

Andrew S. Morgenstern, OD, FAAO, FNAP

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TB EYE: Vision Dysfunction Associated with Traumatic Brain Injury

Traumatic Brain Injury (TBI): Definitions, Epidemiology, and Military Context

A. Definitions and taxonomy

- **Traumatic brain injury (TBI):** disruption of brain function caused by external force (acceleration/ deceleration, blast overpressure, object penetration). Severity stratified by GCS, LOC, PTA, neuroimaging, and functional impact (mild/concussion, moderate, severe, penetrating).
- **Military-specific mechanisms:** blast overpressure (high and repetitive low-level), blunt trauma, falls, MVAs, training accidents, and combat injuries. Repetitive subclinical blast exposures are an increasing focus of surveillance. ([AP News](#))

B. DoD epidemiology (surveillance backbone: TBICoE)

- **Cumulative burden:** Since 2000, **>500,000 U.S. service members** have been diagnosed with TBI across all theaters and duty locations. **Annual diagnoses exceed 20,000**, with **~80% classified as mild** in recent years. ([AP News](#))
- **Reporting & dashboards:** TBICoE maintains the official **DoD TBI Worldwide Numbers** time series and downloadable reports/“At-a-Glance” PDFs (annual and quarterly). Use these for the most current cumulative totals, severity mix, and service-component distributions. ([Health.mil](#))
- **U.S. population comparator** (contextualizing military burden): CDC estimates (civilian) underscore the public-health significance (e.g., ~214k TBI-related hospitalizations in 2020; ~69k deaths in 2021), while undercounting ED/primary-care-managed or untreated concussions. ([CDC](#))

C. Policy/organizational landscape

- **TBICoE (DHA):** DoD’s office of responsibility for TBI data, clinical tools, education, and care pathways (e.g., **Acute Concussion Care Pathway; MACE-2**; progressive return-to-activity). ([Health.mil](#))
 - **Vision Center of Excellence (VCE):** Joint DoD–VA center advancing prevention, diagnosis, and rehabilitation of visual system injury; publishes clinical recommendations and provider resources specific to **vision after TBI**. ([Health.mil](#))
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Page 2 — Neuro-anatomy of the Visual System & TBI-Vulnerable Pathways

A. Afferent visual pathways (sensory)

- **Eye to cortex:** Photoreceptors → bipolar/ganglion cells → **optic nerve** → **chiasm** (nasal decussation) → **optic tract** → **lateral geniculate nucleus (LGN)** → **optic radiations** (Meyer's loop/temporal; Baum's loop/parietal) → **V1 (striate cortex)** → **extrastriate dorsal ("where/how") and ventral ("what") streams.**
- **Vulnerability in TBI:**
 - **Diffuse axonal injury (DAI)** affects long associative fibers (dorsal stream visuo-spatial/visuomotor control; motion processing).
 - **Shear injury** of optic radiations → homonymous field defects; cortical contusions → central visual processing deficits (crowding, simultanagnosia, impaired global motion).
 - **LGN and pulvinar** susceptibility to blast overpressure and rotational forces.

B. Efferent/oculomotor and vestibulo-ocular systems (motor)

- **Frontal/parietal eye fields, superior colliculus, cerebellar vestibular circuits, paramedian pontine reticular formation** (saccades), **rostral interstitial nucleus** (vertical gaze), and **oculomotor nuclei (III/IV/VI)** with **medial longitudinal fasciculus (MLF)** integration.
- **TBI impacts:** saccadic dysmetria, increased latency, pursuit gain reduction, **convergence insufficiency (CI)**, accommodative insufficiency, **vergence facility** deficits, **vestibulo-ocular reflex (VOR)** impairment contributing to oscillopsia, dizziness, motion sensitivity. ([NCBI](#))

C. Visual cortical networks and cognition

- **Dorsal stream** (parietal/MT/MST) → visuospatial attention, motion, eye–hand coordination; **Vulnerable to DAI**(balance/reading guidance, navigation).
- **Ventral stream** (occipitotemporal) → object/face/word recognition (crowding, processing speed).
- **Interplay with executive networks** (fronto-parietal, cerebellar) modulates reading fluency, fixation stability, and visual–vestibular integration; frequently perturbed post-concussion.

Page 3 — Vision Dysfunction After TBI: Phenotypes, Screening & Initial Management

A. Common post-TBI visual/oculomotor phenotypes

- **Afferent:** reduced acuity/contrast (rarely optic neuropathy), photophobia, **visual field loss** (homonymous hemianopia/quadrantanopia), impaired motion perception, visual crowding/overload.
- **Efferent/omotor: CI,** accommodative insufficiency, vergence facility deficits, pursuit/saccadic anomalies, fixation instability, ocular misalignment (intermittent tropia/phoria), nystagmus.
- **Visual-vestibular:** VOR intolerance, postural instability, visually induced dizziness, motion sensitivity.
- **Functional:** reading fatigue, slowed processing, headaches, asthenopia, impaired driving tolerance, return-to-duty/learn/work limitations. Consolidated evidence reviews and clinical narratives in military cohorts highlight high prevalence of **omotor/visuovestibular** problems even with normal structural imaging. ([PMC](#))

B. Screening & examination — VCE/TBICoE guidance

- **Rapid eye-care screening (VCE clinical recommendation) for oculomotor dysfunction following TBI:** symptom survey, near point of convergence, accommodative amplitude/facility, saccades/pursuits, cover test/alignments, stereopsis, and targeted visual fields → triage for full examination and rehab. ([Health.mil](#))
- **Comprehensive eye exam** for all patients with TBI (DoD/VA paradigm): even if visual complaints are absent, evaluate afferent and efferent systems; consider field testing and glare/photophobia assessment. ([VA Research](#))
- **Acute concussion care (TBICoE): MACE-2-anchored** assessment; **Acute Concussion Care Pathway** with staged, symptom-guided **progressive return to activity/duty**; integrate vision/vestibular symptom monitoring into serial re-evaluation. ([Health.mil](#))

C. Differential diagnosis & red flags

- **Red flags:** afferent pupillary defect, progressive field loss, cranial neuropathies, vertical diplopia with skew, penetrating/ocular injury signs, papilledema/raised ICP, new-onset seizures, worsening focal deficits → **urgent neuro-ophthalmology/neurology.**
- **Confounders:** migraine, cervical dysfunction, anxiety/sleep disturbance, medications, pre-existing binocular/accommodative disorders unmasked by concussion.

D. Initial management principles

- **Task/lighting/visual hygiene,** provisional **prism** for diplopia, **tints/filters** for photophobia (short trial with functional endpoints), **accommodative/vergence tasking** with pacing, **head-movement exposure** graded for VOR tolerance, and early **education** on symptom-limited activity. (Embed within TBICoE's staged

return-to-duty algorithm and refer for formal rehabilitation as indicated.)
([Health.mil](#))

Page 4 — Rehabilitation, Care Pathways, and Programmatic Integration (DoD/VA)

A. Evidence-informed rehabilitation in military settings

- **Oculomotor & vergence/accommodation therapy:** addresses CI, accommodative insufficiency, saccadic/pursuit deficits; track objective endpoints (NPC, near phoria, vergence ranges) and functional outcomes (reading speed, headache frequency).
- **Visual field rehab/compensation:** scanning training; selective prism strategies; task-specific adaptation for mobility/ADLs; align with VCE materials on visual field loss after TBI/ABI. ([Health.mil](#))
- **Visual-vestibular rehab:** gaze-stabilization (VOR x1/x2), optokinetic tolerance, graded motion desensitization; integrate with balance/vestibular PT.
- **Cognitive-visual integration:** processing-speed training, crowding management (typography/contrast/spacing), environmental accommodations.

B. TBICoE clinical infrastructure & tools

- **Acute Concussion Care Pathway (ACCP):** standardized assessment, education, rest-then-gradual exertion, duty modifications, and **progressive return-to-activity** with visual symptom checkpoints; embedded **MACE-2** cognitive/neurologic screening. ([Health.mil](#))
- **Provider education and tech:** TBICoE training for ACCP; DHA's **Warfighter Brain Health Provider Toolkit** mobile app supports assessment/treatment of concussion "anytime, anywhere." ([Health.mil](#))
- **Rehabilitation approach:** stepwise return-to-duty protocols with interdisciplinary care coordination (optometry, neuro-ophthalmology, vestibular PT, behavioral health, primary care, case management). ([PMC](#))

C. Roles and resources for vision after TBI

- **VCE mission:** prevent, diagnose, treat, and help patients recover from visual system injury; collaborates with VA and academic partners; curates **clinical recommendations** and **provider resources** (e.g., screening for oculomotor dysfunction; management of visual field loss after TBI/ABI; eye/vision care after blast exposure). ([Health.mil](#))
- **Clinical pathway integration:** embed VCE screening/CRs inside TBICoE ACCP to ensure early identification of oculomotor and field deficits; establish referral triggers and outcome measures relevant to duty readiness and ADLs.

D. Program metrics & reporting (what to track)

- **Operational metrics:** time to initial eye-care screening post-concussion; percentage receiving oculomotor/field testing; referral completion to vision rehab; return-to-duty timelines.
 - **Patient-reported outcomes:** symptom scales for photophobia/reading fatigue/visual motion sensitivity; activity-specific function; driving/flight/weapon-sighting tolerance.
 - **Quality/safety:** red-flag capture rates, escalation timeliness, adverse events (e.g., unmitigated diplopia), adherence to ACCP stages.
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Notes on numbers & keeping them current

- DoD totals change quarterly. The figures above (>~500,000 cumulative since 2000; ~20,000+ annually; ~80% mild) reflect the most recent public reporting and press coverage; for exact current totals in a manuscript, cite the newest **TBICoE DoD TBI Worldwide Numbers** PDF corresponding to your cut-off date (e.g., “2000–2024 Q4” or “2000–2025 Q1”). ([Health.mil](#))
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Key Sources

- TBICoE — **DoD TBI Worldwide Numbers** (official totals, quarterly/annual PDFs) and **Provider Resources/ACCP**. ([Health.mil](#))
- VCE — **About/mission, Clinical Recommendation: Screening for Oculomotor Dysfunctions, Provider resources for visual field loss and blast-related eye care**. ([Health.mil](#))
- CDC — U.S. population TBI burden (context). ([CDC](#))
- Peer-reviewed/overview: TBICoE approach to concussion rehab in service members; systematic coverage of post-TBI visual dysfunctions. ([PMC](#))