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Specialty-Specific Diagnoses in Pediatric Patients With Postconcussion Syndrome: Experience From a Multidisciplinary Concussion Clinic

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Abstract

Objective: To describe the collaborative findings across a broad array of subspecialties in children and adolescents with postconcussion syndrome (PCS) in a pediatric multidisciplinary concussion clinic (MDCC) setting. **Design:** Retrospective analysis. **Setting:** Multidisciplinary concussion clinic at a pediatric tertiary-level hospital. **Patients:** Fifty-seven patients seen in MDCC for evaluation and management of PCS between June 2014 and January 2016. **Interventions:** Clinical evaluation by neurology, sports medicine, otolaryngology, optometry, ophthalmology, physical therapy, and psychology. **Main Outcome Measures:** Specialty-specific clinical findings and specific, treatable diagnoses relevant to PCS symptoms. **Results:** A wide variety of treatable, specialty-specific diagnoses were identified as potential contributing factors to patients' postconcussion symptoms. The most common treatable diagnoses included binocular vision dysfunction (76%), anxiety, (57.7%), depression (44.2%), new or change in refractive error (21.7%), myofascial pain syndrome (19.2%), and benign paroxysmal positional vertigo (17.5%). **Conclusions:** Patients seen in a MDCC setting receive a high number of treatable diagnoses that are potentially related to patients' PCS symptoms. The MDCC approach may (1) increase access to interventions for PCS-related impairments, such as visual rehabilitation, physical therapy, and psychological counseling; (2) provide patients with coordinated medical care across specialties; and (3) hasten recovery from PCS.

Key Words: concussion, postconcussion syndrome, multidisciplinary, accommodative dysfunction, convergence insufficiency, benign paroxysmal positional vertigo

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INTRODUCTION

Traumatic brain injury (TBI) has shown a steady increase in incidence in children and young adults between 2001 and 2012.[1] Many TBIs are defined as minor TBI or concussion. Concussion is a brain injury caused by direct or indirect forces to the head, which result in temporary loss of normal brain function.[2] Symptoms include physical, cognitive, and emotional impairment and symptoms typically resolve within 1 month.[2] Postconcussion syndrome (PCS) is defined as the persistence of this constellation of symptoms beyond the 4-week timeframe.[2] The reported incidence of PCS among concussion patients varies between 12% and 30%.[3–6]

The presentation of PCS varies by patient and often is multidimensional. Many chronic symptoms result from injuries to structures and pathways in the head and neck that do not specifically involve the brain. Large-scale studies have investigated PCS among patients from a single setting, such as the emergency department, neurosurgical setting, or sports medicine clinic[7–9]; however, there are potential advantages to expanding the care of children and adolescents with PCS beyond the realm of neurology, sports medicine, and primary care pediatrics to include related specialties in a cooperative, multidisciplinary setting.[10–12]

We hypothesized that a multidisciplinary approach to these patients would confirm dysfunction across numerous systems with specific diagnoses related to patients' symptoms. A better understanding of the patient as a whole would facilitate more efficient and coordinated treatment regimens for patients, potentially leading to earlier symptom resolution and recovery. This overall concept inspired the development of the Brain Injury Center's Multidisciplinary Concussion Clinic (MDCC) at Boston Children's Hospital (BCH), which was established in the spring of 2014. This clinic serves as a tertiary referral clinic for patients with PCS and coordinates same-day appointments with otolaryngology, ophthalmology, optometry, physical therapy (PT), psychology, and neurology or sports medicine (the latter 2 specialties alternate between each monthly clinic). Each monthly clinic session concludes with a meeting of all involved specialists to establish an

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individualized, collaborative treatment plan for each patient, which is subsequently relayed to the patient and family in conjunction with any needed coordination of care to facilitate the recommended treatments. The primary goal of this study was to describe the clinical findings and array of specialty-specific, treatable diagnoses potentially related to patients' PCS symptoms that were identified in this MDCC setting and to see if this supports the hypothesis that a multidisciplinary approach to these patients would facilitate identification of cross-specialty issues.

METHODS

We retrospectively reviewed the electronic medical records of all patients seen at the MDCC at BCH from July 2014 to January 2016. Patients were identified by examining the clinic schedule during the study period. Patients were included in the study if they were younger than 21-year-old at the time of assessment and experienced postconcussion symptoms persisting for 30 days or more beyond the date of injury. Patients were excluded if their intake questionnaires (described below) were incomplete. This study was approved by the Institutional Review Board at BCH and adhered to all Tenets of the Declaration of Helsinki.

As part of the clinical protocol of the MDCC, each patient completed a structured intake questionnaire, which included the Post-Concussion Symptom Scale (PCSS),[13] Convergence Insufficiency Symptom Scale,[14] patient demographics, history (including injury mechanism), and a detailed review of systems. These data were abstracted to provide the historical context for each patient. Examination findings, test results, diagnoses, and recommended/administered treatments were recorded by the review of the electronic clinic notes from each provider within the MDCC. These data were incorporated into a database for qualitative analysis. The number of new, treatable diagnoses assigned to each patient during their visit to the MDCC was determined, but this additional analysis was limited to the 21 patients seen in the MDCC within 100 days from their most recent concussion to limit the potential impact of additional disease processes that may have been unrelated to the injury. Diagnoses were only included in this analysis that were considered by the clinic providers to be likely contributing factors to their PCS symptoms and that have known treatments that have been well described in the medical literature. This diagnosis analysis did not include diagnoses of concussion, headache, dizziness, sleep disturbance, or other diagnoses that were previously assigned to patients outside of their evaluations in the MDCC. Pre-existing diagnoses were determined based on a combination of previous medical records and a patient/family report. Additional criteria were applied for the analysis of optometry/ophthalmology findings. Patients needed at least 20/30 best-corrected visual acuity in each eye for distance and near at presentation, no strabismus nor amblyopia, absence of anterior or posterior ocular disease, and no previous experience with vision therapy.

A limited number of patients did not see all of the specialists in the clinic, which was determined on a case-by-case basis. This typically occurred either when a patient did not report any symptoms on their intake paperwork that would warrant an evaluation by a particular specialist or when a patient's insurance did not approve a visit with a particular specialist because they were already followed by a similar specialist outside the MDCC. This latter issue was particularly common for PT.

RESULTS

Fifty-seven patients seen in the MDCC clinic between July 2014 and January 2016 were included for analysis. Patient demographics, injury characteristics, and referral sources are outlined in Table. The median time from the most recent concussion to evaluation in the MDCC was 118 days (interquartile range, 67–219). The self-reported, chief complaints of patients at the time of their initial presentation are outlined in Figure 1. Multiple chief complaints were included for each patient, as most presented with concerns about more than one symptom. All patients received at least one additional, treatable diagnosis related to their presenting symptoms during their MDCC evaluation other than concussion, headache, or sleep disturbance (Figure 2). Key specialty-specific findings, diagnoses, and treatments are summarized below in separate sections for each specialty domain.

Otolaryngology/Vestibular

A total of 55 (96.5%) of the patients were seen by otolaryngology. The examination showed abnormal dynamic visual acuity testing in 14 (25.5%) patients, abnormal Dix–Hallpike maneuver in 10 (18.2%) patients, and an abnormal head impulse test in 2 (3.6%) patients. Altogether, 18 (32.7%) patients demonstrated physical examination findings that were consistent with peripheral vestibular dysfunction (PVD) on examination during their otolaryngology evaluation in the MDCC. Fifteen patients were referred for a further vestibular test battery, yielding results consistent with PVD or impairment in 11 (20%) patients and hearing loss in 2 patients. Otolaryngology follow-up was recommended in 21 (38.2%) patients. No patients had premorbid vestibular diagnoses before their evaluation in the MDCC. Vestibular diagnoses and treatments are summarized in Figure 3.

Ophthalmology/Optometry

All 57 patients were seen by the optometry and ophthalmology team, but 11 subjects were excluded from the analysis because of the known pre-existing diagnosis of one or more of the conditions listed under the ophtho/opto exclusion criteria in the methods section above. Of the 11 subjects who were excluded, 5 had strabismus and/or amblyopia, 3 patients had poor entering visual acuity unexplained by refractive error (RE) or ocular pathology, 2 had uncorrected RE reducing the entering visual acuity below 20/30, and 1 had significant loss in accommodation decreasing the entering acuity for both distance and near that precluded ability to do a full binocular vision assessment. Symptoms other than headache commonly reported during the visit were difficulty in reading (n = 33, 71.7%), blurred vision (n = 23, 50%), difficulty in focusing (n = 19, 41.3%), double vision (n = 16, 34.7%), light sensitivity (n = 12, 26.1%), and eye fatigue/strain (n = 10, 21.7%). The mean score on the convergence insufficiency scale was 27.02 ± 14.24. All patients wore refractive correction if spherical equivalent RE in either eye had myopia >-0.75 D, hyperopia $>+1.50$D, and astigmatism >0.75 D. Refractive error distribution of the cohort was (19 (41.3%) with emmetropia (RE: ± 0.50D), 21 (45.65%) with hyperopia (spherical equivalent RE $\geq +0.75$D), and 6 (13.0%) with myopia, (spherical equivalent RE ≤ -0.75D). Of the 46 patients, 7

TABLE. Demographics, Concussion Characteristics, and Referral Sources for 57 Patients From the Multidisciplinary Concussion Clinic Included in the Study Sample

	Mean ± SD (Range)	N (%)
Gender		
Male		26 (45.6)
Female		31 (54.4)
Age at time of evaluation (yr)	15.1 ± 2.8 (7.9–20.9)	
Time since most recent concussion (d)	181 ± 214 (31–1192)	
No. of lifetime concussions	1.81 ± 1.55 (1–11)	
Patients with >1		24 (42.1)
PCSS score*	53.1 ± 23.5 (0–99.5)	
Loss of consciousness		7 (12.3)
Mode of concussion		
Sports		29 (50.9)
Motor vehicle crashes		15 (26.3)
Others†		13 (22.8)
Referral source		
Neurology		24 (42.1)
Sports medicine		21 (36.8)
Otolaryngology		7 (12.3)
Primary care		4 (7.0)
Ophthalmology		1 (1.8)

** Total possible PCSS score = 132.*
† Fall, altercation, or impacts with object (unrelated to sports activities).

wore corrective lenses for RE at presentation. Based on the evaluation, 3 were recommended to continue with the same prescription, 4 were recommended a change in prescription, and 6 were prescribed glasses for the first time for a total of 10 (21.7%) patients requiring a new or an updated glasses prescription. Binocular vision deficits (BVDs) (Figure 4A) were identified in 35 (76%) patients, consisting of vergence deficits (impaired eye teaming) in 25 (54.3%) patients and accommodative dysfunction (impaired eye focusing) in 34 (52.2%) patients. A combination of both accommodative dysfunction and vergence deficits was identified in 14 (31.4%) patients. Treatments that were recommended for BVD are outlined in Figure 4B. Follow-up with optometry/ophthalmology was recommended for 34 (73.9%) patients.

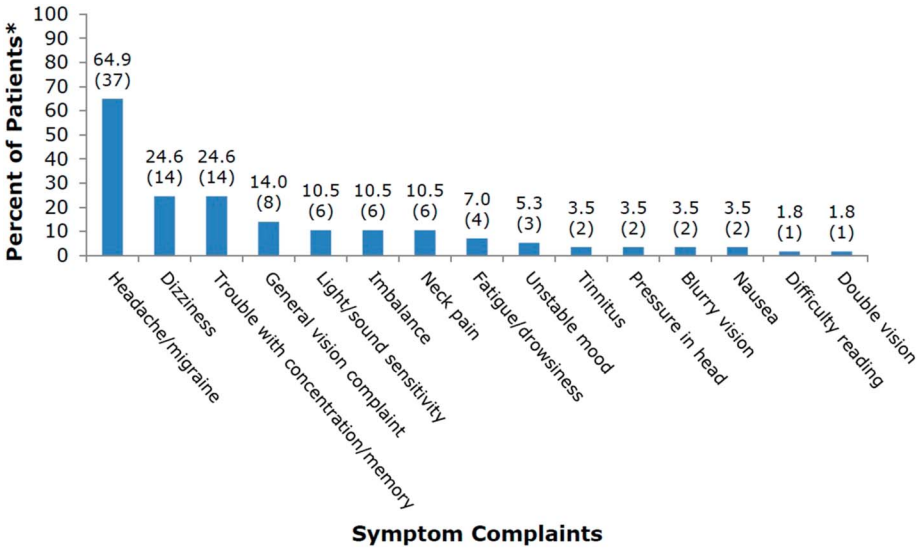

Figure 1. Self-reported chief complaints by patients at the time of their initial presentation to the multidisciplinary concussion clinic (out of 57 patients). Patients were allowed to give multiple chief complaints [data label format: percentage (number of patients)].

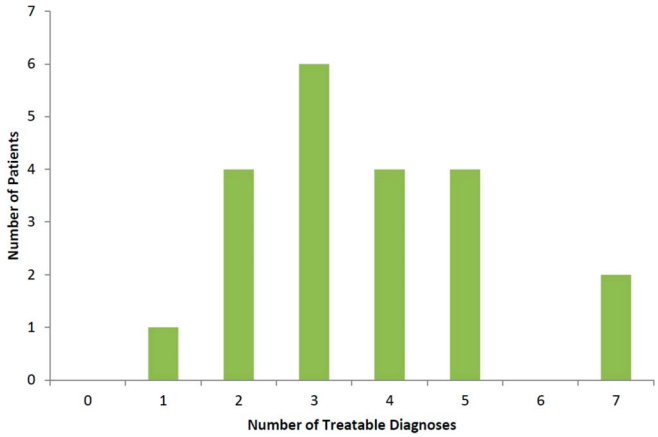

Figure 2. Number of new, treatable diagnoses assigned to each patient during their MDCC visits excluding diagnoses of concussion, headache, dizziness, sleep disturbance, or other diagnoses that were previously assigned to patients outside of their evaluations in the MDCC. Patients seen in the MDCC >100 days from the time of injury were excluded from this analysis.

Physical Therapy

A total of 50 (87.7%) patients were seen by the PT team. Patients had a mean balance error scoring system (BESS) score of 22.26 ± 12.02 with 33 (78.6%) of the 42 patients who went through BESS testing demonstrating an abnormal score of >13. Patients had a mean dynamic gait index of 21.6 ± 2.81 with 4 (9.1%) of the 44 who were tested demonstrating a higher risk of falling (score of ≤19). All patients were given home exercise regimens at the time of their visit, and 32 (64.0%) of the patients seen by PT were also referred for ongoing outpatient PT, either internally through our own program or to external PT providers.

Psychology

A total of 52 (91.2%) patients were seen by the psychology team. Premorbid psychiatric diagnoses included anxiety in 21 (40.4%) patients, depression in 11 (21.2%) patients, post-traumatic stress disorder in 3 (5.8%), panic disorder in 2 (3.8%), and bipolar disorder and obsessive-compulsive disorder in 1 patient each (1.9%). Symptoms of anxiety and depression were identified in 30 (57.7%) and 23 (44.2%) patients, respectively, at the time of their evaluation by psychology in the MDCC. Thirteen patients (25.0%) went on to have formal neuropsychological testing on a separate day after their visit to the MDCC. Follow-up with a mental health specialist was recommended to 23 (44.2%) patients at the time of their MDCC appointments.

Neurology

A total of 26 (45.6%) patients were seen by the neurologist. Headache was reported in 43 (82.7%) patients, whereas

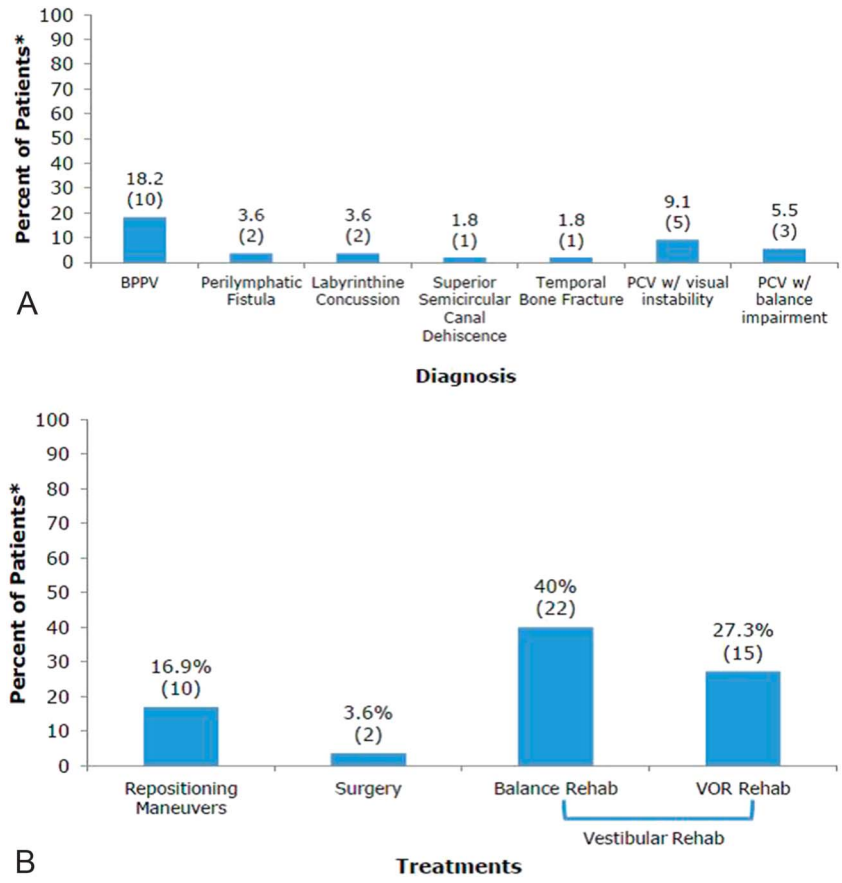

Figure 3. Vestibular diagnoses (A) and treatments (B) of 55 patients seen by otolaryngology. PCV, post-concussive vestibulopathy; VOR, vestibulo-ocular reflex; rehab–rehabilitation [data label format: percentage (number of patients)].

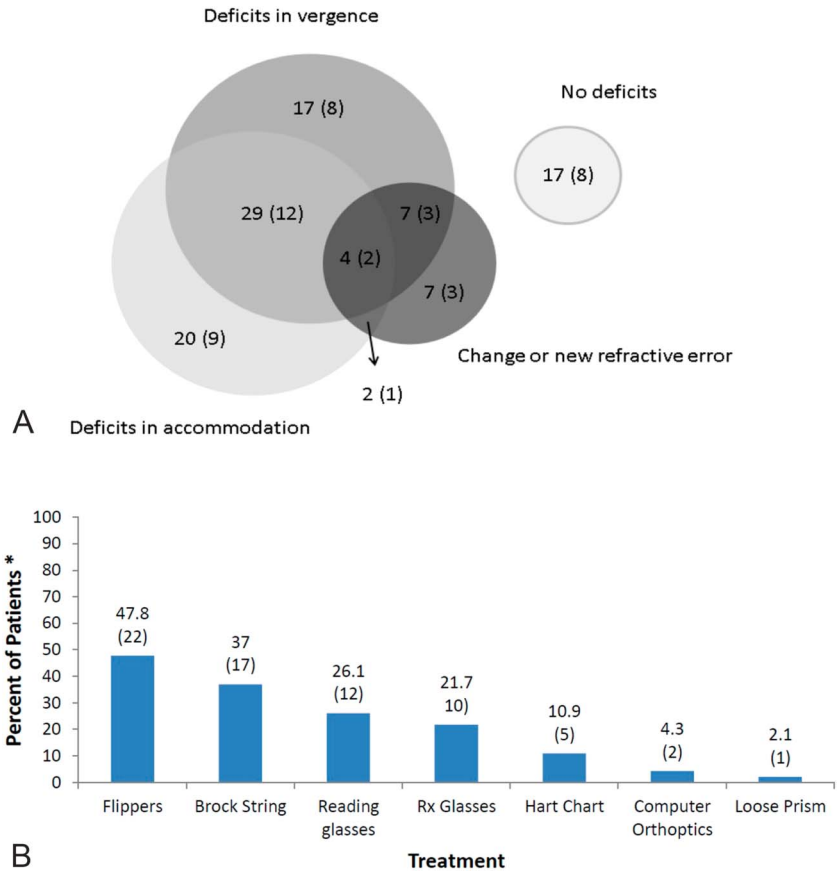

Figure 4. Ophthalmologic/optometric diagnoses (A) and recommended treatments (B) of 46 patients seen by ophthalmology/optometry. HTS, home therapy system; Rx glasses, prescribed glasses for distance and near wear [data label format: percentage (number of patients)].

photophobia and phonophobia were reported in 28 (53.8%) and 26 (50.0%) patients, respectively. Chronic daily headache symptoms were present in 32 (61.5%) patients. Nine (17.3%) patients had a history of migraine headaches before their injury. All 26 had a reassuring nonfocal, normal neurological examination. Interventions were recommended for 15 (57.7%) patients, and follow-up was recommended for 18 (69.2%).

Sports Medicine

A total of 26 (45.6%) patients were seen by the sports medicine specialist. Occipital and trapezius point tenderness were identified in 9 (34.6%) and 10 (38.5%) patients, respectively. Myofascial pain syndrome was diagnosed in 5 (19.2%) patients with 1 receiving recommendations for massage therapy, 3 for PT, and 4 also warranting a recommendation for potential trigger point injections. In all, 8 patients received a recommendation of intervention from the sports medicine specialist, and follow-up was recommended in 16 (61.5%) patients.

DISCUSSION

The time to recovery from concussion is highly variable and is known to be influenced by a number of factors, including a history of prior concussions, symptom severity at the time of injury, gender, and age.[15–19] Although the recovery time varies, most patients do recover within the typical time frame of approximately 4 weeks or less.[20] The term "postconcussion syndrome" reflects the notion that symptoms persisting beyond the typical recovery period may not be a direct result of concussion pathophysiology as we currently understand it and instead may occur through a number of additional indirect mechanisms. These include factors such as isolation, frustration with lack of progress, physical and psychological deconditioning, pre-existing comorbidities such as anxiety or migraine, and injury to extracranial structures of the head and neck.[19,21,22] The effective diagnosis and treatment of many of these additional factors may fall outside of the wheelhouse of many primary concussion providers. The cross-specialty collaboration of our MDCC has allowed us to identify and efficiently manage a number of specialty-specific, treatable diagnoses that may contribute to ongoing symptoms in PCS patients. Early recognition and management of such diagnoses may help to hasten PCS recovery.

A number of different MDCC models have been developed in recent years, but the specific specialties involved vary widely and are often quite limited.[10–12] The number and variety of subspecialties involved in our MDCC is especially broad, allowing us to describe the potential yield of the inclusion of each individual subspecialty in such a model. We hope that this may serve as a helpful guide in the design and development

of future MDCC programs. Specific subspecialty domains that merit consideration are discussed in further detail including otolaryngology, optometry/ophthalmology, PT, and psychology.

Otolaryngology/Vestibular

Children with dizziness at the time of concussion have 6 times the risk of developing PCS, and dizziness is the second most common symptom of PCS in pediatric patients.[23,24] Postconcussion dizziness initially results primarily from the impact on the brain.[25,26] However, dizziness beyond the typical recovery period may also result from PVD in the inner ear,[27] which was found in 18 (31.6%) patients in our study. Ten patients were diagnosed with and treated for benign paroxysmal positioning vertigo (BPPV) at the MDCC, none of whom had received this diagnosis before the visit. Benign paroxysmal positioning vertigo results from displacement of crystals in the inner ear causing vertigo with head movements and can be diagnosed and treated in the office with head maneuvers. A study of adult military patients found that approximately a third had BPPV within a few days after concussion and that early treatment resulted in a more rapid return to duty compared with other concussion patients with dizziness.[28] Another 8 MDCC patients had other causes of PVD warranting either PT or surgery. Thus, involving a vestibular specialist early may help to expedite recovery of persistent dizziness in children with PCS.

Optometry/Ophthalmology

Vision complaints are common in PCS, many of which result from BVD. Master et al[29] reported accommodation disorders in 51% and convergence insufficiency in 49% of adolescent concussion patients. Refractive error and/or BVD were identified in 82.6% of our MDCC patients. Binocular vision deficit can cause many symptoms that are common in PCS, including difficulties with blurry vision, double vision, shifting focus, reading for long periods, headaches, or eye strain.[30–32] Vergence and accommodation deficits more commonly occur together (14/46; 30.4%) than in isolation. Treatments for BVD are directed at each patient's specific deficits and may include RE correction and/or visual rehabilitation exercises.[33,34] Concussion providers should have a low threshold for referring PCS patients with vision symptoms to an optometrist or ophthalmologist with experience in the diagnosis and management of BVD, either independently or in an MDCC setting.

Physical Therapy

Concussion commonly results in static and/or dynamic balance deficits.[35] A majority of MDCC patients were recommended for ongoing PT for a variety of indications, including treatment of imbalance, vestibular dysfunction, deconditioning, and myofascial pain. A majority of MDCC patients demonstrated balance impairments on BESS testing, and nearly a third was diagnosed with PVD, many of which required PT for treatment. Balance retraining and vestibular rehabilitation can significantly improve imbalance and dizziness after concussion.[35,36] Postconcussion syndrome patients are also frequently impacted by deconditioning, which can be supported by a reconditioning program under PT guidance,[37] as reflected in a large proportion of our MDCC cohort. The inclusion of PT in MDCC teams should be strongly considered given the numerous indications for PT in PCS patients across multiple specialties.

Psychology

A large proportion of patients were found to have anxiety and/or depression during their evaluation with the psychologist in the MDCC, and in a number of cases, these diagnoses were known to predate their concussions. Unfortunately, it was not possible to determine what proportion of patients with a new anxiety or depression diagnosis from the MDCC may have already had these disorders before their injury as many of them had not had a previous psychological evaluation. Concussion can exacerbate preexisting mental health conditions and new psychological issues can be caused by both the injury itself and the recovery process.[38,39] Ellis et al[40] found that 11.5% of youth with sports-related concussions endorsed psychological symptoms, and that a higher PCSS score predicted the presence of a mental health disorder. However, many patients with low PCSS scores also had preexisting or new mental health disorders. Therefore, the inclusion of supplemental psychological surveys, such as the Beck Depression Inventory-II or the Revised Children's Manifest Anxiety Scale, should be considered in the evaluation of PCS patients to better identify those with psychiatric conditions.[41,42] Evidence-based psychological interventions for PCS symptoms, including headaches and dizziness, include Cognitive-Behavioral Therapy (CBT) and biofeedback.[38,40] A previous study found that pediatric PCS patients receiving a collaborative intervention that included CBT showed significant improvements compared with adolescents who received standard care from sports medicine providers and neuropsychologists.[43] Early evaluation by a mental health provider may help to facilitate screening of a greater proportion of PCS patients for contributing psychological factors, yielding more consistent initiation of such therapies for those who need them.

Benefits of the Multidisciplinary Approach

The already high overall loss of productivity from concussion is theoretically doubled for pediatric patients because of patients missing school and parents missing work for medical appointments and patient care at home.[44–46] The MDCC model may reduce this for PCS patients by consolidating multiple appointments into a single day and also by potentially reducing recovery time. The need for multiple copays for the MDCC may be balanced out for those who would otherwise already require visits with all MDCC specialties on separate days.

Another advantage to the MDCC approach is facilitation of interspecialty collaboration in evaluating symptoms and examination/test findings that may cross specialties. Both PVD (vestibular) and BVD (optometry) can cause any of the following: visual disturbances, dizziness, imbalance, impaired visual acuity or tracking, nystagmus, exacerbation of headache or fatigue, and reduced post-traumatic migraine trigger threshold for visual and/or motion stimuli.

We have also reported in another recent study that receded near point of convergence correlates with deficits in gait.[47] Our end-of-clinic MDCC team meeting helps to clarify the etiology of such symptoms for each individual patient and facilitates a streamlined management plan.

Study Limitations and Future Directions

There are a several limitations to this study. The generalizability of the results across all PCS patients is limited by the retrospective study design and relatively small sample size. Most of the patients seen in the MDCC were referred by concussion specialists and not by primary care providers, which may have also resulted in a referral bias yielding a disproportionate number of patients on the higher end of the PCS spectrum for degree of injury severity and symptomatic burden. In addition, an analysis of the impact of specific specialists, diagnoses, and treatments on patient symptoms and overall recovery could not be effectively conducted through this study design, primarily because of the lack of a control group, a uniform follow-up schedule, and consistent, objective measures of recovery across the sample.

This study does provide an initial descriptive analysis about the type of patients seen at a MDCC and their clinical presentation across a wide breadth of specialties. However, a prospective study is required to determine effectively the added value of an interprofessional approach to concussion management on overall recovery and patient quality-of-life relative to a single-provider model of care, and such a study is currently underway at our program. We have also initiated studies on the interactions between specialty-specific findings in patients with PCS and on the cost-benefit analysis of the MDCC model, both of which are also greatly needed.

CONCLUSION

Many systems can be affected by a concussion, both within the brain itself and beyond, and a variety of disorders across interacting systems may contribute to a prolonged recovery. Expertise in the evaluation and management of these disorders across multiple disciplines may be more effectively achieved in a multispecialty setting. The MDCC approach to PCS management yields many specialty-specific treatable diagnoses that may be contributing factors to patients' PCS symptoms, and it also increases patients' access to interventions for commonly identified problems in PCS that they typically would otherwise require multiple separate appointments (eg, PT, migraine management, CBT, etc). These benefits have the potential to improve the efficiency of recovery for children and adolescents after concussion.

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