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Oculomotor Rehabilitation Post-Concussion:

Convergence Training Using the CL Convergence Cord *"Brock String"*

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Oculomotor Dysfunction Post-Concussion: Convergence Insufficiency

- A concussion injury can produce a myriad of **vision and oculomotor** problems like blurry vision, reading difficulties, diplopia or eyestrain, dizziness or disequilibrium exacerbated in visually-stimulating environments, visual field loss or restriction, light sensitivity and colour-blindness[1]
- ***Convergence insufficiency (CI), accommodative insufficiency (AI), and saccadic dysmetria*** (i.e., saccadic inaccuracy) are the most frequent oculomotor deficits found in the visually symptomatic mTBI clinic population, with 90% having a diagnosed oculomotor dysfunction[2]
  - In this study:
    - 43% of the TBI subgroup = convergence insufficiency
    - 40% of TBI subgroup = accommodative insufficiency
    - 90% of TBI subgroup = overall frequency of occurrence of oculomotor dysfunction
- Oculomotor dysfunction is hypothesized to occur post-concussion due to neurometabolic and structural damage such as **diffuse axonal injury** (DAI) and **damage to multiple ocular structures** (e.g. primary & secondary visual pathways, brainstem, refractive ocular structures etc)[1-3]
- Abnormal **accommodation** function identified within the first 14-days post-concussion has been correlated with prolonged recovery[4]

1. Greenwald BD, Kapoor N, Singh AD. Visual impairments in the first year after traumatic brain injury. *Brain Inj.* 2012;26(11):1338-1359. doi:10.3109/02699052.2012.706356. Accessed on May 28, 2020.
2. Ciuffreda KJ, Kapoor N, Rutner D, Suchoff IB, Han ME, Craig S. Occurrence of oculomotor dysfunctions in acquired brain injury: a retrospective analysis. *Optometry.* 2007;78(4):155-161. doi:10.1016/j.optm.2006.11.011. Accessed on May 28, 2020.
3. Gallaway M, Scheiman M, Mitchell GL. Vision Therapy for Post-Concussion Vision Disorders. *Optom Vis Sci.* 2017;94(1):68-73. doi:10.1097/OPX.0000000000000935. Accessed on May 28, 2020.
4. Master CL, Master SR, Wiebe DJ, et al. Vision and Vestibular System Dysfunction Predicts Prolonged Concussion Recovery in Children. *Clin J Sport Med.* 2018;28(2):139-145. doi:10.1097/JSM.0000000000000507. Accessed on May 28, 2020.

Vision Therapy: Convergence Insufficiency

- Treatment of concussion-related vision disorders often involves the **use of vision therapy/rehabilitation** to remediate vergence, accommodation and version eye movements[1]
- A sample of 95 concussion patients who were diagnosed with CI (47%) or AI (42%) and elected to proceed with vision therapy responded positively and had an excellent success rate to vision therapy (see Table 1)[1]
  - For those w/ CI (41 patients) = success (85%), improved (15%)
  - For those w/ AI (39 patients) = success (33%), improved (67%)

Table 1

Criteria for success with vision therapy

Convergence insufficiency
Success: (all 3) NPC <6 cm, BO >20 or pass Sheard's criteria, and CISS <16
Improved: improved CISS by 10 or more, and either improved NPC >4 cm or normal or improved BO >10
Accommodative insufficiency
Success: (all 3) Normal accommodative amplitude (15–1/4 age), MAF/BAF >6, CISS <16 or improved by >10
Improved: (1 or 2) Normal accommodative amplitude (15–1/4 age), or MAF/BAF >6
Saccadic dysfunction
Success: Both ratio and error scores ≥50th percentile
Improved: Either ratio or error scores ≥50th percentile

BO, base-out; CISS, Convergence Insufficiency Symptom Survey; NPC, near point of convergence.

- In a prospective study of 79 children aged 9 to 17 years with symptomatic convergence insufficiency (a receded NPC break of 6 cm or greater + additional inclusion criteria), 84% were asymptomatic after completing 12 weeks of vision therapy (office-based vergence/accommodative therapy), and maintained their improvements in symptoms and signs for at least 1 year after discontinuing treatment [2]
- In order to treat these insufficiencies, a convergence cord ("Brock String") is a great tool for patients to gain instant feedback about whether their eyes are working together correctly to focus on an object at various distances
  - The "Brock String" was named after Frederick Brock, who developed it as a tool for convergence therapy in those with binocular vision deficits

Binocular vision is the ability to maintain visual focus on an object with both eyes, creating a single visual image

1. Gallaway M, Scheiman M, Mitchell GL. Vision Therapy for Post-Concussion Vision Disorders. *Optom Vis Sci.* 2017;94(1):68-73. doi:10.1097/OPX.0000000000000935. Accessed on May 28, 2020.
2. Convergence Insufficiency Treatment Trial Study Group. Long-term effectiveness of treatments for symptomatic convergence insufficiency in children. *Optom Vis Sci.* 2009;86(9):1096-1103. doi:10.1097/OPX.0b013e3181b6210f. Accessed on May 28, 2020.

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Convergence Therapy - CL Convergence Cord

- Convergence therapy is recommended for those with a receded **NPC break of 6 cm or greater**, but further studies need to explore the effects of convergence therapy post-concussion
  - **See VOMS post for NPC test explanation*
  - ***Caution needs to be taken in convergence therapy for symptomatic patients post-concussion as symptoms may worsen in those with additional underlying oculomotor, vestibular, or CNS deficits, or in those that begin binocular exercises too soon after injury*

→ Refer patients with positive oculomotor screening findings to a neuro-optometrist in order to collaborate on an appropriate vision therapy and physical therapy rehabilitation program

Convergence Therapy Training Objective

- Used to develop skills of convergence, ocular motor performance as well as minimize suppression[1]
- Helps fixation skills under binocular conditions[1]
- Build visual stamina

Equipment

- CL Convergence Cord (“Brock String”)

1. Clark JF, Colosimo A, Ellis JK, et al. Vision training methods for sports concussion mitigation and management. *J Vis Exp.* 2015; (99):e52648. Published 2015 May 5. doi:10.3791/52648. Accessed on May 28, 2020.

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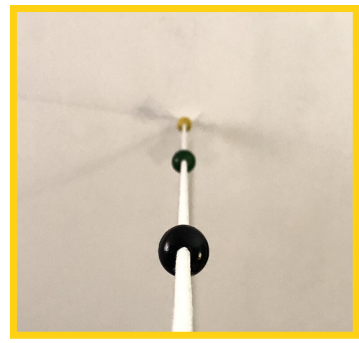
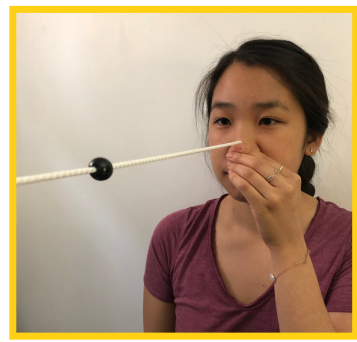
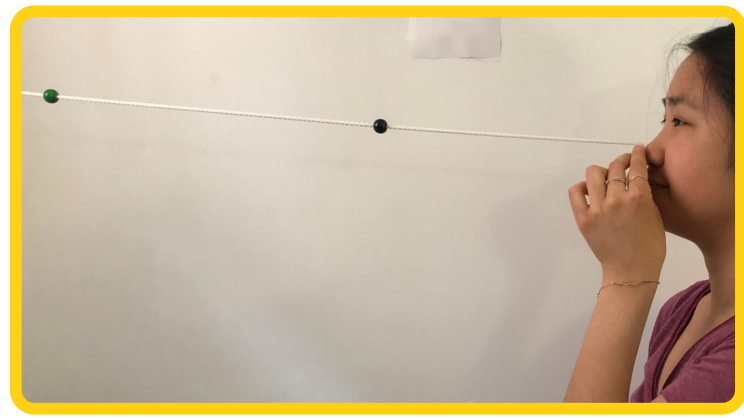
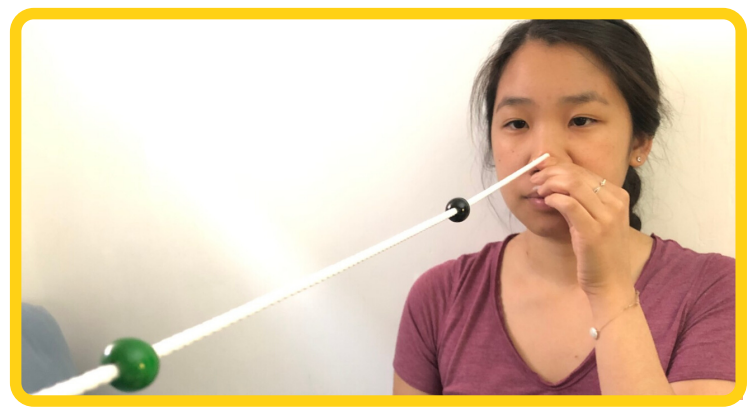
CL Convergence Cord Set Up[1]

- Tie one end of convergence cord to fixed point
- The patient must hold the other end of the convergence cord on the tip of their nose
  - Patient can be in a standing or seated position with head in a neutral position
- Initially the fixed point is horizontal with respect to the height of the nose point but the exercise can be progressed or regressed by elevating or declining the fixed point
- The HCP must instruct the patient to pull on the cord so it is stretched tight between their nose and the fixed point
- Space the five colored beads on a length of string approximately 12 inches apart starting about 10 inches from the nose.
  - Vary the spacing according to the patient's needs (may be dependent on sport or task or symptoms)
    - E.g. combat sports such as boxing may need more beads less than 3 feet away, whereas field sports such as football and soccer might need beads around 10 feet. Patients with convergence symptoms may need to start with the closest bead further away from them.



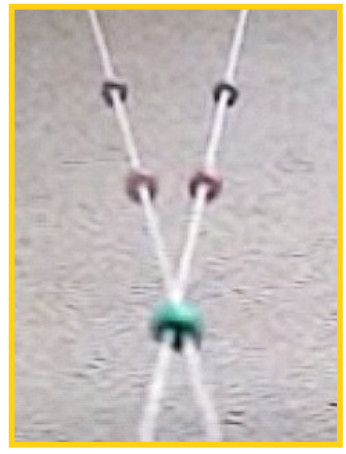


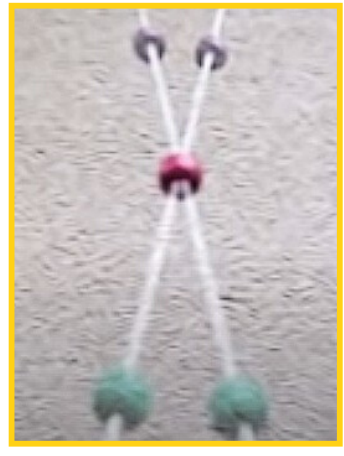


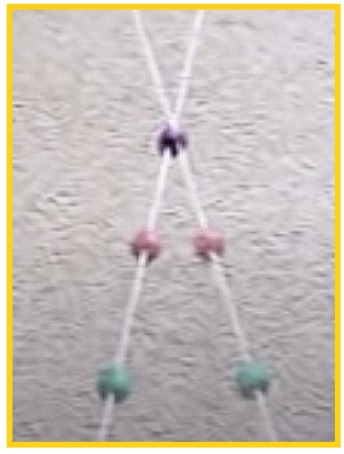


1. Clark JF, Colosimo A, Ellis JK, et al. Vision training methods for sports concussion mitigation and management. *J Vis Exp.* 2015; (99):e52648. Published 2015 May 5. doi:10.3791/52648. Accessed on May 28, 2020.

CL Convergence Cord Procedure[1]







- Instruct the patient to fixate on a bead → the patient should see two strings leading to the fixation bead which should appear to meet exactly at the bead, forming an ‘X’ through the bead
  - The string should also appear to separate after the fixation bead
- If the patient reports they see the ‘X’ slightly before or after the fixation bead, instruct the patient to find the ‘X’ and pull it toward the bead in focus.
  - If the fixation bead is seen as a double, this may indicate an eye teaming problem
  - If the patient only sees one string, the patient is suppressing one eye
  - If the strings seem to cross in front of the beads (“eso-posture”), the patient perceives objects closer than they really are
  - If the strings seem to cross behind the beads (“exo-posture”), the patient perceives objects farther away than they really are
- The subject should alternate fixation and focus from one bead to the next
  - Note the visual input of each eye and the patient’s sensation of convergence → formation of an ‘X’ image at each point
  - Ask the patient to report any symptoms that are aggravated throughout the exercise and modify or stop the exercise if any symptom provocation occurs

1.Clark JF, Colosimo A, Ellis JK, et al. Vision training methods for sports concussion mitigation and management. *J Vis Exp.* 2015; (99):e52648. Published 2015 May 5. doi:10.3791/52648. Accessed on May 28, 2020.

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CL Convergence Cord Progressions

1. **Hold an 'X' at each bead**
   - Hold fixation at each bead for 30s
   - Move fixation to different beads and repeat

2. **Quickly jump between beads**
   - Quickly jump from the far → middle → near bead
   - Try to perform as many cycles as you can in 1 min
   - Change the direction and order in which you travel from bead to bead

3. **Bug on string → moving "X" through string**
   - Slowly move the 'X' from to each bead by pulling/pushing the 'X' along the string with with your eyes only
   - Patient may need to begin by using their finger to push the bead along the string and follow with their eyes, then progress to the eyes only

4. **Dynamic Head Movement**
   - Add head movements like nodding "yes" and "no" (horizontal and vertical VOR movements) while performing the exercises above

5. **Move the string side-to-side with increasing speeds (slow → fast)**
   - Continue to perform exercises #1-4 while moving the string horizontally

6. **Elevate/lower fixed point**
   - Change angle of string from 10° to 25° to 45° over a time frame where the tasks are challenging but still comfortable
   - Perform exercises #1-5 above at the various levels