger sample size with a multicenter approach is required to measure the significance of this card.

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**Patient Consent:** Informed consent was obtained from all patients involved in this study.

**Ethical Approval:** Ethical approval for this study was granted by The ethical and research committee of Tawam Hospital.

### REFERENCES

1. Ansons, Alec M, Davis Helen, (2014)). Diagnosis and management of ocular motility disorder page 421-42. 4th edition.
2. Rouse MW, Hyman L, Hussein M, Solan H CIRS group. Frequency of convergence insufficiency in optometry clinic settings. *Optom Vis Sci.* 1998;75(2):8896. doi: 10.1097/00006324-199802000-00012.
3. Scheimann M. The Convergence Insufficiency Treatment Trial: Design, Methods, and Baseline Data. *Ophthalmic Epidemiol* 2008;15(1):24-36. doi: 10.1080/09286580701772037.
4. Bartuccio M. The treatment of convergence insufficiency: A historical overview of the literature. *J Behav Optom* 2009;20(1):7-11.
5. Hayes GJ, Cohen BE, Rouse MW, De Land PN. Normative values for the near point of convergence of elementary school children. *Optom Vis Sci* 1998;75(7):506-12. doi: 10.1097/00006324-199807000-00019.
6. Scheiman M, Cotter S, Rouse M, Mitchell GL, Kulp



- effectiveness of base-in prism reading glasses versus placebo reading glasses for symptomatic convergence insufficiency in children. *Br J Ophthalmol* 2005;89(10):1318-23. doi: 10.1136/bjo.2005.068197.
7. Gallaway M, Scheiman M, Malhotra K. The effectiveness of pencil pushups treatment for convergence insufficiency: a pilot study. *Optom Vis Sci* 2002;79(4):26567. doi: 10.1097/00006324-200204000-00013.
8. Chin FH, Faibish B, Hisaka C, Thal L, Tsuda K. A survey of the treatment of convergence insufficiency. *J Beh Optom* 1995;6:912.
9. Scheiman M, Cooper J, Mitchell GL, LP de, Cotter S, Borsting E, et al. A survey of treatment modalities for convergence insufficiency. *Opt Vis Sci* 2002;79(3):15157. doi: 10.1097/00006324-200203000-00009.
10. Hashemi H, Nabovati P, Khabazkhoob M. The prevalence of convergence insufficiency in Iran: A population-based study. *Clin Exp Optom* 2017; 100(6): 704-9. doi: 10.1111/cxo.12522.
11. Lavrich Judith B. Convergence insufficiency, and its current treatment. *Curr Opin Ophthalmol* 2010; 21(5): 356-60. doi: 10.1097/ICU.0b013e32833cf03a.
12. Aletaha M, Daneshvar F, Mosallaei M, Bagheri A, Khalili M. Comparison of three vision therapy approaches for convergence insufficiency. *J Ophthalmic Vis Res* 2018; 13(3): 307-14. doi: 10.4103/jovr.jovr\_99\_17.
13. Horan LA, Ticho BH, Khammar AJ, Allen MS, Shah BA. Is the convergence insufficiency symptom survey specific to convergence insufficiency? A prospective, randomized study. *Am Orthopt J* 2015; 65:99-103. doi: 10.3368/aoj.65.1.99.
14. Jang JU, Jang JY, Tai-Hyung K, Moon HW. Effectiveness of vision therapy in school children with symptomatic convergence insufficiency. *J Ophthalmic Vis Res* 2017; 12(2): 187-92. doi: 10.4103/jovr.jovr\_249\_15.
15. Mohan A, Kaur N, Sen P, Jain E, Gajraj M. Efficacy of smartphone-based exercises in conjunction with modified glasses prescription in the treatment of convergence insufficiency and fusion weakness. *J Binocul Vis Ocul Motil* 2019; 69(1): 30-3. doi: 10.1080/2576117X.2019.1578594.
16. Scheiman M, Talasan H, Alvarez TL. Objective assessment of disparity vergence after treatment of symptomatic convergence insufficiency in children. *Optom Vis Sci* 2019; 96(1): 3-16. doi: 10.1097/OPX.0000000000001320.
17. Scheiman M, Gwiazda J, Li T. Non-surgical interventions for convergence insufficiency. *Cochrane Database Syst Rev* 2011; (3): CD006768. doi: 10.1002/14651858.CD006768.pub2
18. Grisham DJ. Visual therapy results for convergence insufficiency: A literature review. *Am J Optom Physiol Opt* 1988; 65(6): 448-54. doi: 10.1097/00006324-198806000-00004.
19. Scheiman M, Kulp MT, Cotter SA, Lawrenson JG, Wang L, Li T. Interventions for convergence insufficiency: A network meta-analysis. *Cochrane Database Syst Rev* 2020; 2020;12(12): CD006768. doi: 10.1002/14651858.CD006768.pub3.
20. Scheiman M, Talasan H, Alvarez TL. Objective assessment of disparity vergence after treatment of symptomatic convergence insufficiency in children. *Optom Vis Sci* 2019; 96(1): 3-16. doi:10.1097/OPX.000000000000132