Vision Disturbances Following Traumatic Brain Injury

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Opinion statement

- Vision disturbances following traumatic brain injury (TBI) include anomalies of accommodation, version, vergence (nonstrabismic, as well as strabismic), photosensitivity, visual field integrity, and ocular health.
- Traumatic brain injury patients with complex diplopia patterns, noncomitant strabismic anomalies, and advanced ocular health anomalies are either monitored by or referred to neuro-ophthalmologists and ophthalmologists for evaluation and possible surgical or medical intervention, as needed.
- Anomalies of accommodation, vergence, version, photosensitivity, and field of vision are amenable to noninvasive, rehabilitative interventions, such as vision therapy, which is rendered by optometrists and is described in this article. Further, vision therapy may be performed in isolation or in conjunction with the application of the following:
  Fusional prism spectacles (for diplopia)
  Tinted spectacles (for photosensitivity)
  Yoked prism spectacles (for visual-spatial hemispheric inattention, with or without a manifest visual field defect), as appropriate
- Dependent on the severity of vision impairment post-TBI, other types of rehabilitation, such as vestibular, physical, cognitive, and occupational rehabilitation, are deferred pending the stabilization of vision function to an appropriate level.
- Rehabilitative optometric intervention is appropriate and beneficial for many TBI patients. Therefore, it should be offered as a possible evaluation and treatment option to investigate the patient's symptoms and determine the prognosis for treatment, as would be done with any other therapeutic modality.

Introduction

Vision disturbances following traumatic brain injury (TBI) are common, but vary in their prevalence from 30% to 85%, dependent on the condition [1,2, 3–7, Class II; 8–10, Class III]. Conditions include anomalies of accommodation, version, nonstrabismic vergence, strabismus, photosensitivity, visual field integrity, and ocular health [1,2, 3–7, Class II; 8–10, Class III]. Several studies address the occurrence of such vision problems in the TBI population, and are beneficial in alerting ophthalmologists, neurologists, neuro-ophthalmologists, optometrists, and others in the rehabilitation medicine field to the expected post-TBI vision disturbances (*see* Table 1) and associated vision complaints (*see* Table 2). However, few studies address treatment options for vision disturbances [11, Class III; 12–14, Class II; 15,16, Class III], other than scanning problems and visual field defects [17,18, Class III; 19–24, Class II; 25,26, Class III]. The purpose of this article is to inform clinicians of available rehabilitative optometric treatment options for the previously mentioned vision anomalies, other than complex diplopia patterns, noncomitant strabismus, and advanced ocular health problems.

Table 1. Common vision disorders occurring secondary to traumatic brain injury

Accommodative dysfunction (insufficiency, infacility)
Version deficits (fixation, pursuits, saccades, nystagmus)
Vergence dysfunction (convergence, insufficiency, exophoria)
Visual field deficits (with or without inattention)
Photosensitivity

Traumatic brain-injured patients often manifest unusual symptoms, some of which appear to have a poorly understood physiologic basis. However, the vision disorders and most of the vision complaints outlined in Table 1 and Table 2, respectively, may be correlated. In terms of the underlying mechanisms responsible for the anomalies of accommodation, version, and vergence, the shearing forces incurred during diffuse axonal injury are thought to trigger them. Visual field anomalies are typically secondary to damage along the primary visual pathway to the occipital lobe for frank visual field deficits, or along the parieto-occipital pathway for patients with inattention and spatial awareness problems [17,27–32 Class III]. Anomalies of light sensitivity are considered related to light and dark adaptation responses, which deviate from those of non-brain-injured individuals [3,13,14, Class II; 10,33, Class III].

First, anomalies of accommodation may result in either intermittent or constant blurred vision, depending on the severity of the anomaly. Intermittent blurring may occur when altering one's visual focus from far-to-near (accommodative infacility), when altering focus from near-to-far (accommodative excess or accommodative infacility), when initially focusing at near (accommodative insufficiency), or while focusing at near after 5 or 10 minutes of performing a continuous near vision task (ill-sustained accommodation) [34, Class III]. In addition, frank spasm of accommodation may occur on rare occasions [35, Class III].

Second, anomalies of version, such as abnormal saccades, pursuits, and fixation, impact primarily on reading and may result in loss of place while reading, skipping or missing lines, re-reading lines or words, and a reduced and less efficient reading speed, as well as inefficient visual scanning patterns during diverse everyday activities [15,36,37, Class III].

Third, anomalies of vergence, with convergence insufficiency, intermittent exotropia, large exophoria, and vertical heterophorias being more common [4,7,12, Class II; 2,8, Class III], may result in either intermittent or constant diplopia, eyestrain, a sense that the print is "shimmering" or "floating" on the page, or a browache after 5 or 10 minutes of performing a near-vision task such as reading, as well as increased visual sensitivity to motion in one's daily environment [38, Class III].

Table 2. Vision complaints and associated vision disorders

Complaint	Associated vision disorder
Intermittent blur	Accommodative dysfunction
Loss of place while reading, skipping, or re-reading words	Version deficits
Reduced, inefficient reading speed	Version deficits
Double vision	Vergence deficits
Eyestrain or browache	Vergence deficits
Motion sensitivity	Vergence deficits
"Shimmering vision"	Vergence deficits
Spatial perceptual deficits	Visual field deficits (with or without inattention)
Spatial awareness deficits	Visual field deficits (with or without inattention)
Extreme light sensitivity	Photosensitivity
Waviness of vision	Unknown
Graininess of vision	Unknown

Fourth, anomalies of visual field integrity, which can occur with or without inattention to the affected field, may result in spatial perceptual deficits [17,18,25,27–32, Class III]. Patients may report that objects do not visually appear to be in the same place as they do tactually. Conversely, inattention to a given field of vision, which may exist with or without a frank visual field deficit, may result in impaired spatial awareness. For example, patients may express that they are unaware of the left side of the room, table, chair, or even their own body.

Fifth, anomalies of light sensitivity, such as photosensitivity and photophobia, may result in the patient's increased sensitivity to otherwise normal levels of illumination [3,13,14, Class II; 10,33, Class III]. Typically, photosensitivity in TBI patients exists in the absence of an anterior chamber reaction and true pain, and is, therefore, distinct from the photophobia that is evident in patients with inflammatory ocular disease [33, Class III].

The presence of any of the mentioned vision anomalies adversely impacts on an individual's rehabilitation and overall quality of life. For example, clear and single binocular vision is required to participate actively in physical therapy, vestibular therapy, cognitive therapy, speech therapy, and occupational therapy. Clear and single distance vision is required as one ambulates through an increasingly complex environment. Alternatively, clear and single near or intermediate vision is required for paper and pencil tasks, computer work, reading comprehension tasks, and word/phrase recognition tasks. Therefore, impaired vision will impact the rehabilitative process negatively.

Treatment

Interventional Procedures

Vision therapy for deficits of fixation

Standard procedure Evaluate the ability to maintain steady fixation/gaze on targets in five positions (20 degrees up, down, left, right, and center) is first trained, with emphasis on the position (or positions) exhibiting difficulty, such as pronounced slow drift, gaze instability, or jerk nystagmus. The goals are to 1) be able to fixate accurately in each position for 10 seconds, and 2) decrease the patient's symptomatology.

Training begins by having the patient fixate carefully on a distant target (*eg,* 10 feet or greater) for 3 seconds, then close their eyes for 3 seconds, and repeat at least 10 times in each of the five positions. Gradually, fixation time is increased to 10 seconds in each of the five positions. This is performed under monocular and binocular viewing conditions. It is begun with relatively large targets (5 degrees) and gradually with smaller targets (1 degree) to increase the level of skill difficulty. It should also be practiced at near (*eg,* at arm's length) under binocular viewing conditions.

Contraindications Presence of manifest-latent nystagmus wherein occlusion of one eye exacerbates the nystagmus intensity, which results in further reduction of visual acuity and possibly initiation of oscillopsia.

Complications Several factors may arise that may complicate vision therapy for deficits of fixation such as 1) paresis or paralysis of an extraocular muscle producing gaze limitation, 2) presence of reduced visual acuity in one or both eyes, which reduces neuro-sensory aspects and impairing bifixational accuracy, and 3) presence of impaired fusional vergence at near (*see* section on vergence therapy).

Special points Use of novel forms of enhanced foveal visual feedback (*eg,* afterimages) [40, Class III] or oculomotor auditory feedback (*ie,* one "hears" their eye movements and related positional/velocity errors) to serve as adjunct forms of vision therapy [36,37, Class III]. Use of a computer orthoptic training system [40, Class III] to standardize training and to control characteristics of the training stimuli better than done conventionally in the clinic.

Cost/cost effectiveness Weekly to monthly office therapy visits ($60 per session, re-evaluate after eight sessions) for 12 to 16 sessions, plus home therapy. This would be followed by quarterly visits for 1 year and then twice per year. This treatment has long-term financial benefits with respect to producing rehabilitation sufficient to return the patient to the workforce part-time. Insurance companies usually cover this treatment after the receipt of letter of medical necessity, which specifies that the deficit of version (*ie,* fixation, pursuits, saccades) is secondary to a medical condition (*ie,* TBI).

Vision therapy for deficits of pursuit

Standard procedure Evaluate the ability to move the eyes smoothly and accurately to targets in the horizontal and vertical directions at ocular excursions ±5 and ±10 degrees from center (*ie,* primary position; midline) at near (*eg,* at arm's length). The goals are to 1) move the eyes conjugately and smoothly at the same velocity as the target with minimal corrective saccades present, and 2) decrease the patient's symptomatology.

Training begins by having the patient attempt to smoothly track, in a saccade-free manner, a small, hand-held target moving relatively slowly in the horizontal direction (±5 degrees) for 5 to 10 seconds followed by a 5 second rest period (perhaps with the eyes closed). Ten repetitions of this excursion are appropriate. This procedure is repeated for the vertical direction. This is then repeated in the horizontal and vertical directions for larger target excursions (±10 degrees). Gradually, target velocity is increased using the same overall training paradigm to increase the level of skill difficulty. This is done under monocular and binocular viewing conditions and may be performed at any distance depending on the diagnostic findings and patient symptomatology.

Contraindications Attempted with caution in patients manifesting extreme dizziness or motion sensitivity, as concurrent background movement may exacerbate their symptoms. Presence of manifest-latent nystagmus wherein occlusion of one eye exacerbates the nystagmus intensity, which results in further reduction of visual acuity and possibly initiation of oscillopsia.

Complications Several factors may arise that may complicate vision therapy for deficits of fixation such as 1) paresis or paralysis of an extraocular muscle producing gaze limitation, 2) presence of reduced visual acuity in one or both eyes, which reduces neurosensory aspects and impairing bifixational accuracy, and 3) presence of impaired fusional vergence at near (*see* section on vergence therapy).

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Vision therapy for deficits of saccades

Standard procedure Evaluate the ability to move the eyes rapidly and accurately in the horizontal, vertical, and oblique directions at excursions of ±10 and ±20 degrees from center at distance and near, with emphasis on the position (or positions) exhibiting difficulty. The goals are to 1) move the eye accurately with only one saccade executed, and 2) decrease the patient's symptomatology.

Training begins by having the patient execute large obliquely directed saccades into the four corners of a room (±20 degrees). This is repeated 10 times. This is then repeated making large horizontal and vertical saccades between the side walls, and the ceiling and floor, respectively, 10 times. Gradually, the intended saccadic excursions are reduced to ±10 degrees, and then even further, until they are only a few degrees in extent to increase the level of difficulty. This is performed under monocular and binocular viewing conditions. This can then be repeated at near using small, hand-held targets. In addition, training can be extended at near using two columns of numbers or letters separated horizontally by 10 degrees, with the task of reading off the symbols from left-to-right down the columns. Also, prisms of small amounts (*ie,* one to four prism diopters or approximately 0.5 to 2 degrees) can be interposed monocularly, which increases the task complexity by producing small target step displacements subsequently corrected by saccades.

Contraindications Attempted with caution in patients manifesting extreme dizziness or motion sensitivity, as concurrent background movement may exacerbate their symptoms. Presence of manifest-latent nystagmus wherein occlusion of one eye exacerbates the nystagmus intensity, which results in further reduction of visual acuity and possibly initiation of oscillopsia.

Complications Several factors may arise that may complicate vision therapy for deficits of fixation such as 1) paresis or paralysis of an extraocular muscle producing gaze limitation. 2) Presence of reduced visual acuity in one or both eyes, which reduces neurosensory aspects and impairing bifixational accuracy. 3) Presence of impaired fusional vergence at near (*see* section on vergence therapy).

Special points Use of novel forms of enhanced foveal visual feedback (*eg,* afterimages) [40, Class III] or oculomotor auditory feedback (*ie,* one "hears" their eye movements and related positional/velocity errors) to serve as adjunct forms of vision therapy [36,37, Class III]. Use of a computer orthoptic training system [40, Class III] to standardize training and to control characteristics of the training stimuli better than done conventionally in the clinic.

Cost/cost effectiveness Weekly to monthly office therapy visits ($60 per session, re-evaluate after eight sessions) for 12 to 16 sessions, plus home therapy. This would be followed by quarterly visits for 1 year and then twice per year. This treatment has long-term financial benefits with respect to producing rehabilitation sufficient to return the patient to the workforce part-time. Insurance companies usually cover this treatment after the receipt of letter of medical necessity, which specifies that the deficit of version (*ie,* fixation, pursuits, saccades) is secondary to a medical condition (*ie,* TBI).

Vision therapy for nonstrabismic vergence dysfunction

Standard procedure Evaluate the integrity of fusional vergence at both near and far distances. The goals are to establish 1) adequate fusional reserves at both near and far distances, and 2) asymptomatic, binocular viewing for 20 minute intervals, followed by 5 minute rest periods.

The training is performed under binocular conditions and incorporates both ramp (*ie,* altering the vergence demand for convergence, as well as divergence, smoothly and gradually) and step (*ie,* altering the vergence demand for convergence, as well as divergence, rapidly) stimulus paradigms using first-, second-, and third-degree targets, starting with larger targets and with them gradually decreasing in size to increase task complexity [40, Class III]. The ramp training regimen starts by increasing the vergence demand (*ie,* convergence) slowly and gradually, until the patient reports diplopia and then decreasing the demand gradually until single vision is reported. This is performed five times. Subsequently, five repetitions of analogous ramp training are performed for divergence.
Step vergence training involves rapidly altering the vergence demand, with the increments starting small and increasing gradually, until the patient reports diplopia. Ten repetitions of step vergence are performed.

Ramp and step vergence techniques are performed at both near and far distances, gradually placing greater emphasis on the distance at which vergence is most problematic. Improving the patient's ability to fuse on command, as well as maintain that level of vergence, increases the patient's ability to perform various prolonged vision tasks in his or her daily life, such as reading and computer use.

Although fusional prism is incorporated at times in the patient's spectacle prescription for nonstrabismic vergence disorders such as convergence insufficiency, loose or hand-held prisms are often an integral component of vergence training. The following targets are used typically and frequently in association with hand-held prisms for vergence training purposes: polarized vectograms, anaglyphs, computerized random-dot stereograms, and the Brock string [40, Class III].

Contraindications Perform with caution in patients manifesting vestibular dysfunction, as the perception of the retinal-image motion of the surround environment, during the actual vergence movement, may provoke sensations of nausea and disorientation due to increased motion sensitivity. Additionally, fusional prism of large magnitude (10 prism diopters or greater) may produce nausea and disorientation in patients with vestibular dysfunction and increased motion sensitivity under certain conditions, due to the variable nonuniform magnification across the visual field with head movement. Not appropriate for individuals with 1) greater than two lines of difference in best corrected, monocular visual acuity, 2) noncomitant strabismus with variable superimposition on application of neutralizing prism, and 3) large angle comitant strabismus with no evidence of superimposition on application of neutralizing prism.

Complications None.

Special points For patients with vestibular dysfunction, dynamic vergence training with visual biofeedback is employed, using the Brock string with or without overlay prisms.

Cost/cost effectiveness Weekly to monthly office therapy visits ($60 per session, re-evaluate after eight sessions) for 12 to 16 sessions, plus home therapy. This would be followed by quarterly visits for 1 year and then twice per year. Less costly than extraocular muscle surgery, and having long-term financial benefits with respect to producing rehabilitation sufficient to return the patient to the workforce part-time. Insurance companies usually cover this treatment after the receipt of letter of medical necessity, which specifies that the vergence dysfunction is secondary to a medical condition (*ie,* TBI).

Vision therapy for strabismic vergence dysfunction

Standard procedure Neutralize the angle of the oculomotor deviation. Determine constancy, laterality, periodicity, and comitancy of the strabismus. Evaluate for superimposition, fusion, and stereopsis at near and far distances, on application of the neutralizing fusional prism. The goals are to establish 1) adequate fusional reserves at both near and far distances, and 2) asymptomatic, binocular viewing for 20 minute intervals, followed by 5 minute rest periods.

The vergence-training paradigm is the same as for nonstrabismic vergence, which is described earlier, except that it is performed in conjunction with the prescription of spectacles with ground-in fusional prism.

Contraindications Perform with caution in patients manifesting vestibular dysfunction, as the perception of the retinal-image motion of the surround environment, during the actual vergence movement, may provoke sensations of nausea and disorientation due to increased motion sensitivity. Additionally, fusional prism of large magnitude (10 prism diopters or greater) may produce nausea and disorientation in patients with vestibular dysfunction and increased motion sensitivity under certain conditions, due to the variable non-uniform magnification across the visual field with head movement. Not appropriate for individuals with 1) greater than two lines of difference in best corrected, monocular visual acuity, 2) noncomitant strabismus with variable superimposition on application of neutralizing prism, and 3) large angle comitant strabismus with no evidence of superimposition on application of neutralizing prism.

Complications None.

Special points For patients with vestibular dysfunction, dynamic vergence training with visual biofeedback is employed, using the Brock string with or without overlay prisms.

Cost/cost effectiveness Weekly to monthly office therapy visits ($60 per session, re-evaluate every eight sessions) for 18 to 24 sessions, plus home therapy. This would be followed by quarterly visits for 1 year and then twice per year. Less costly than extraocular muscle surgery, and having long-term financial benefits with respect to producing rehabilitation sufficient to return the patient to the workforce part-time. Insurance companies usually cover this treatment after the receipt of letter of medical necessity, which specifies that the vergence dysfunction is secondary to a medical condition (*ie,* TBI).

Vision therapy for accommodative dysfunction

Standard procedure Evaluate the accommodative amplitude, accommodative dynamic facility, and accommodative error. The goals are to 1) improve accommodative amplitude and dynamic facility, 2) decrease the accommodative error, 3) decrease the patient's symptom of intermittent blur, and 4) establish the patient's ability to experience clear vision for 20 minute intervals, followed by 5 minute rest periods.

Accommodative training incorporates ramp (*ie,* altering the accommodative demand gradually) and step (*ie,* altering the accommodative demand rapidly) techniques, which may be performed in free space with or without overlay lenses [40, Class III]. Techniques may be performed in conjunction with the prescription of separate single vision spectacles for near vision tasks, and are performed in the following sequence: monocularly, bi-ocularly (*ie,* with optically-imposed vertical diplopia), and then binocularly with antisuppression controls. Target size starts large and decreases gradually to increase task difficulty as the patient's accommodative ability improves.

Ramp accommodation is trained most easily in free space (versus instrument space), because of the presence of reinforcing proximal and proprioceptive information. The target is brought from arm's length slowly and smoothly towards the patient, until the target blurs. Then the target is slowly and smoothly moved back to arm's length. This is repeated 10 times.

Step accommodation is trained in free space with or without overlay lenses. In free space, the patient looks at a target 10 feet away for 3 seconds, and then looks at a target 16 inches away for 3 seconds. This is repeated 10 times. At each session, the near distance is moved progressively closer to the patient, while still maintaining the ability to attain clear vision on command. With overlay lenses, the

patient views a target through a concave lens (*ie,* to increase the accommodative stimulus) for 10 seconds, and then views the target through a convex lens (*ie,* to decrease the accommodative stimulus) for 10 seconds. This is repeated 10 times. At each session, the dioptric power of the lenses is increased, thereby increasing the induced change in accommodation executed by the patient to increase task difficulty.

Contraindications Perform with caution in patients manifesting vestibular dysfunction and increased motion sensitivity, because the perception of the blurred retinal-image relative to the surround environment, during the actual shift in the accommodative state, may provoke sensations of nausea and disorientation.

Complications None.

Special points None.

Cost/cost effectiveness Weekly to monthly office therapy visits ($60 per session, re-evaluate every eight sessions) for 12 to 16 sessions, plus home therapy. This would be followed by quarterly visits for 1 year and then twice per year. This treatment produces an improvement in vision function, which is sufficient to return the patient to the workforce part-time. Although accommodative therapy may be as much as five times more expensive than a near vision spectacle prescription, this rehabilitation regimen treats and remediates the accommodative dysfunction, whereas the near vision correction simply compensates optically for the dysfunction; the basic accommodative dysfunction persists whenever the spectacles are not worn. Insurance companies usually cover this treatment after the receipt of letter of medical necessity, which specifies that the accommodative dysfunction is secondary to a medical condition (*ie,* TBI).

Vision therapy for visual field defects (specifically hemianopias and quadrantanopias)

Standard procedure Evaluate the integrity of the visual field using automated perimetry. Evaluate for inattention using confrontation visual field assessment with double simultaneous presentation, cancellation tasks, and line bisection [20,21,24, Class II; 18,25,27, Class III]. The goals are to 1) increase the awareness of the affected field, 2) increase the ability to scan routinely into the affected field, and 3) decrease the frequency of the patient's symptoms related to visual field defects (*ie,* bumping into objects more so on one side than the other, missing food on one side of the plate, having difficulty dressing one side of the body more so than the other, having trouble shaving or applying cosmetics to one side of the face more so than the other, and missing words on one side more so than the other when reading).

Training to increase awareness of the affected field and scanning techniques may be performed in conjunction with the application of yoked prism spectacles or field-enhancing prism spectacles. The training may involve the practicing of cancellation techniques, line-bisection, or scanning for target on a surface or wall. Start with a small number of targets, and increase the target number slowly to increase task difficulty as proficiency improves. The targets should be biased towards the affected field. Continual verbal reinforcement to gaze and attend into the affected field is required.

Contraindications Perform with caution in patients with vestibular dysfunction and increased motion sensitivity. Either yoked or field-enhancing prisms of large magnitude (10 prism diopters or greater) may produce nausea and disorientation in patients with vestibular dysfunction and increased motion sensitivity, due to the variable nonuniform magnification across the visual field with head movement.

Complications None.

Special points Functional visual fields software [18,25,35,41, Class III] may be used in patients as a computerized training modality to increase awareness to the affected field.

Cost/cost effectiveness Weekly to monthly office therapy visits ($60 per session, re-evaluate every eight sessions) for 8 to 12 sessions, plus home therapy. This would be followed by quarterly visits for 1 year and then twice per year. This treatment approach for visual field disorders often provides long-term financial benefits with respect to producing rehabilitation sufficient to return the patient to the workforce part-time, albeit with certain restrictions. Insurance companies usually cover this treatment after the receipt of letter of medical necessity, which specifies that the visual field anomaly is secondary to a medical condition (*ie,* TBI).

Assistive devices

Spectacle prescription

Usage For patients who are ambulatory, or soon-to-be ambulatory, with accommodative dysfunction or presbyopia, a treatment option is the prescription of two distinct pairs of spectacles—one pair for distance and one pair for near. In patients with accommodative dysfunction, a near vision spectacle correction, which compensates for the accommodative symptoms, is often used in conjunction with vision therapy for accommodative disorders, which treats the problem itself. Although multifocal lenses (*ie,* bifocal, trifocal, and progressive lenses) with variable magnification properties are not appropriate for ambulation in patients with either TBI or vestibular dysfunction because of their increased motion sensitivity, they are acceptable and convenient as long as they are used when the patient is relatively stationary.

Special points If a patient does not want two pairs of spectacles, one pair may be prescribed in conjunction with nontinted, near vision clip-on lenses. If the patient is photosensitive, a 35% solid tint (in the color of the patient's subjective preference, most prefer brown, gray, or blue) in the distance prescription is beneficial for indoor tasks and 55% tinted clip-on lenses for use over the originally-tinted (*ie,* 35% tint) distance correction for outdoor use.

Cost/cost effectiveness Spectacles range from $250 to $500 depending on the patient's refractive state and the inclusion of ground-in prism, tint, scratch-resistant coatings, and anti-reflective coatings. Clip-on lenses range from $70 to $100 depending on the optical dispensary. This approach to spectacle prescription often provides long-term financial benefits with respect to producing rehabilitation sufficient to return the patient to the workforce part-time. Insurance companies usually cover the cost of the multiple pairs of spectacles, with or without clip-on lenses, after the receipt of letter of medical necessity, which specifies that the patient has suffered a TBI.

Fusional prism

Usage In patients with vergence dysfunction, there are occasions in which fusional prism is required to obtain single vision. In patients with vergence dysfunction, fusional prism, which compensates for the vergence symptoms (*ie,* diplopia), is often used in conjunction with vision therapy for vergence disorders, which treats the problem itself. Often, this prism is ground into the spectacles. If the magnitude of the deviation differs between distance and near vision, separate pairs of spectacles may be required.

Special points If the magnitude of the neutralizing prism is less than 10 prism diopters, temporary prisms (*ie,* flexible vinyl Fresnel prisms) may be applied to the patient's existing spectacle correction. Rather than prescribing two pairs of spectacles, one pair may be prescribed in conjunction with nontinted, near vision clip-on lenses.

Cost/cost effectiveness The incorporation of fusional prism spectacles increases the cost of spectacles by as much as $100. This is less expensive than extra-ocular muscle surgery and provides long-term financial benefits with respect to producing rehabilitation sufficient to return the patient to the workforce part-time. Insurance companies usually cover the cost of ground-in, fusional prism, in addition to the multiple pairs of spectacles, with or without clip-on lenses, after the receipt of letter of medical necessity. The letter specifies that the patient will require multiple pairs of spectacles incorporating fusional prism due to the presence of diplopia, which is secondary to a TBI.

Yoked prism and field–enhancing prism

Usage In patients with lateralized visual field deficits, there are occasions in which the application of either yoked prisms or field-enhancing prisms subjectively and objectively improve the patient's ability to function and attend to the affected field. In these cases, the prism is ground into the spectacles to shift optically the perceived visual space in the direction of the nonaffected field or enhance the field of vision. The magnitude of prism may be different between the near and far viewing distances. In such cases, two distinct pairs of spectacles are indicated.

Cost/cost effectiveness The incorporation of yoked prism or field-enhancing prism spectacles increases the cost of spectacles by as much as $200. The prescription of yoked prism spectacles often provides long-term financial benefits with respect to producing rehabilitation sufficient to return the patient to the workforce part-time, albeit with certain restrictions. Insurance companies usually cover the cost of ground-in, yoked prism, in addition to the multiple pairs of spectacles, with or without clip-on lenses, after the receipt of letter of medical necessity. The letter specifies that the patient will require multiple pairs of spectacles incorporating yoked prism due to the presence of a visual field anomaly, which is secondary to a TBI.

Tints

Usage In photosensitive patients, the application of 35% tint for indoor use and 85% to 90% tint for outdoor use is beneficial in decreasing the symptom of light sensitivity.

Special points If the patient does not want two pairs of spectacles, a pair of spectacles may be tinted with a 35% solid tint (in the color of the patient's subjective preference, most prefer brown, gray, or blue) for indoor tasks and 55% tinted clip-on lenses for use over the tinted (*ie,* 35%) distance spectacles for outdoor use. If a near vision correction is required, nontinted near vision clip-on lenses may be used over the tinted spectacles.

Cost/cost effectiveness The incorporation of tint may increase the cost of spectacles by as much as $100. The prescription of a tint often provides long-term financial benefits with respect to producing rehabilitation sufficient to return the patient to the workforce part-time. Insurance companies usually cover the cost of a tint, in addition to the multiple pairs of spectacles, with or without clip-on lenses, after the receipt of letter of medical necessity. The letter specifies that the patient will require multiple pairs of spectacles incorporating a baseline tint and a tinted clip-on lens due to the presence of a photosensitivity, which is secondary to a TBI.

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