Mild Traumatic Brain Injury and Postconcussion Syndrome: Neuropsychology's Role

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Case Scenario

- 35 year old
- Motor vehicle accident, rear ended.
- Head struck the seat/headrest during rear-end impact, with acceleration-deceleration forces; no reported loss of consciousness.
- At ER, ROS and Neuro exam normal. CT normal.
- Later records report patient experienced dizziness at the time. Period of months with no concern but 4-6 months later reports increased symptoms or dizziness, headache, nausea, brain fog, depression and anxiety, and cognitive symptoms.
- Multiple medical appointments with various medications tried. Impressions from multiple records indicate patient sustained a cerebral concussion and now has long term post concussive symptoms.
- PT, OT, Speech therapies.
- Patient previously employed. Considering reduced work or disability.
- Not getting significantly better.

Patient referred to Neuropsychology

First Step

What is the question?

What do you (the referring provider) want to know? Examples of referral questions.

What's going on?

Are there structural problems in the brain that explain symptoms?

Are the patient's headaches, dizziness, visual symptoms, balance problems caused by the concussion?

Has the patient sustained permanent brain damage?

Are the cognitive complaints due to the concussion, depression, anxiety, PTSD, sleep disturbance, pain, or some combination?

Is the patient malingering?

Can the patient return to work, school, or driving?

Is there objective evidence of cognitive impairment and if so in what domains?

Are the patient's cognitive complaints congruent with the cognitive profile?

How should cognitive findings be interpreted in the context of patient's premorbid functioning, injury history, and current status?

What factors might be contributing to the patient's ongoing cognitive complaints?

What factors do we consider in Neuropsychological Assessment?



What happened?

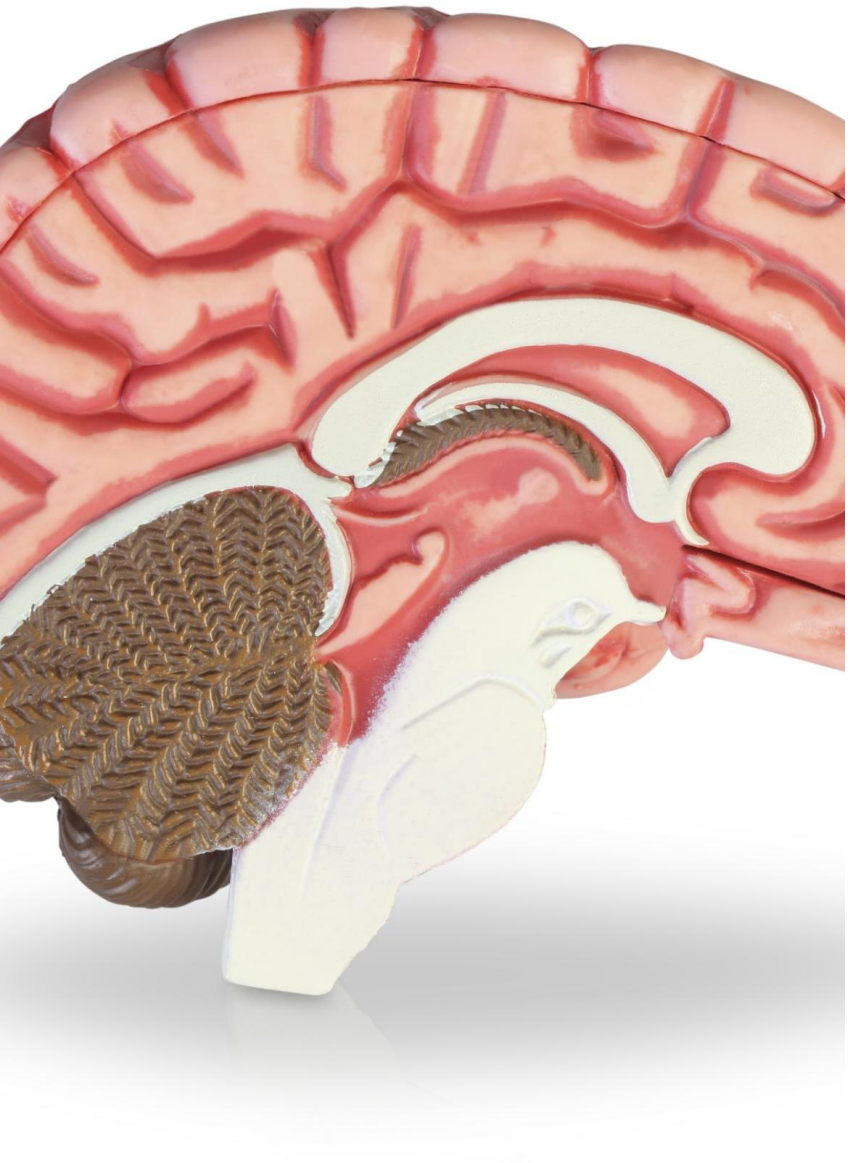
Medical record review

Ask the patient: Can you walk me through what happened?



Foundations and Definitions





Overview of MTBI and Postconcussion Syndrome

Definition and Characteristics

MTBI is characterized by an acute alteration in brain function following direct or indirect biomechanical forces. Loss of consciousness, posttraumatic amnesia, disorientation, confusion, or other acute neurological findings may occur but are not individually required.

ACRM Definition (Silverberg et al., 2023):

A concussion (MTBI) is a brain injury caused by direct or indirect biomechanical forces transmitted to the head, resulting in acute neurological impairment. Diagnosis is based on clinical signs, symptoms, or examination findings (loss or alteration of consciousness, amnesia, neurological symptoms), not requiring positive neuroimaging. Routine structural neuroimaging is often normal, and positive neuroimaging is not required for diagnosis.

Neurocognitive Effects in Sports-Related MTBI



Acute Neurocognitive Deficits

Single concussions cause mild to moderate deficits, especially memory, typically resolving within 7 to 10 days.

Recovery Variability

Most athletes recover quickly, but about 10% have prolonged symptoms requiring extended recovery periods.

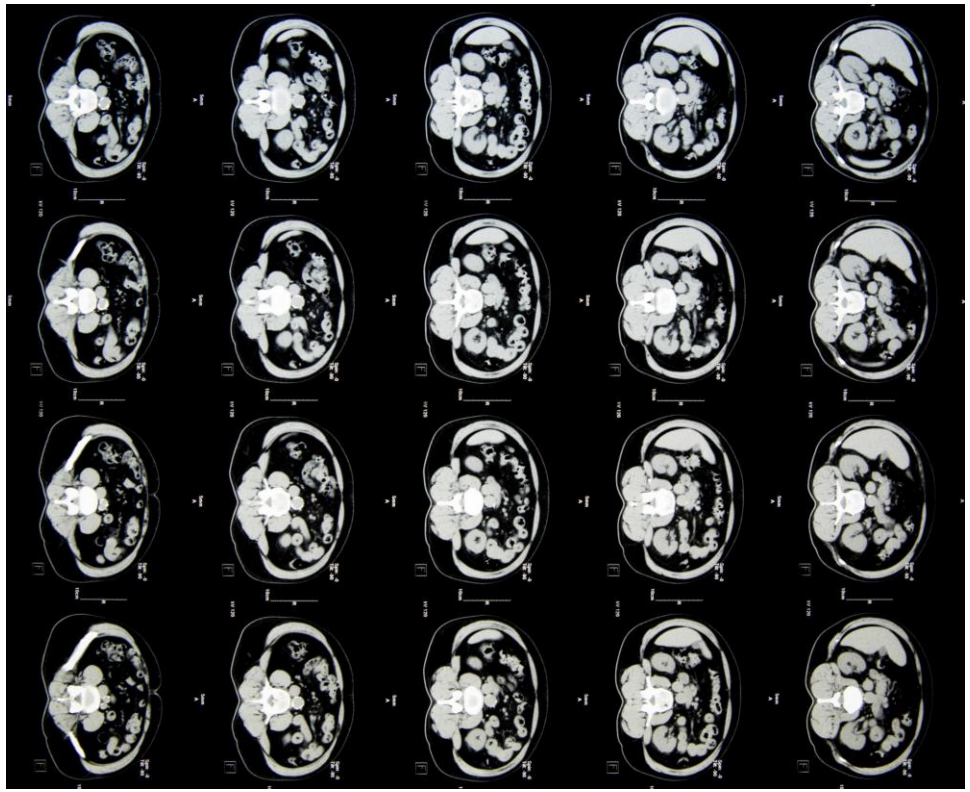
Effects of Repeat Concussions

Multiple concussions may lead to prolonged recovery and subtle deficits in attention and executive function.

Population Differences and Caution

Findings from athletes may not generalize broadly due to different injury mechanisms and psychosocial factors.

Neurocognitive Outcomes in General Patient Populations



Heterogeneous Recovery Patterns

MTBI recovery varies widely among patients, with most regaining cognitive function within months but some facing long-term difficulties.

Commonly Affected Cognitive Domains

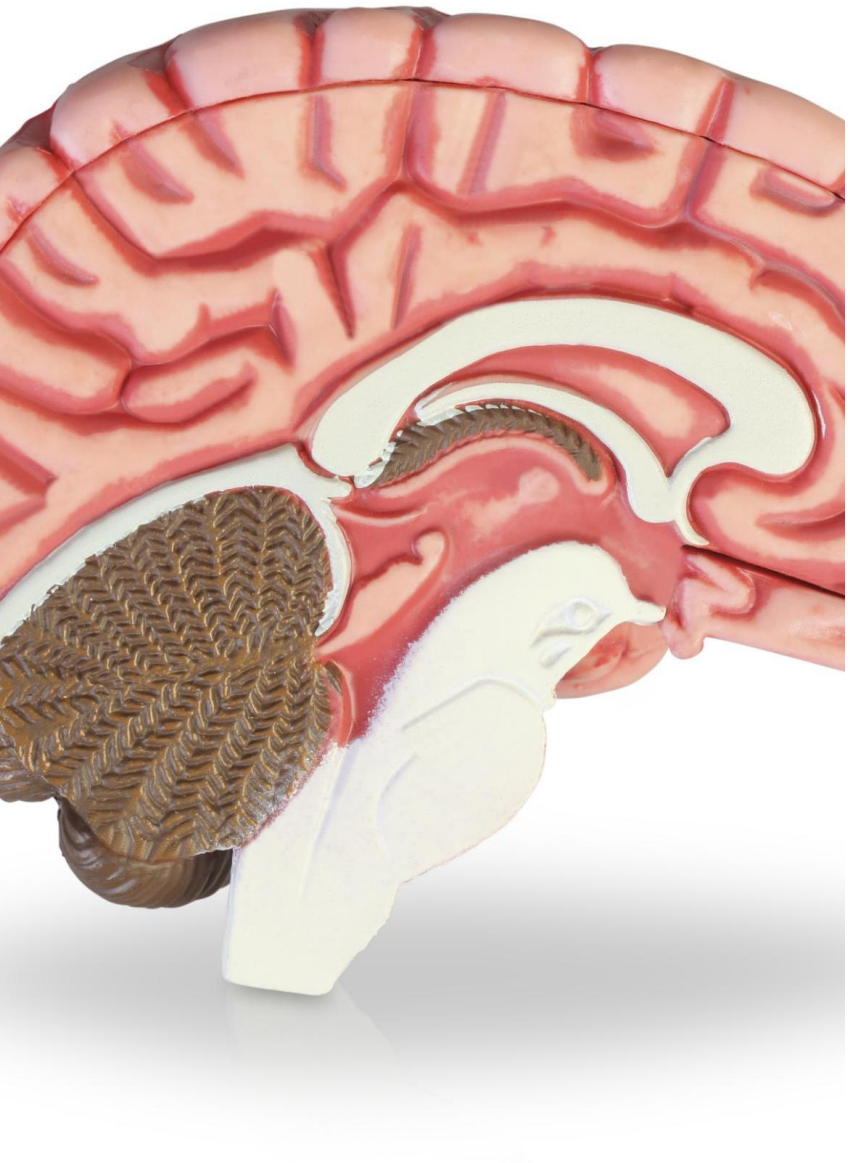
Verbal fluency, delayed memory, and attention are typically impacted during the acute phase after MTBI.

Vulnerable Subgroups

A subset of patients experience persistent neurocognitive deficits influenced by premorbid vulnerabilities and psychosocial stressors.

Spectrum Model of Recovery

Most patients recover fully, while others show delayed or incomplete recovery requiring targeted interventions.



Overview of MTBI and Postconcussion Syndrome

Postconcussion Syndrome Overview

PCS involves persistent physical, cognitive, and emotional symptoms lasting weeks to years post-injury. Estimates vary widely depending on the population, follow-up interval, symptom threshold, and diagnostic definition. Most individuals recover within days to weeks, while a clinically meaningful minority report persisting symptoms.

Neurological and Psychological Interaction

PCS reflects complex interplay between neurological disruption and psychological factors like mood and coping.

Epidemiology and Controversy

About 80% of TBIs are mild, with 10-15% developing persistent symptoms, raising neurological vs. psychological debate.

Defining MTBI and PCS: Diagnostic Controversies

MTBI Diagnostic Variability

MTBI is defined by transient brain function disruption with varying diagnostic criteria including Glasgow Coma Scale and amnesia duration.

PCS Diagnostic Ambiguity

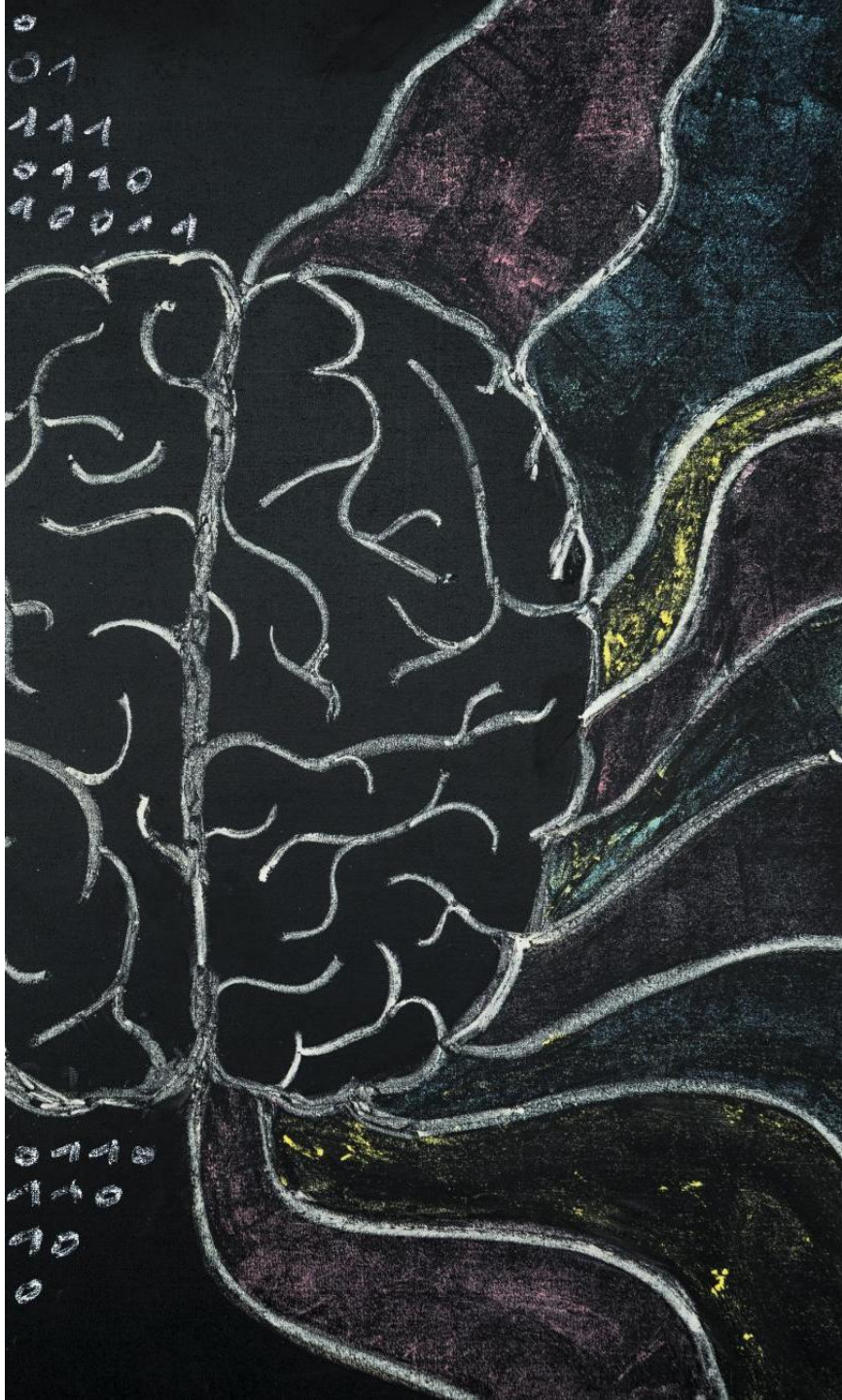
Historical diagnostic frameworks, particularly DSM-IV and ICD-10, used substantially different criteria and produced widely varying prevalence estimates. Current classifications no longer retain PCS as a single distinct diagnostic category, contributing to continued terminology and attribution challenges.

Symptom Overlap Challenges

PCS symptoms overlap with depression, chronic pain, and whiplash, complicating precise diagnosis.

Multidimensional Assessment Importance

Experts recommend focusing on functional impact and symptom severity rather than strict labels for diagnosis.



Psychological & Lifestyle Factors in PCS-Like Symptom Reporting

Balasundaram et al. (2016)

A large university sample showed that symptom-checklist scores vary meaningfully with sleep, alcohol use, mental fatigue, anxiety, stress, and depression.

N = 603 STUDENTS



A cross-sectional web survey tested whether everyday psychological and lifestyle variables altered symptom reporting.

603

University students

18–30

Participant age range

95.1%

Survey completion rate

- SCAT2 postconcussion symptom scale produced Total Symptom Score (TSS; 0–22) and Symptom Severity Score (SSS; 0–132).
- Predictors included stress, physical and mental fatigue, anxiety, depression, sleep difficulty, recent alcohol/caffeine use, physical activity, and gender.
- Separate multiple linear-regression models were fit for TSS and SSS, including two-way interactions.
- Data were collected July–October 2012.

Balasundaram et al., 2016

At baseline, the average student endorsed nearly 10 of 22 symptoms.

9.74 / 22

Mean Total Symptom Score

22.65 / 132

Mean Symptom Severity Score

38.6%

Trouble sleeping the prior night

13.1%

Alcohol in prior 24 hours

Core implication: elevated symptom scores can occur in the absence of concussion and may reflect ordinary but clinically relevant fluctuations in sleep, mood, stress, fatigue, and lifestyle.

Balasundaram et al., 2016, Tables 1 and 3

Interpret symptom scales as context-sensitive indicators, not stand-alone proof of concussion or recovery.

Before interpreting

Ask about last night's sleep, recent alcohol use, mental fatigue, stress, anxiety, and depression.

When deciding RTP

Use symptom-report data within a multifaceted assessment. Context can raise or lower scores independent of concussion status.

Methodological cautions

Cross-sectional associations do not establish causation. Several lifestyle variables were measured with single yes/no items, including alcohol quantity-unspecified.

Bottom line: symptom scores are clinically useful, but base rates and biopsychosocial modifiers matter.

Balasundaram et al., 2016, Discussion

Personality and Postconcussion-Like Symptoms

Garden, Sullivan, & Lange (2010)

Healthy adults frequently endorsed symptoms typically associated with PCS, and endorsement covaried with personality and psychopathology measures.

NONCLINICAL SAMPLE



Can healthy, non-head-injured adults endorse “postconcussion-like” symptoms, and how are those reports related to personality?

N = 93

Healthy participants analyzed

46 + 47

First-year students + community participants

18–78

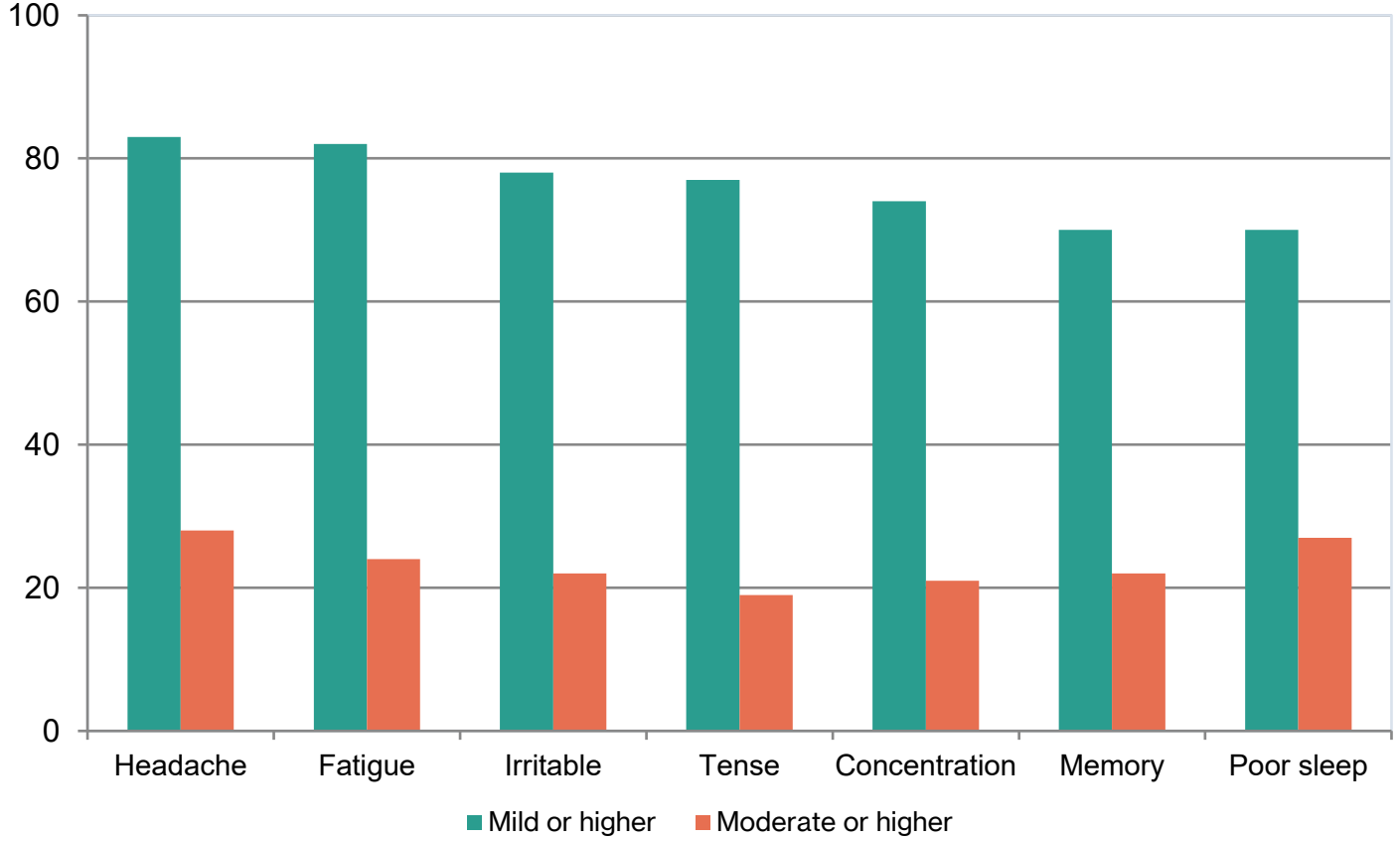
Age range; 70% were 18–29

- Excluded history of brain injury or neurological disorder.
- Measures: British Columbia Postconcussion Symptom Inventory (BC–PSI) and MCMI–III.
- BC–PSI assessed frequency and intensity of 13 symptoms over the prior two weeks.
- Primary analysis examined associations between symptom burden and MCMI–III scales.

Garden et al., 2010

PCS-like symptoms were common without brain injury

Mild symptom endorsement was widespread; several symptoms also reached at least moderate levels.



55 of 93

Met ICD-10 Criterion C symptom threshold used by the study

Clinical meaning

A symptom checklist can identify substantial symptom burden in healthy people. Symptom presence alone is therefore not specific evidence of concussion.

Garden et al., 2010, Table 2

Personality and psychopathology scales tracked symptom burden

The association was broad rather than confined to a single trait.



Statistically significant group differences

- Depressive
- Dependent
- Sadistic
- Negativistic
- Borderline
- Anxiety
- Somatic
- Dysthymia
- Major depression

Effect sizes across these nine scales ranged from medium to very large (d = 0.5–1.5).

Garden et al., 2010, Tables 3–4

Interpretation and limitations

The paper supports cautious attribution, not dismissal of genuine post-injury symptoms.

1

What the data support

PCS-like symptoms lack specificity. Personality and psychological factors may contribute to their production, amplification, or maintenance.

2

What the data do not show

The study did not test people with mTBI and cannot determine whether any individual symptom is caused by personality rather than injury.

3

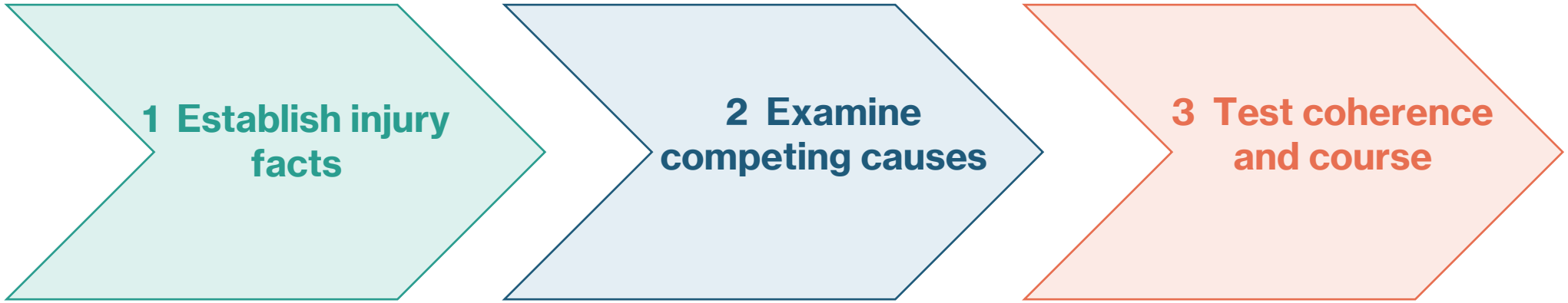
Key limitations

Convenience sample; self-report shared-method variance; MCMI–III normed in psychiatric samples; possible item overlap; limited generalizability.

Garden et al., 2010, Discussion

Clinical takeaway

Require a full clinical formulation before attributing persistent symptoms to concussion.



Symptoms are real data, but they are not etiologically self-interpreting.

Integrate symptom pattern, onset, time course, objective findings, mood, sleep, pain, premorbid traits, contextual factors, and functional change.

Psychiatric Comorbidity and PTSD



Role of Psychiatric Comorbidity

Psychiatric conditions like depression, anxiety, and PTSD significantly affect persistent post-concussion symptoms.

PTSD Development Mechanisms

PTSD can develop despite amnesia through fragmented memory and conditioned fear responses.

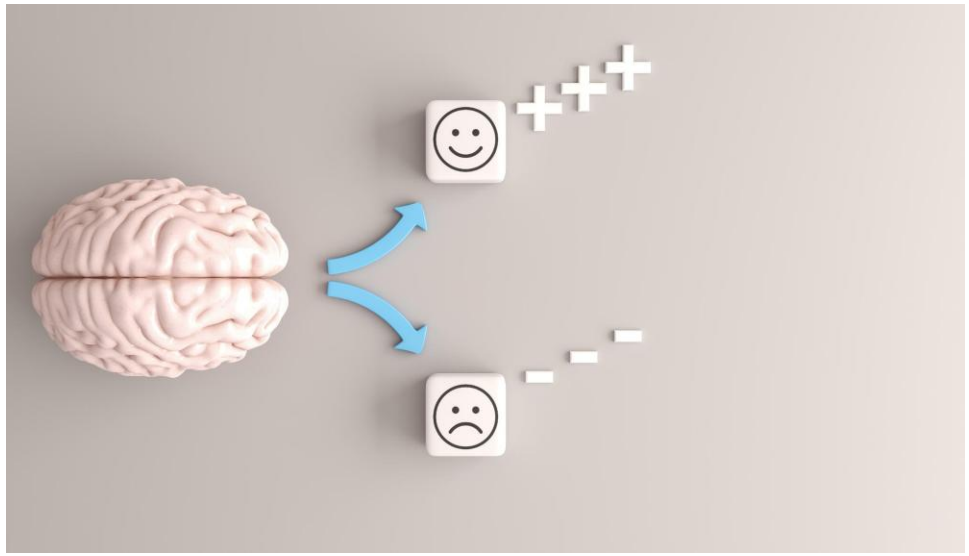
PTSD's Impact on PCS

PTSD not only co-occurs with PCS but can mediate symptom persistence and severity over time.

Importance of Psychiatric Assessment

Including psychiatric evaluation in PCS care is crucial for effective symptom management and recovery.

Expectations, Attributions, and Symptom Appraisal



Cognitive and Emotional Appraisals

Cognitive and emotional appraisals significantly influence the persistence of postconcussional symptoms beyond formal diagnoses.

Expectation Effects on Symptoms

Expectations alone can shape symptom perception, as shown by uninjured individuals anticipating PCS symptoms after reading about head injuries.

Impact of Injury Interpretation

Viewing injury as serious early on increases likelihood of reporting persistent symptoms months later.

Clinical Management Strategies

Effective management requires communication, validation, and addressing maladaptive illness perceptions without catastrophizing.

Performance Validity Tests (PVT'S)

Stand-alone and embedded measures designed to evaluate the validity of cognitive test performance. Most are relatively insensitive to genuine cognitive impairment within their intended clinical range but sensitive to invalid or noncredible performance.

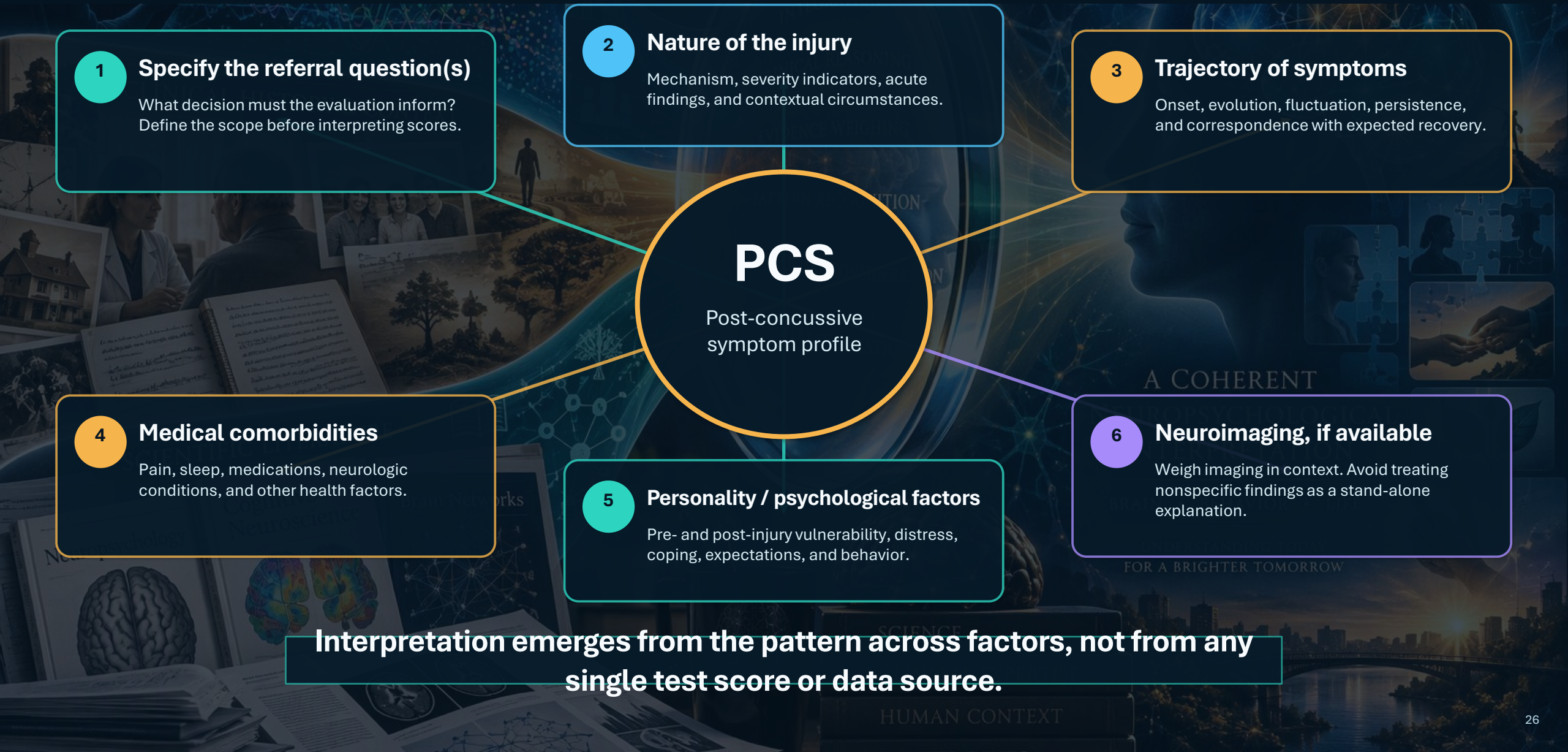
PVT's are typically passed by most clinical groups.

Reported PVT failure rates vary widely across samples and settings and are influenced by methodology, referral context, injury severity, and incentives.

PVT performance impacts neuropsychological assessment interpretation and can have implications for treatment response.

PCS is interpreted through a multifactorial lens

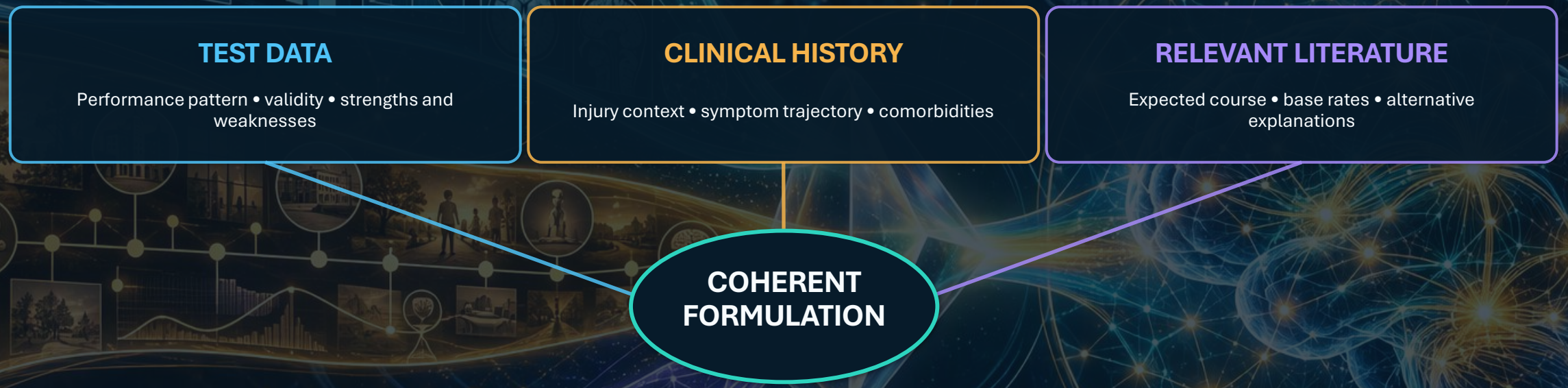
Neuropsychological assessment integrates injury details, symptom course, person-level factors, and converging evidence.



Interpretation emerges from the pattern across factors, not from any single test score or data source.

Now look at the neuropsychological test results

The question is not simply “Are scores low?” It is whether the full pattern is coherent with the history and evidence.



Given all of these factors, what interpretation makes the most sense?

Integrate the test data, clinical history, and relevant literature into the most parsimonious, clinically useful formulation.

Best fit, not single-cause certainty

POST-CONCUSSIVE SYMPTOMS • NEUROIMAGING



“But what if I’m brain damaged?!”

The question feels specific. The image often isn’t.

Why “normal testing” cannot rule out mTBI neuropathology

Bigler et al. challenge the historical use of legacy tests as standalone evidence of recovery.

1 **Legacy tests have limits**

Most traditional measures were not developed to detect subtle, heterogeneous, network-level effects of mTBI.

2 **Modern methods reveal more**

SWI, diffusion MRI, MEG, and connectivity analyses may detect abnormalities missed by CT, routine MRI, or standard testing.

3 **Recovery may reflect adaptation**

Compensatory networks can support normal-range performance despite persisting biological change or symptom burden.



Clinical implication

Interpret tests, imaging, biomarkers, history, and biopsychosocial context together.

Bigler, E. D., Allder, S., Dunkley, B. T., & Victoroff, J. (2025). What traditional neuropsychological assessment got wrong about mild traumatic brain injury. I. Brain Injury, 39(14), 1161–1183. https://doi.org/10.1080/02699052.2025.2551162



Clinical counterbalance: sensitivity is not attribution

Your critiques identify the gap between detecting a signal and establishing clinically meaningful mTBI-related dysfunction.

01 Sensitivity ≠ specificity

Imaging abnormalities may be real yet nonspecific. Psychiatric, medical, pain, sleep, vascular, and premorbid factors can contribute to similar findings in the “unclean” clinical patient.

02 Structure ≠ function

A structural or functional imaging difference does not establish cognitive impairment. White-matter or connectivity abnormalities may coexist with intact cognition, behavior, and everyday function.

03 Risk of misattribution

Labeling subtle findings as “brain damage” may promote nocebo effects, symptom monitoring, illness identity, and attribution of ordinary lapses to injury, without creating an actionable treatment target.

Balanced conclusion

Normal neuropsychological findings do not prove the absence of neuropathology. Conversely, an imaging abnormality does not, by itself, prove clinically meaningful dysfunction caused by mTBI.

Bigler, E. D., Allder, S., Dunkley, B. T., & Victoroff, J. (2025). What traditional neuropsychological assessment got wrong about mild traumatic brain injury. I. Brain Injury, 39(14), 1161–1183. https://doi.org/10.1080/02699052.2025.2551162



Neuroimaging and Cognitive Correlates

Structural Imaging in MTBI

Structural MRI and CT reveal abnormalities linked to worse acute cognitive performance in complicated MTBI cases.

Functional Imaging Insights

fMRI shows altered brain activation during tasks, indicating increased neural effort in MTBI patients.

White Matter Abnormalities

DTI studies may detect group-level differences in white-matter microstructure, including within the corpus callosum and internal capsule.

Limitations in Predicting Outcomes

Imaging correlates weakly with long-term symptoms and functional recovery, better for early deficit understanding.

Assessment, Treatment, and Key Takeaways

Assessment and Early Intervention

Comprehensive MTBI Assessment

MTBI assessment integrates symptom reports, cognitive tests, and contextual factors for accurate diagnosis and management.

Standardized Symptom Questionnaires

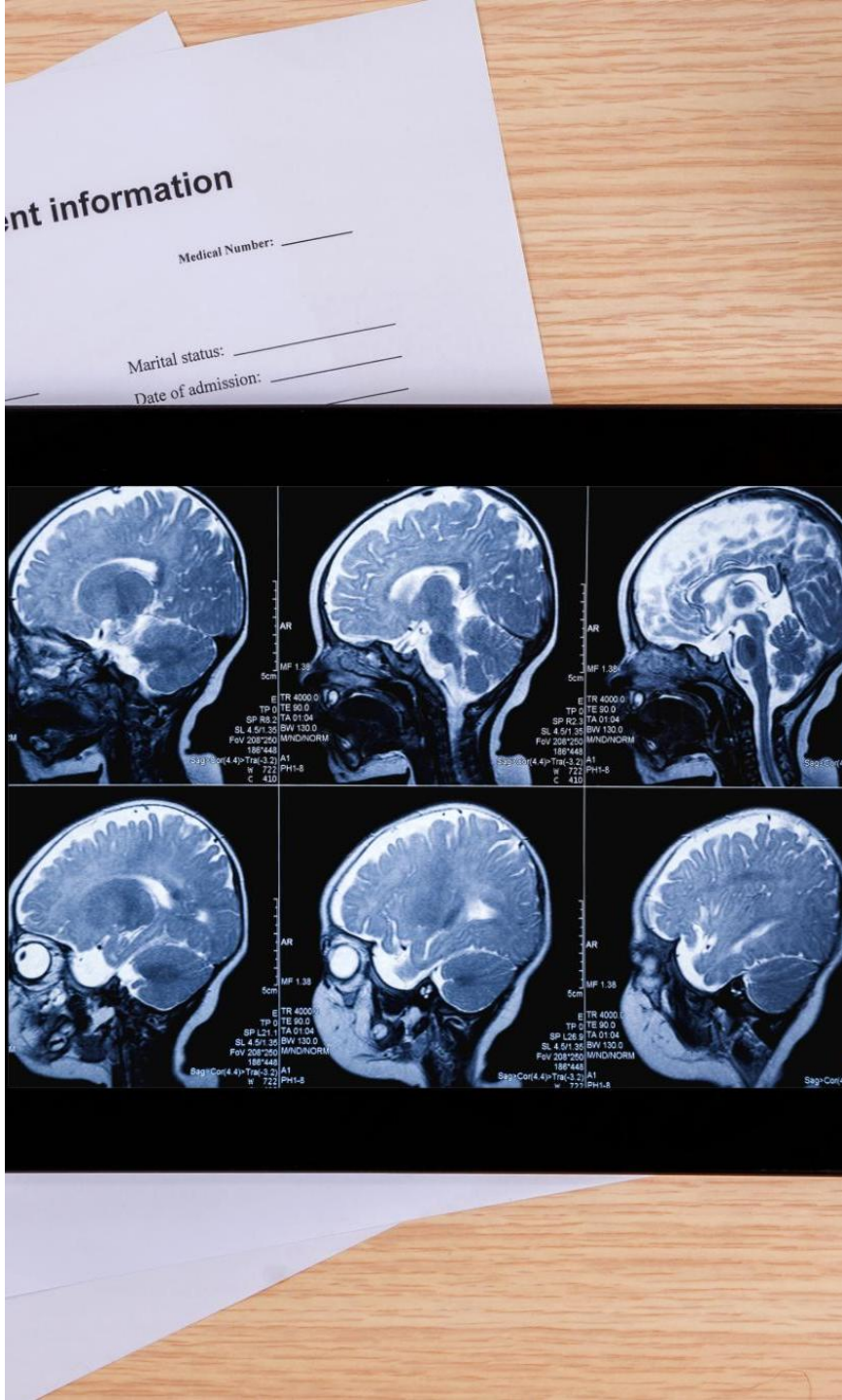
Using standardized tools helps track symptom severity and functional impact in PCS patients.

Early Intervention Benefits

Early reassurance and educational interventions reduce long-term PCS risk by promoting coping and normalizing symptoms.

Psychological Screening and Support

Screening for mood and PTSD symptoms enables timely referral for psychological care, enhancing recovery outcomes.





Treatment of Persistent Postconcussion Syndrome

Integrated Therapeutic Approach

Treatment is individualized and symptom-targeted. Depending on the formulation, it may incorporate education, graded return to activity, cognitive-behavioral strategies, headache or vestibular treatment, sleep intervention, trauma-focused care, and selected cognitive-rehabilitation approaches.

Addressing Cognitive and Emotional Symptoms

Targeting both cognitive deficits and emotional challenges improves attention, mood, and coping mechanisms in PCS patients.

Individualized Treatment Plans

Tailored interventions consider neurological and psychological factors, addressing heterogeneity and comorbid psychiatric conditions like PTSD.

Key Conclusions and Clinical Implications



Balanced Understanding of MTBI

Most individuals recover fully from MTBI, but some experience persistent symptoms needing clinical attention.

Role of Neurocognitive Deficits

Early neurocognitive deficits relate to injury severity and can indicate delayed recovery in complicated MTBI cases.

Psychological Factors in Symptoms

Mood disorders, PTSD, and symptom perceptions play critical roles in maintaining long-term post-concussion symptoms.

Integrated Clinical Management

Effective care combines neurological and psychosocial approaches with education, early assessment, and targeted intervention.

Back to our case scenario

- 35 year old
- Motor vehicle accident, rear ended.
- Head struck the seat/headrest during rear-end impact, with acceleration-deceleration forces; no reported loss of consciousness.
- At ER, ROS and Neuro exam normal. CT normal.
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Neuropsychological Findings

1. **Neurocognitive performance was broadly within normal limits, with minor nonspecific inefficiencies.**
2. **The MMPI-2-RF showed elevations on scales associated with possible overreporting, unusually high symptom distress, and somatic complaints. These elevations exceeded those typically observed in many clinical comparison groups.**
3. **The patient reported no history of mental health treatment before the collision.**
4. **The overall presentation was considered most consistent with emotional distress, symptom appraisal and attribution processes, and the effects of chronic neck and back pain following the collision.**
5. **Although the patient did not demonstrate clinically significant PTSD symptoms, mild-to-moderate anxiety was reported in response to accident-related triggers.**

Suggested Readings and References

Definitions, recovery course, and clinical formulation

Silverberg, N. D., Iverson, G. L., Cogan, A. M., et al. (2023).
The American Congress of Rehabilitation Medicine diagnostic criteria for mild traumatic brain injury. Archives of Physical Medicine and Rehabilitation, 104, 1343–1355.

Romeu-Mejia, R., Giza, C. C., & Goldman, J. T. (2019).
Concussion pathophysiology and injury biomechanics. Current Reviews in Musculoskeletal Medicine, 12, 105–116. https://doi.org/10.1007/s12178-019-09536-8

Williams, W. H., Potter, S., & Ryland, H. (2010).
Mild traumatic brain injury and postconcussion syndrome: A neuropsychological perspective. Journal of Neurology, Neurosurgery & Psychiatry, 81, 1116–1122. https://doi.org/10.1136/jnnp.2008.171298

McIntosh, S. J., Vergeer, M. H., Galarneau, J.-M., Eliason, P. H., & Debert, C. T. (2025).
Factors associated with persisting symptoms after concussion in adults with mild TBI: A systematic review and meta-analysis. JAMA Network Open, 8(6), e2516619. https://doi.org/10.1001/jamanetworkopen.2025.16619

Hecker, L., King, S., Wijenberg, M., et al. (2025).
Catastrophizing thoughts and fear-avoidance behavior are related to persistent post-concussion symptoms after mild traumatic brain injury. Neurotrauma Reports, 6(1). https://doi.org/10.1089/neur.2024.0136

Suggested Readings and References

Symptom reporting, psychological factors, and performance validity

Balasundaram, A. P., Athens, J., Schneiders, A. G., McCrory, P., & Sullivan, S. J. (2016).
Day-to-day variability of post-concussion-like symptoms reported over time by a non-concussed cohort. Brain Injury, 30(13–14), 1599–1604. https://doi.org/10.1080/02699052.2016.1199902

Garden, N., Sullivan, K. A., & Lange, R. T. (2010).
The relationship between personality characteristics and postconcussion symptoms in a nonclinical sample. Neuropsychology, 24(2), 168–175. https://doi.org/10.1037/a0017431

Carone, D. A., & Bush, S. S. (Eds.). (2013).
Mild traumatic brain injury: Symptom validity assessment and malingering. Springer Publishing Company.

Mollica, A., Dedominicis, M., Silverberg, N. D., & Burke, M. J.
Persisting symptoms after concussion and functional neurological disorder: Points of intersection. Seminars in Neurology. https://doi.org/10.1055/a-2752-8940

Suggested Readings and References

Neuroimaging, interpretation, and treatment

Wortzel, H. S., Kraus, M. F., Filley, C. M., Anderson, C. A., & Arciniegas, D. B. (2011).
Diffusion tensor imaging in mild traumatic brain injury litigation. Journal of the American Academy of Psychiatry and the Law, 39, 511–523.

Bigler, E. D., Allder, S., Dunkley, B. T., & Victoroff, J. (2025).
What traditional neuropsychological assessment got wrong about mild traumatic brain injury. I: Historical perspective, contemporary neuroimaging overview and neuropathology update. Brain Injury, 39(14), 1161–1183. https://doi.org/10.1080/02699052.2025.2551162

Gumus, M., Santos, A., & Tartaglia, M. C. (2021).
Diffusion and functional MRI findings and their relationship to behaviour in postconcussion syndrome: A scoping review. Journal of Neurology, Neurosurgery & Psychiatry, 92, 1259–1270.

Smith, A., King, N. S., Carrigan, N., & Reed, N. (2025).
What psychological interventions are effective for individuals with prolonged post-concussion symptoms of at least 12 months following mild traumatic brain injury? A systematic review. Neuropsychological Rehabilitation, 35(8), 1664–1694. https://doi.org/10.1080/09602011.2024.2435283