Concussion Evaluation and Management: An Osteopathic Perspective

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Concussions have been increasingly reported over the past decade, but the reported incidence likely minimizes the actual numbers of people affected. Associated symptoms include emotional, somatic, and cognitive complaints, which may be prolonged in patients with certain risk factors. Neurologic examination is necessary to exclude upper motor neuron lesions and thus the need for brain imaging. Cervical conditions are often found concurrently with head injury and displays a similar presentation to concussions. Therefore, determining symptom origin can be problematic. Neuropsychological, oculomotor, and balance evaluations expose specific deficits that can be successfully managed with rehabilitation. Osteopathic assessment of the cranium, spine, sacrum, and thorax for somatic dysfunctions allows for prudent interventions. Patients involved in sports may begin an established graduated return-to-play protocol once cleared by their physician. Concurrently, a parallel return-to-learn program, with applicable academic accommodations, is recommended.

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In 2013, approximately 2.8 million emergency department visits in the United States were related to traumatic brain injury (TBI), including mild TBI or concussion.[1] Concussions occur as a consequence of forces transmitted to the head causing acceleration/deceleration of the brain and typically result in temporary impairment in neurologic functioning.[2] However, up to 15% of patients have persistent symptoms for more than 3 months and demonstrate increased rates of disability and health care use.[3-5]

Acceleration/deceleration forces result in several neurometabolic abnormalities in the acute postconcussion period.[6] Forces directed to the brain also cause axonal stretch, which impairs microstructural components of neurons.[6] Unmyelinated fibers are found to be more susceptible to these injuries, which may inform concussion prognosis in children.[6] Repetitive head trauma can result in long-term sequelae, such as the progressive neurodegenerative disease *chronic traumatic encephalopathy*.[2]

The purpose of this review is to educate health care professionals on an evidenced-based approach to evaluate and manage concussions in the outpatient setting.

Summary of Evidence

When evaluating a patient who has sustained a concussion, many factors must be considered, such as medical history, symptoms, and vital signs, and several examinations and

assessments may be required. Examination components (Table 1) and assessment tools (Table 2) are discussed in the following paragraphs.

History and Symptom Report

Concussions can result in a constellation of symptoms that are marked by their heterogeneity in presentation.[2] Somatic complaints include headache, dizziness, photophobia, phonophobia, nausea, and vomiting. Emotionally, patients report irritability, sadness, anxiety, or depression. Cognitive features include difficulty concentrating, feeling in a "fog," and amnesia.[2] Additionally, sleep disturbances such as insomnia or somnolence are common.[2] Loss of consciousness, once considered a hallmark of concussion, is now found to be featured in less than 14% of cases.[7] Certain factors, such as history of concussion, female gender, younger age, attention-deficit/hyperactivity disorder, psychiatric comorbidity, and prolonged loss of consciousness are associated with prolonged recovery.[8] The sports concussion assessment tool, produced at the international conference on concussion in sport, is sensitive and specific for concussion identification.[9]

Vital Signs

Concussion can cause temporary (<72 hours) autonomic disruption of the cardiovascular system most likely due to its effect on associated brain regions.[10] Autonomic dysregulation may manifest as increases in systolic blood pressure as a result of reduced arterial baroreceptor sensitivity. Orthostatic intolerance, with a significant increase in heart rate, has also been recognized in patients with concussion. Although resting heart rate is typically unchanged, abnormal fluctuations can occur during exercise after concussion.[10]

Cervical Examination

Biomechanical research indicates that as little as 4.5 g of acceleration of the neck can result in a cervical strain.[11] Studies examining accelerations that culminated in a concussion demonstrated that 60 to 160 g of linear acceleration was necessary.[11] Thus, it is likely that forces causing concussions also result in cervical injuries. Symptoms associated with cervical spine injury include headaches, dizziness, and visual deficits, symptoms that also largely overlap with those of concussion.[12] Therefore, the presence of cervicogenic symptoms may or may not indicate the presence of a concussion and should be correlated with the overall patient presentation.[12]

KEY POINTS

- Concussions have heterogeneous presentations and prognoses.
- Risk factors for protracted symptoms include history of concussion, psychiatric comorbidities, and prolonged loss of consciousness.
- Physical examination should include cervical, neurologic, neuropsychological, oculomotor, balance, and osteopathic assessments.
- Imaging is warranted in mild traumatic brain injury if there is concern for more serious brain injury or intracerebral hemorrhage.
- Visual, vestibular, or cognitive rehabilitation are recommended for persistent concussion symptoms.

Repetitive head trauma can result in long-term sequelae, such as chronic traumatic encephalopathy.

Neurologic Examination

Cranial nerve (I, III, IV, and VII) injuries were found to be present in approximately 13% of mild and moderate TBIs. Also, 80% of patients with a cranial nerve injury had correlating abnormalities on computed tomographic (CT) images.[13] Abnormalities found on manual muscle testing, deep tendon reflexes, and tests for upper motor neuron lesions (eg, pronator drift) have been associated with more severe injuries.[13]

Neuropsychological Examination

For concussion-related cognitive deficits, neuropsychological testing has moderate sensitivity.[14] Evaluation is most commonly accomplished via the computerized

Table 1.
Examination Components for Patients With Concussion

Examination	Assessment	Indication
History and symptom report	Date and mechanism of injury; symptoms checklist (SCAT5); psychiatric conditions; migraines; learning disorders (ADD/ADHD); medications	Concussion classification; individualized plan of care; risk factors for prolonged recovery
Vital signs	Orthostatic intolerance	Autonomic dysfunction
Cervical spine	Range of motion; tenderness to palpation	Cervicogenic disorder
Neurologic examination	Cranial nerves (I, III, IV, and VII); deep tendon reflexes; manual muscle testing	Rule out more severe head injury
Neuropsychological examination	MoCA; ImPACT	Cognitive dysfunction
Oculomotor assessment	Accommodation; convergence; saccades; smooth pursuit; King-Devick	Visual dysfunction
Vestibular/balance assessment	Gait including tandem Romberg test Dix-Hallpike maneuver SOT; BESS	Balance dysfunctions
Osteopathic examination	Cranium (OA, OM, CRI); spines (cervical-lumbar); ribs (thoracic outlet, diaphragm); sacrum/pelvis	Somatic dysfunctions

Abbreviations: ADD/ADHD, attention-deficit/hyperactivity disorder; BESS, Balance Error Scoring System; CRI, cranial rhythmic impulse; MoCA, Montreal Cognitive Assessment; OA, occipitoatlantal; OM, occipitomastoid; SCAT5, Sport Concussion Assessment Tool 5th Edition; SOT, sensory organization test.

platform Immediate Post Concussion Assessment and Cognitive Testing. Although less comprehensive, computerized tests have been validated against traditional testing methods and are more practical to administer.[14] The Montreal Cognitive Assessment, although not as well studied in the setting of concussion, has 72% sensitivity in detecting concussion-related memory impairment.[15]

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Oculomotor Assessment

Convergence insufficiency or accommodative dysfunction has been identified in up to 65% of patients with concussion.[16] Smooth pursuit and saccadic dysfunction are also prevalent in this population, affecting an estimated 60% and 30% of patients, respectively,[16] and correlate with a poorer recovery.[13] Observation of eye position, symmetry, strabismus, nystagmus, accommodation, and range of ocular movements is recommended.[17] Smooth pursuits can be observed by instructing the patient to allow his or her gaze to follow a slow-moving object (eg, pen) in the horizontal, vertical, and diagonal planes. Evaluation of saccades requires patients to be assessed on their ability to alternatively fixate across 2 targets. Convergence is measured by bringing an object from approximately 1 arm length away from the eyes closer to the nose until double vision is reported (normally, 6 cm). King-Devick testing offers a validated and objective 1- to 2-minute assessment of saccades, attention, and language.[16]

Vestibular/Balance Assessment

Dizziness affects an estimated 67% of patients with concussion and is associated with increased rates of anxiety and depression.[17] Other vestibular impairments associated with concussions include benign paroxysmal positional vertigo, posttraumatic Meniere disease, and

Table 2.
Assessment Tools for Patients With Concussion

Tool	Description	Components	Approximate Duration
SCAT5	Brief multidimensional assessment for patients aged ≥13 y	Symptom checklist; cognitive screening; orientation immediate; memory digits backwards; months in reverse order; delayed recall; neurologic screen; balance examination; Modified BESS	10 min
MoCA	Brief screen for mild cognitive impairment for patients aged ≥18 y	Modified trail making; copy of cube; clock drawing; naming (animals); digits forwards/backwards; letter a tapping test; serial "7" subtraction; sentence repetition; letter *f* fluency; recall/delayed recall; word abstraction; orientation	10 min
ImPACT	Online neurocognitive assessment for patients aged 12-59 y	Symptom checklist; word/design memory; symbol/color matching; Xs and Os (visual processing speed); 3-letter memory	25 min
King-Devick test	Assessment of saccades	Rapid number naming	2 min
BESS	Postural stability assessment	Firm/padded surface: single leg stance; double leg stance; tandem stance	10 min
SOT	Postural control assessment by CDP	Fixed/sway referenced surface: normal vision; eyes closed; sway referenced vision	15 min

Abbreviations: ADD/ADHD, attention-deficit/hyperactivity disorder; BESS, Balance Error Scoring System; CDP, computerized dynamic posturography; CRI, cranial rhythmic impulse; MoCA, Montreal Cognitive Assessment; OA, occipitoatlantal; OM, occipitomastoid; SCAT5, Sport Concussion Assessment Tool 5th Edition; SOT, sensory organization test.

superior canal dehiscence.[17] Physical examination should include observation of gait and tandem gait, the Romberg test, and the Dix-Hallpike maneuver. Further balance examination could include computerized dynamic posturography with sensory organization testing or the balance error scoring system. Sensory organization testing renders objective scores based on normative data for overall equilibrium, in addition to somatosensory, visual, and vestibular ratios. The balance error scoring system is a less expensive, easy-to-administer alternative with high specificity, but it is less sensitive and has low interrater reliability.[17]

Osteopathic Structural Examination

The production of reactive oxygen species in the brain and the glymphatic drainage system's involvement in head injury supports the role of osteopathic manipulative treatment.[18] Osteopathic manipulative treatment has been shown to yield significant improvement in symptoms associated with concussion, such as headache and vertigo.[18,19] Additionally, craniosacral therapy and visceral and neural manipulation have produced significant improvement in pain, cervical range of motion, and memory in former professional football players.[20] Recent research also demonstrates the safety of osteopathic cranial manipulative medicine in the treatment of patients with concussion.[19] However, studies are needed to determine appropriate patient selection. Therefore, assessment should involve the cranium, including the occipitoatlantal joint, occipitomastoid suture, strain patterns, and cranial rhythmic impulse; the spine, including cervical, thoracic, and lumbar somatic dysfunctions; the rib cage, including the first rib, thoracic outlet, sternoclavicular joint, and thoracic diaphragm; and the sacrum and pelvis.

Table 3.
Return-to-Play Protocol for Patients With Concussion

Stage	Aim	Activity	Goal
1	Symptom-free activity	Activity of daily living not causing symptoms	Returning to work/school activities as tolerated
2	Light aerobic exercise	Stationary bicycle or walking	Increase heart rate
3	Sport-specific activities	Running, swimming, etc	Incorporating movement
4	Noncontact practice	Resistance training, sports simulation without potential for head injury	Exercise with coordination and thinking
5	Full contact practice	Simulation of sport activities, normal training activities	Build confidence, allow for assessment by athletics staff
6	Return to sport	Game play	Unrestricted game play

Source: Adapted from Consensus statement on concussion in sport—the 5th International Conference on Concussion in Sport held in Berlin, October 2016, McCrory P, Meeuwisse W, Dvorak J, et al, 51, 838-847, 2017 with permission from BMJ Publishing Group Ltd.

Imaging

Imaging is not indicated to diagnose concussion in the acute setting.[21] However, if clinical suspicion exists for a more serious TBI, structural lesion, or intracerebral hemorrhage, CT or magnetic resonance imaging is appropriate. Suggestive symptoms include loss of consciousness, posttraumatic amnesia, altered mental status, focal neurologic deficit, evidence of skull fracture, or worsening neurologic symptoms.[21] In 2018, the US Food and Drug Administration approved blood tests for the proteins ubiquitin carboxy-terminal hydrolase L1 and glial fibrillary acidic protein, which, if positive, have a high sensitivity and specificity for predicting intracranial lesions on CT.[22] Other imaging modalities, such as diffusion tensor imaging, hold promise, but they are not yet commercially available and their clinical relevance is not yet established.[23]

Certain factors are associated with prolonged recovery.

Return to Play/Learn

For patients involved in sports, a protocol to support graduated return to play has been established (Table 3).[2] When the patient is asymptomatic at rest, he or she can be cleared by a qualified health care professional to begin the return-to-play protocol.[2] This protocol involves 5 stages of increasing activity, with each one taking place during a 24-hour period. If symptoms begin to occur during this protocol, patients should be advised go back to the previous stage and attempt to advance again when asymptomatic for 24 hours.[2]

The recommended approach for return to learn after a concussion is similar to that of return to play in that patients should return to activity in a graduated manner. However, for return to learn, patients need not be symptom free to initiate the process. The literature supports a prompt but gradual return to cognitive activity that is individualized to the student, his or her clinical presentation, and specific academic needs.[24,25]

Referral and Rehabilitation

Although most adults are expected to recover within 10 to 14 days after a single concussion, and most children are expected to recover within 4 weeks, many patients have symptoms that persist beyond this timeframe.[26] Persistent symptoms may include visual, vestibular,

Table 4.
Targeted Rehabilitation for Patients With Concussion

Intervention	Conditions	Goals
Vestibular rehabilitation	BPPV; cervicogenic dizziness; vestibulo-ocular reflex impairment	Restore postural control; sensory organization training
Visual rehabilitation	Convergence insufficiency; accommodation insufficiency; light sensitivity	Improvement of smooth pursuits and saccades; convergence; integrate vision with posture, balance, and motor skills
Cognitive rehabilitation	Inattention; memory impairment; decreased reaction	Improve memory and attention

Abbreviation: BPPV, benign paroxysmal positional vertigo.

cognitive, emotional, and sleep disturbances and are often characterized as postconcussion syndrome.[2] Rehabilitation including visual, vestibular, and cognitive therapy has demonstrated effectiveness in several postconcussion conditions (Table 4).[27,28] Additionally, a growing body of evidence supports the use of supervised aerobic exercise programs administered at subsymptom thresholds.[27]

Conclusion

Concussions require a comprehensive evaluation to assess pertinent risk factors, as well as cervical, neurologic, neuropsychological, oculomotor, balance, and osteopathic structural examinations. Visual, vestibular, or cognitive rehabilitation are recommended for persistent concussion symptoms.

Targeted concussion evaluations enable health care professionals to offer interventions that improve patient care.

Given the high incidence of concussions and their variable presentations, knowledge of an appropriate examination is warranted. A targeted but thorough assessment will yield results that are crucial in determining a management plan inclusive of return to learn/play and rehabilitation.

Author Contributions

Drs Yao and Finn provided substantial contributions to conception and design, acquisition of data, or analysis and interpretation of data; Drs Zwibel and Leder drafted the article or revised it critically for important intellectual content; all authors gave final approval of the version of the article to be published; and all authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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