CHIROPRACTIC MANAGEMENT OF THREE YOUNG ATHLETES WITH CONCUSSION

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ABSTRACT

Objective: The purpose of this case series is to describe chiropractic management and return-to-play of 3 student football players who had experienced concussion.

Clinical Features: Three young football players (ages 16, 15, and 11) sought care within 3 days after sustaining a concussion. Each athlete had neck pain accompanied by a headache.

Intervention and Outcome: Manual therapies and therapeutic exercises were provided by a chiropractor to help treat cervical spine symptoms and dysfunction. Each patient was also taken through computerized neurocognitive testing during the evaluation of the return-to-play process. At the conclusion of the treatments, all symptoms had resolved including neck pain and headaches. Additionally, cervical spine dysfunction had resolved, the neurocognitive testing scores had improved and each person was returned to play.

Conclusion Three football players with cervical spine symptoms, all having sustained a concussion, were managed and treated by a doctor of chiropractic. Manual therapies and therapeutic exercises were directed toward reducing cervical spine dysfunction, which appeared to have a beneficial effect on resolution of symptoms and return-to-play. (*Chiropr J Australia 2017;45:29-47*)

Key Indexing Terms: Chiropractic; Concussion; Sports Medicine

INTRODUCTION

Concussion recognition and management is an important and often complex process within the sports medicine and neurology fields. A concussion, or mild traumatic brain injury (mTBI), is a sub-cate.g.ory of traumatic brain injury (TBI) and has an annual prevalence according to the Center for Disease Control and Prevention (CDC) of 2.5 million emergency department visits, hospitalizations, or deaths in the United States. Additionally, TBI rates in emergency department visits increased 70% from 2001-2010. Approximately 250,000 of those visits involved sports and recreation-related injuries with a diagnosis of concussion or TBI in children (age 19 or younger) (1).These statistics do not include the estimated number of people with mTBI's who receive other medical care or who receive no care at all.

Although the primary etiology of the majority of acute concussion symptoms can be attributed to functional neuronal disturbance as well as neurometabolic changes, the

same forces capable of causing an mTBI may also concurrently injure the soft tissue structures and joints of the cervicothoracic spine (2). A whiplash injury to the neck often results in cervicothoracic spine injury or dysfunction, which has been shown to cause headache, dizziness, loss of balance, nausea, visual and auditory disturbance, reduced cognitive function, and many other signs and symptoms considered synonymous with concussion (2). In comparison, indicators of a concussion may include: (1) Symptoms—somatic (e.g., headache), cognitive (e.g., feeling like in a fog) and/or emotional symptoms (e.g., lability); (2) Physical signs (e.g., loss of consciousness (LOC, amnesia); (3) Behavioral changes (e.g., irritability); (4) Cognitive impairment (e.g., slowed reaction times); (5) Sleep disturbance (e.g., insomnia) (3). Many of the symptoms present in concussion may also be present in a patient with injury or dysfunction of the cervical spine. Increased awareness regarding the involvement of the cervical spine in concussion management and prevention is becoming increasingly important and evident. There is some evidence that suggests that neck strength may protect against concussion but definitive conclusions do require further research. (4-5)

Multimodal physiotherapy treatment for individuals with clinical evidence of cervical spine and/or vestibular dysfunction may be of benefit (3). A combined approach to treatment of the cervical spine and vestibular systems may facilitate recovery and decrease time lost from sport in individuals with persistent symptoms of dizziness, neck pain and/or headaches following a sport-related concussion (6). Due to the correlation between cervical spine trauma symptoms and concussion symptoms, manual therapies and therapeutic exercises were directed toward reducing cervical spine dysfunction, which appeared to have a beneficial effect on resolution of symptoms and return-to-play.

The purpose of this paper is to detail the management of 3 patients diagnosed with a concussion who were assessed and treated in the chiropractic setting following American-football injuries.

CASE REPORT

The following is a case-series involving 3 patients with concussion resulting from football participation. All athletes had sustained a concussion and presented for an initial diagnosis, management and treatment, or a combination of both into a chiropractic office. During the course of care, they underwent concussion evaluation, including neurological evaluation, musculoskeletal evaluation, computerized neurocognitive testing (ImPACT) and balance testing. Computerized neurocognitive baseline testing was performed with 2 of the 3 patients. One of the patients did not receive baseline testing as the baseline assessments were performed on all students in 7^{th}-12^{th} grades and he was in 6^{th} grade. However, all patients performed the computerized neurocognitive testing upon presentation with concussion symptoms and once again prior to completing their RTP protocol. After a thorough examination was performed on all patients, a course of treatment was initiated consisting of:

1. Instrument-assisted soft tissue mobilization
2. Myofascial release (MRT)

3. Spinal manipulative therapy (SMT)

Case 1

Initial Office Visit

A 16-year-old male high school football player was injured during a game, where he was struck directly under the chin in a collision. He did not lose consciousness and continued to play for a brief period until he was removed by coaching staff. He presented to an emergency department where he received negative plain films of his cervical spine and was diagnosed by the emergency room doctor with a concussion. Three days later he presented to a chiropractic clinic with symptoms which included a headache that started at the top of his head and running down to the cervical-thoracic spinal junction, sound sensitivity which aggravated his headache, episodes of vertigo, difficulty with concentration when reading, fatigue, and neck pain with reduced cervical range of motion (ROM).

Upon examination, he had slight difficulty in single leg balance on the right. . Assessment of muscular strength, sensory testing, and reflexes were all within normal limits. He was alert. He was able to engage in proper word recall and able to recite up to five digits backwards. This examination was performed using the SCAT3 assessment and his scores are reported in Table 1 below. Examination of the cervical spine included palpation, active and passive ROM, manual muscle strength testing, and orthopedic testing, which revealed joint restrictions with decreased fluidity of motion compared to the spinal segments above and below at the occiput, C7 and T2. Cervical compression with right and left rotation caused cervical spine pain without radicular symptoms. Muscle spasms were noted in the bilateral suboccipital muscles, bilateral cervical paraspinals, bilateral scalenes, bilateral upper trapezius muscles and bilateral levator scapulae muscles. The chiropractic physician reviewed the emergency room doctor's notes and agreed with the diagnosis of a concussion and moved forward with a treatment plan to address the patient's symptoms.

The treatment plan included instrument assisted soft tissue mobilization (IASTM) to the muscular spasms as the patient performed active and pain free cervical spine ROM. Myofascial release was performed to the muscular spasms. Spinal manipulative therapy (SMT) of the restricted joints was also performed.

He was sent home with instructions of physical and cognitive rest, which were consistent with the instructions that he received from the emergency department doctor. He was told that he could not have any physical activity in gym class or football for 24 hours after his symptoms had resolved. He was limited to one hour of television per day and was to avoid loud noise and bright lights. He was able to go to school for full days as tolerated with instructions to limit homework to 1 hour per day. His lunch hour was to be in a quiet space and the school was told to provide accommodations for him to sit in the front of the classroom. If his symptoms were to become aggravating he was told to just go home. Lastly, he was told that he should not take any school examinations for one week. Due to the nature of his symptoms, he was not cleared to return to practice.

Table 1. SCAT 3 scoring summary.

SCAT 3 Scoring Summary		
Test Domain	**Score**	
	Office Visit 1 / 3 Days Post-Concussion	**Office Visit 2 / 7 Days Pot-Concussion**
Number of Symptoms of 22	**8**	**0**
Symptom Severity Score of 132	**33**	**0**
Orientation of 5	**5**	**5**
Immediate Memory of 15	**15**	**15**
Concentration of 5	**5**	**5**
Delayed Recall of 5	**5**	**5**
SAC Total	**30**	**30**
BESS (total errors	**3**	**0**
Tandem Gait (seconds)	**14**	**10**
Coordination of 1	**0**	**1**

Second Office Visit

The patient followed up with care 4 days after his first chiropractic appointment. At that time, he did not report any symptoms. He indicated that all of his symptoms had resolved the day after his initial treatment. After 24 hours of symptom resolution, the patient started his return-to-play (RTP) protocol and was on the 3rd step in which he could participate in non-contact training drills as described by the 2012 Zurich Consensus Statement (3). The patient reported that he progressed along the RTP protocol without any setbacks. The SCAT 3 was utilized for evaluation and the patient's scores are reported on Table 1. Further examination of the cervical spine revealed continued joint restrictions compared to the spinal segments above and below at the occiput, C7 and T2. Cervical compression with right and left rotation was negative for cervical pain or radicular symptoms. Muscular spasms were noted in the suboccipital muscles, cervical paraspinals, scalenes, upper trapezius muscles and levator scapulae muscles bilaterally. However, the muscular spasms had improved from the initial visit. The same treatment was performed on this second visit.

At this visit, he was evaluated with computerized neurocognitive testing. The athlete had a baseline score which was obtained when the patient was asymptomatic prior to the start of the football season. His post-injury test was performed exactly 7 days after his initial concussion. His scores are reported in Table 4 below. It is important to note that this testing was performed after the patient had been symptom-free. His memory composite (verbal), memory composite (visual), visual motor composite, reaction time composite and impulse control composite scores all returned to baseline levels or better. However, the patient had a symptom score of 15 at his baseline test and that was because at the time he was having headaches and neck pain. This testing helped

the treating chiropractic physician with the RTP decision. Additionally, he was sent back to school with the previous restrictions lifted. After his second chiropractic office visit, he was followed up with via a phone conversation in regards to his RTP protocol. He successfully completed his RTP protocol without suffering any setbacks and was cleared for full contact game play by the treating chiropractic physician. A total of 12 days went by from the onset of his concussion until the day he was cleared. He was monitored throughout the remainder of the year. He did not sustain any more concussions nor did he have any more concussion symptoms, neck pain, or headaches.

Case 2

Initial Office Visit

A 11-year-old male football player was injured during practice, where he sustained a hard head-to-head collision. He did not lose consciousness and attempted to participate in further play but was removed by the coach. He presented to a chiropractic clinic 20 minutes after the injury where he was diagnosed with a concussion due to the signs and symptoms of concussion after biomechanical forces were transmitted to the head and neck. Symptoms at the time of presentation included pain in the top left part of his skull, a headache, and mild neck pain. He denied all other concussion-like symptoms.

Upon examination, he had had neck pain and a headache. There were no neurological deficits noted. He was alert and cognitive to date, time, place and month. He was able to engage in proper word recall and able to recite up to 5 digits backwards. His balance coordination was within normal limits. This examination was performed using the SCAT3 assessment and his scores are reported in Table 1 below. This examination was performed using the SCAT3 assessment and his scores are reported in Table 2 below. The patient was diagnosed with a concussion without loss of consciousness. He was held out of the remainder of practice and did not participate in the following day's game. His RTP protocol was started 2 days after his initial visit into the chiropractic office.

The initial treatment consisted of discussing the current RTP guidelines with the patient, parent, and coach. He was sent home with the same physical and cognitive rest instructions as described in case 1. Due to the present nature of his symptoms, he was not yet cleared to return to practice.

Second Office Visit

The patient was seen again 8 days after concussion occurrence on the day of the first office visit. He came for continued post-concussion management. At that visit, he indicated that he was only at stage 3 of his post-concussion RTP protocol due to a headache that he had 5 days earlier, which did fall on a weekend. Symptoms at the time of presentation included mild neck pain in the right posterior scalene musculature and cervical spine stiffness. He denied any other concussion-like symptoms.

Table 2. Scoring summary.

SCAT 3 Scoring Summary			
Test Domain	**Score**		
	Office Visit 1 / Same day of Concussion	**Office Visit 2 / 8 days Post-Concussion**	**Office Visit 3 / 14 days Post-Concussion**
Number of Symptoms of 22	**10**	**1**	**0**
Symptom Severity Score of 132	**38**	**2**	**0**
Orientation of 5	**3**	**5**	**5**
Immediate Memory of 15	**13**	**13**	**14**
Concentration of 5	**3**	**4**	**5**
Delayed Recall of 5	**4**	**4**	**5**
SAC Total	**23**	**26**	**29**
BESS (total errors	**3**	**0**	**0**
Tandem Gait (seconds)	**16**	**12**	**10**
Coordination of 1	**0**	**1**	**1**

He was oriented to time, day, age, grade and date. His gait and balance was normal and he did not have any neurological deficits. He had slightly reduced cervical spine ROM upon visual inspection. Foraminal compression and brachial plexus tension testing were ne.g.ative. He did have spasms in the posterior right scalenes and cervical paraspinals extending inferior to T2. There were cervical joint restrictions with loss of ROM at C6 and T2 levels.

A course of treatment was initiated consisting of instrument assisted soft tissue mobilization (IASTM), myofascial release and SMT. IASTM was performed to the muscular spasms as the patient was going through an active and pain free cervical spine ROM.

Third Office Visit

He next came 6 days later, which was 2 weeks following his initial concussion. It should be noted the earlier follow-up was not necessary for cognitive or athletic participation as the school was on fall break. He again indicated that he was at stage three of his RTP protocol, which is where he was at his last visit. He indicated that after completing stage 3, he developed a headache. Due to the schedule of his games, he ended up taking the remainder of the week off. The patient was asymptomatic at this visit. He denied having

a headache, cervical stiffness, muscular spasms, or neck pain. He denied all other concussion-like symptoms.

At this visit, he did not have any neurological deficits or balance deficits. The patient had normal cervical spine ROM upon visual inspection. Foraminal compression and brachial plexus tension testing were negative. He did have mild spasms in the posterior right scalenes and cervical paraspinals extending inferior to T2, however these spasms had improved from the previous visit. Examination of the cervical spine revealed joint restrictions with loss of se.g.mental ROM at C6 and T2 levels. A course of treatment was again performed consisting of the same treatment that was previously rendered.

We lacked a baseline measure of his computerized neurocognitive testing. All athletes between grades 7-12 were screened at his school; however, this athlete was currently in 6th grade. His first computerized neurocognitive test was performed 8 days after his initial concussion with the second test performed six days after the initial test. During both tests, the athlete did indicate that he was symptom-free. In evaluating his test results, the memory composite (verbal), memory composite (visual), visual motor composite, reaction time composite, impulse control composite, and symptom scores all improved as compared to his initial post-injury test, again helping the physician make a safe RTP decision.

Following his 3rd chiropractic office visit, he was followed up with phone conversation. He successfully completed his RTP protocol with no further setbacks. He was cleared to play and follow-up throughout the remainder of the year took place, with the athlete not suffering any more concussions or concussion-like symptoms. It took the athlete 24 days to return-to-play after sustaining his initial concussion.

Case 3

Initial Office Visit

A 15-year-old male high school football player sought care 2 days after a participating fully in a game in which he had denied any traumatic hit or injury during that game. He presented with a pressure-like pain in his head and felt as though he was in a dream. He had a mild headache but reported a severe headache the previous morning. He had been waking up every 30 minutes the last 2 nights due to headache pain. The pain had been ranging between a 4/10 to an 8/10. These symptoms started the morning after his game. He had been using ibuprofen to modulate his symptoms. He had not been attending school. The patient indicated that he previously had 2-3 concussions with similar symptoms

Upon examination, there were not any neurological deficits noted. He was alert and cognitive to date, time, place and month. He was able to engage in proper word recall and able to recite up to 5 digits backwards. His balance coordination and gait was within normal limits. The SCAT 3 assessment scores are reported in Table 3 below. He had a mild loss of cervical spine ROM in all directions. Foraminal compression and brachial

plexus tension testing were negative. He did have moderate spasms in the bilateral suboccipitals, paraspinals from C4-T4, upper trapezius muscles and the levator scapulae. Examination of the cervical spine revealed joint restrictions with loss of se.g.mental ROM at C1 and T1 levels. A course of manual therapy was initiated consisting of IASTM, myofascial release and SMT. IASTM was performed to the muscular spasms as the patient was going through an active and pain free cervical spine ROM.

He was also taken through a computerized neurocognitive test at his initial visit. He did score below his baseline levels, seen in Table 4. He was diagnosed with a concussion without loss of consciousness. Instructions were then given to both him consisting of physical and cognitive rest as described in case 1. Due to the present nature of his symptoms, he was not yet cleared to return to practice. He was also told that due to the time frame of his next game, should be become symptom-free immediately he would not be eligible to participate in the game due to a lack of time to follow the recommend RTP concussion protocol. He was informed that he could be.g.in practice after he had been symptom-free for a full 24 hours. The patient was told to follow-up with care 2 days later.

Second Office Visit

He did not return for care until 12 days later, despite the recommendation given to follow up two days after his initial office visit. He reported that he was not concerned as to the timeline for follow up care for multiple reasons. First, he reported overall scheduling conflicts. Secondly, his football team had lost their last playoff game and the season had ended. Last, he did not have gym class and was not concerned about having physical activity limitations. At the time of presentation, he indicated that he had been symptom-free since the day after his initial treatment. He denied any headaches, feeling in a dream and pressure or pain in his head. His gait was normal. A cranial nerve examination was negative and he did not display any neurological deficits. He did not have any balance deficits with 1- and 2-legged standing, with eyes open and closed.

His cervical spine ROM was normal in all directions. Foraminal compression and brachial plexus tension tests were negative. He did have mild spasms in the bilateral suboccipitals, paraspinals from C4-T4, upper trapezius muscles and the levator scapulae. Examination of the cervical spine revealed continued mild joint restrictions with loss of segmental ROM at C1 and T1 levels. Treatment was again preformed identical to the treatment rendered at his initial office visit.

The patient was again taken through a computerized neurocognitive test. His scores had improved to his baseline levels. These scores are reported in Table 4 below. He was cleared to fully participate in activity and in school as well. The duration of time from the time he was diagnosed with a concussion to being cleared to play was 12 days. He did indicate that he did not anticipate participating in any strenuous activity for at least another two months until the new semester started and he had gym class.

Table 3

SCAT 3 Scoring Summary		
Test Domain	**Score**	
	Office Visit 1 / 2 days P0st-Concussiono	**Office Visit 2 / 14 days Post-Concussion**
Number of Symptoms of 22	**4**	**0**
Symptom Severity Score of 132	**9**	**0**
Orientation of 5	**5**	**5**
Immediate Memory of 15	**14**	**15**
Concentration of 5	**5**	**5**
Delayed Recall of 5	**5**	**5**
SAC Total	**29**	**30**
BESS (total errors	**3**	**0**
Tandem Gait (seconds)	**17**	**12**
Coordination of 1	**1**	**1**

Table 4.

ImPACT Test Scores							
	Case 1		**Case 2**		**Case 3**		
	Baseline	**Post-Injury Test 1**	**Post-Injury Test 1**	**Post-Injury Test 2**	**Baseline**	**Post-Injury Test 1**	**Post-Injury Test 2**
Memory Composite (verbal)	96	97	75	87	99	79	95
Memory Composite (visual)	93	93	61	80	72	73	68
Visual Motor Composite	37.53	38.28	21.78	25.4	37.92	40.58	39.53
Reaction Time Composite	0.61	0.69	0.78	0.77	0.78	0.75	0.72
Impulse Control Composite	3	3	6	7	7	1	3
Symptom Score	15	0	0	0	0	4	0

DISCUSSION

The first and arguably most important step in concussion management is the ability to recognize the presence of concussion symptoms. Early recognition by healthcare providers, coaches, parents, officials, and athletes provides for rapid assessment, proper management, and ultimately a safe return to play. In order for this accurate recognition to occur, proper concussion education is a fundamental step prior to the start of any athletic season to ensure that a concussed athlete receives the proper management. Those involved in any manner (coaches, players, parents, officials, etc.) should receive education on concussion symptoms, signs, RTP protocol, and treatment options. “The goal of managing a young athlete with concussion is to hasten recovery by ensuring that the athlete is aware of and avoids activities and situations that may slow recovery. It is important to stress to patients and their parents to allow adequate time for full physical and cognitive recovery. Treating young athletes with a concussion is uniquely challenging, because their brains are still developing. Unfortunately, the lack of published data on the preadolescent athlete hinders evidence-based decision-making in this age group” (7). The high school sports associated with the greatest risk of concussion include football for males and basketball and soccer for females. Among high school football players, 1 in 5 players will suffer a concussion each academic year (8). Other high-risk sports include rugby, ice hockey, and lacrosse (9). For reasons currently not fully understood, within a given sport, females incur a higher rate of concussions than males (9). Return to neurocognitive baseline after concussive injury is often prolonged in adolescents compared with adults and further complicated by the brain maturation process that occurs in adolescents over time between baseline testing and injury (10).

Sports physician use of concussion assessment tools with both pre- and post-concussion testing is essential for establishing a baseline for athletes. Comparing an athlete’s baseline testing with their current cognitive and physical state at the time of injury further validates their performance on a comprehensive assessment tool such as the SCAT3 or a computerized neurocognitive test such as ImPACT (Pittsburgh PA). Since every individual may perform differently on an assessment tool, baseline assessments provide a reference point for which to compare that particular individual’s neurocognitive state at the time of injury. Computerized assessment offers a number of advantages, including easy data storage, improved accuracy in measuring reaction time, and rapid integration of data into report format for professional interpretation (11). Additionally, the use of concussion assessment tools is increasingly important for early recognition and evaluation of concussion due to the correlation between greater symptom severity at the time of injury and increased post-concussion syndrome (PCS) (12).

Due to the wide variety of injuries that chiropractors may see, chiropractic physicians should be up-to-date on the most current and accepted guidelines and literature related to concussions. Although there are a number of concussion guidelines available through various professional organizations, a particularly concise accord on the issue of concussions is the "Consensus Statement on Concussion in Sport: the 4th International Conference on Concussion in Sport held in Zurich, November 2012." The utilization of these guidelines and recommendations can provide unanimity regarding the concussion evaluation and management process. The management of athletes with head injuries requires specific clinical decision making, adherence to established protocols, and integrated care with other health care professionals (13). For that reason, it is important that a uniform perspective be established, implemented, and utilized by all health care professionals or trained individuals that take part in the evaluation and treatment of concussions.

Manual therapy treatment of patients who have sustained a concussion could be increasingly important to patient recovery and return to play due to the presence of a cervicogenic component and injury that one sustains during the concussion injury (13). The symptoms of headache and dizziness, so prevalent in concussion-type injuries, may actually be the result of cervicogenic mechanisms (2). Many other symptoms also present in acute concussion cases may also be present in cervical spine injury or dysfunction, including acceleration/deceleration (whiplash) injuries. Regarding the pathophysiology of concussions, it is hypothesized that, during the acute phase of mTBI, there are ion imbalances, metabolic disruption, blood flow abnormalities, and autonomic nervous system disruption that may be the cause of the pathophysiology (2). However, the proposed mechanisms for post-concussion symptoms are inconsistent. The cervical spine whiplash injury mechanism has been proposed but not examined in great detail. The same mechanism of injury that results in concussion may also result in a whiplash injury to the cervicothoracic spine, which makes the implementation of manual therapy important in these cases. Due to the correlation between cervical spine trauma symptoms and concussion symptoms, manual therapies and therapeutic exercises directed toward reducing cervical spine dysfunction may have a beneficial effect on resolution of symptoms and return-to-play. A proper musculoskeletal examination should be performed in addition to a concussion evaluation, neurological evaluation, and neurocognitive testing prior to an athlete being cleared to resume full contact play.

Currently, for an athlete to safely return to play (RTP) the 2012 Zurich Consensus Statement recommends an athlete must follow a graduated RTP protocol (Table 5.) in which they may not proceed to the next level of the protocol until asymptomatic at the current level (3). International accepted standards suggest that once the physical symptoms resolve, the athlete passes through 5 graded stages. Generally, each step should take 24 hours, so an athlete would take approximately 1 week to proceed through the full rehabilitation protocol once they are asymptomatic at rest with provocative exercise. If any post-concussion symptoms occur while in the stepwise program, the patient should drop back to the previous asymptomatic level and try to progress again after a further 24-hour period of rest has passed (3). The 2012 Zurich

Consensus Statement unanimously agreed that no RTP on the day of concussive injury should occur. This decision was due to the possibility of delayed onset of symptoms post-injury that may not be evident during sideline evaluation. It is important to note that these guidelines rely solely on the athlete being symptom free, rather they do not take into account computerized neurocognitive testing scores.

Table 5. taken from SCAT3, British Journal of Medicine

Graduated return to play protocol		
Rehabilitation stage	**Functional exercise at each stage of rehabilitation**	**Objective of each stage**
1. No activity	Symptom limited physical and cognitive rest	Recovery
2. Light aerobic exercise	Walking, swimming or stationary cycling keeping intensity <70% maximum permitted heart rate. No resistance training	Increase HR
3. Sport-specific exercise	Skating drills in ice hockey, running drills in soccer. No head impact activities	Add movement
4. Non-contact training drills	Progression to more complex training drills, eg. passing drills in football and ice hockey. May start progressive resistance training	Exercise, coordination and cognitive load
5. Full-contact practice	Following medical clearance participate in normal training activities	Restore confidence and assess functional skills by coaching staff
6. Return to play	Normal game play	

The length of recovery and RTP varies from individual-to-individual. The majority (80–90%) of concussions resolve in a short (7–10 day) period, although the recovery time frame may be longer in children and adolescents (3). However, recent research has identified that balance dysfunction and cognitive deficits persist well beyond the physical symptoms of the recovery process (14). The duration of time for the resolution of those symptoms can vary from individual-to-individual, ranging anywhere from one week to several months, leading to the increased importance of proper cognitive and cerebellar post-concussion testing (3).

Several factors may be accurate predictors of concussion recovery and overall outcome. Loss of consciousness was once thought to be a predictor of severity of concussion, severity is currently determined by the nature of the head injury, burden on the athlete, and duration of the clinical post-concussive symptoms (15). The majority of concussions do not involve loss of consciousness or focal neurologic deficits but the

duration of loss of consciousness (LOC) is an acknowledged predictor of outcome (9,3). Negative recovery risk factors following a concussion include LOC greater than 1 minute, amnesia symptoms, and concussive convulsions. The number of symptoms, duration of symptoms (>10 days) and severity of symptoms are all considered concussion modifiers. Additional risk factors that can lead to increased recovery time include repeated concussions over time, multiple concussions in close succession, age (child and adolescent), behavior (dangerous style of play), and the category of sport being played (high-risk activity, contact and collision sport, high sporting level, etc.) (12). Concussions may also have a threshold that needs to be monitored when successive concussions are suffered; repeated concussions may occur with progressively less impact force and further lead to a prolonged recovery after each successive concussion (16). Comorbidities and premorbidities may also play a role in concussion recovery such as migraines, depression or other mental health disorders, ADHD, learning disabilities, and sleep disorders. Furthermore, athletes prescribed medications such as psychoactive drugs or anticoagulants can have alterations to the symptoms and severity of concussion (16).

There are many factors that need to be addressed in assessing and managing concussions and that it should be considered a dynamic process due to the multiple influences on recovery rather than a simple monitoring of symptoms from case-to-case (17). It is important to remember that each athlete being evaluated for a concussion need only be compared to themselves. Using computerized neurocognitive test scores with subjective symptom complaints increases the sensitivity in identifying individuals that may require longer recovery (17). We feel that simply following the current RTP guidelines that utilize an athlete's subjective symptom complaints may not be enough to warrant a safe RTP. Preliminary data suggests that an initial brief period of relative rest (the first 1 to 2 days post-injury) is prudent and may be of benefit, but prolonged bed rest or absence from school or social activities may be detrimental to healing (18). Deciding how much rest and when it is appropriate for an athlete to be.g.in RTP is a delicate process and must balance extensive rest versus increasing risk for another concussion by RTP too promptly. Resting until symptom free is no longer the consensus recommendation because prolonged rest may predispose an individual to fatigue, depression, and deconditioning (19). However, current evidence suggests that the concussed patient is at greatest risk for another concussion within the first 10 days after initial injury (20). A previously concussed athlete may be symptom-free and returned to a neuropsychological baseline, however, the athlete may continue to have prolonged neurological abnormalities that could have resulted in disqualifying them from being ready to return to such a sport as evident by neurocognitive computerized testing (16). We agree previous studies suggesting that combining baseline pre- and post-concussion assessments utilizing neurocognitive computerized testing, incorporating the above listed concussion modifiers, and monitoring subjective symptom complaints, clinicians may more accurately and safely progress an athlete through a graduated RTP with greater certainty for the well-being of the athlete in the future.

Following a concussion, the foundation of mTBI management is physical and cognitive rest until acute symptom resolution has occurred. The addition of manual therapies

directed at reducing cervical spine dysfunction and treating the soft tissue structures of the neck may be of promise in the future management of acute concussion symptoms and post-concussion symptoms. Once the patient is asymptomatic, a graduated RTP and medical clearance for full-participation may occur (3). Other treatments that may be lacking evidence-based recommendations have been utilized such as concussion education, pharmacological therapy (sleep aids, antidepressants), vestibular rehabilitation, manual therapy to the cervical spine, cervical spine manipulation, low-level exercise, visual training, and neurocognitive rehabilitation. Part of the concussion rehabilitation process sometimes utilized by physical therapists, particularly in pediatric patients with PCS, involves manual therapy. During manual therapy intervention, focus is placed on joint mobility and soft tissue mobility (21). Specifically, manual therapy may be utilized for treatment of concussion-related headaches. Randomized Control Trials (RCT's) suggest that physiotherapy and spinal manipulative therapy might be an effective treatment in management of cervicogenic headaches (22). Additionally, balance/vestibular/oculomotor treatment may be incorporated throughout pediatric physical rehabilitation. Eye-head coordination exercise is most often prescribed initially for vestibular rehabilitation after concussion (23). In order to consider other management procedures beyond merely rest, it is important to define what is actually occurring during an impact injury such as a concussion. Diagnostic imaging procedures using conventional structural neuroimaging typically are normal upon investigation of patients with concussion symptoms (2). As previously stated, it is generally well-accepted that acute concussion symptoms are due to functional neuronal disturbances rather than structural changes.

Additionally, many of the symptoms present in acute concussion cases may also be present in cervical spine injury or dysfunction. Based on previously established tissue injury thresholds, acceleration/deceleration of the head-neck complex of sufficient magnitude to cause mTBI is also likely to cause concurrent injury to the joints and soft tissues of the cervical spine (2). Following a concussion, 2 of the most commonly reported symptoms are headaches and dizziness, closely followed by nausea and neck pain (3,6,24). Conceivably when forces sustained from a concussion like injury are transmitted to the head and neck, the cervical spine may be injured (2). Cervical spine trauma may cause prolonged post-concussion symptoms (25). Injury to the upper cervical spine can also cause cervicogenic symptoms; including headaches and dizziness (26). The upper cervical spine is particularly vulnerable to trauma because it is the most mobile part of the vertebral column, with a complex proprioceptive system that has connections to the vestibular and visual systems (27). Cervical vertigo or dizziness after whiplash injury can mimic the symptoms of PCS. It may be due to mechanoreceptor dysfunction (28) or posttraumatic vertebrobasilar circulatory insufficiency (29). It has been shown that multimodal treatment, consisting of manual therapy and exercise, to the cervical spine is effective in individuals with neck pain, cervicogenic symptoms, and with mechanical neck disorders with or without headaches (2, 30, 31). Manual therapy is believed to decrease pain and improve function through a variety of biomechanical and neurophysiological effects (32).

With the chiropractic profession offering numerous different manual therapy techniques, this offers exceptional opportunity for chiropractors to be an inte.g.ral part in the evaluation and management of athletes suffering a concussion. As detailed in the cases of this paper, chiropractic management involving SMT and multiple soft tissue treatment modalities may be effective treatments for those with concussion symptoms not complicated by prolonged functional neuronal changes. Additionally, chiropractic management involving SMT and multiple soft tissue treatment modalities may be an effective treatment for those with post-concussion symptoms. In the current study, all individuals had clinical findings suggesting cervical spine dysfunction. Treatment to the cervical spine rendered in all three cases yielded positive results to those individuals. Improvements were noted in the athletes' headaches, neck pain, muscular spasms and other symptoms described in each case. Furthermore, computerized neurocognitive testing was used to aid in the RTP decision for each athlete.

Chiropractic care is a common form of treatment that patients seek following motor vehicle accidents in which a patient sustains a mTBI (33). Persistent headaches and neck pain is a common symptom following a minor head injury, mTBI, or a concussion, possibly related to simultaneous injury of the structures of the cervical spine (25). In comparing a group of patients with post-concussion headaches (PCH) to a control group, Treleav, et al found that the PCH group was distinguished from the control group by the presence of painful upper cervical segmental joint dysfunction, less endurance in the neck flexor muscles and a higher incidence of moderately tight neck musculature (25). Upper cervical joint dysfunction is a feature of cervicogenic causes of headaches suggesting the inclusion of a precise physical examination of the cervical re.g.ion in diagnosing patients suffering from concussion symptoms (25). Mobilization, manipulation, and clinical massage are all effective interventions for the management of cervicalgia (34). These findings further substantiate the need for manual therapies such as SMT and soft tissue treatment to be utilized in concussion treatment in order to address any cervical spine injury and/or dysfunction present.

Limitations

There are limitations concerning this study. The symptoms that were being treated in each of the 3 cases were primarily neck pain and headaches. The athletes did not have many other symptoms that are typical of concussion injuries, thus it was not evident chiropractic treatment helped with other concussion like symptoms. Furthermore, this study does not suggest that chiropractic care is better at improving concussion symptoms faster than rest alone. Currently there is insufficient evidence to suggest the widespread routine use of cognitive baseline testing. However, more recent literature suggests that children and adolescents between the ages of 10 and 17 display a gradual reduction of post-concussive symptoms over a 30-day time span following the injury. Five days after injury, 87% of the concussed individuals continued to display symptoms. The neurocognitive computerized testing scores returned to baseline levels by day 30 (35). It is the authors opinion that having the ability to compare baseline to post-injury tests helps aid in a safer return-to-play. However, at this time there needs to be increased evidence-based guidelines to suggest the widespread use of such testing.

Therefore, we strongly suggest that future research continues to examine: 1) the relationship between cervical spine injury and concussion-like symptoms and 2) cervical spine dysfunction accompanied by treatment to those athletes in which the cervical spine is likely the primary generator of symptoms.

CONCLUSION

This case series describes the clinical signs and symptoms of 3 football players, all of whom had sustained a concussion. Each athlete was monitored and treated by a doctor of chiropractic who also guided the RTP process. A thorough concussion management program had been put in place by the chiropractor as part of a larger team including all involved with the athletes (coaches, parents, etc.), with each individual having participated. The management program in its entirety did include: concussion education, ImPACT pre- and post-testing, diagnosis, and adherence to the proper RTP guidelines. Furthermore, all 3 participants did receive manual therapy treatment involving SMT and multiple soft tissue treatment modalities. Upon symptom resolution and sufficient comparison of present neurocognitive computerized test scores to baseline scores, all cases were eventually cleared to play following the correct RTP guidelines.

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