

INTEGRATION OF POST-CONCUSSION SUPPORT STRATEGIES INTO CHIROPRACTIC PRACTICE

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Abstract: This is a clinically orientated paper which explores an evidence-based rationale for the inclusion of concussion screening protocols and clinical support of the concussion patient in a general chiropractic practice. It includes topics such as: definitions of concussion, concussion screening, clinical assessment, development of an interdisciplinary referral protocol and network, a description of some in-office clinical treatment and support strategies and a discussion of how to enhance patient and community awareness of the illness burden of undetected post concussion syndrome. This document is not a clinical training or certification document or manual; it is recommended that chiropractors wishing to implement the strategies in this paper undergo clinical training in basic concussion diagnostic and treatment protocols.

Indexing Terms: Chiropractic, Concussion, Post Concussion Syndrome, Vestibular Rehabilitation, Chiropractic Manipulative Therapy

Introduction

This is a clinically orientated paper in which I detail an evidence based/informed, best-practice clinical methodology that includes:

- ▶ Providing an evidence-based rationale for the inclusion of concussion screening protocols and clinical support of the concussion patient in a chiropractic practice;
- ▶ Screening for concussion in a chiropractic practice;
- ▶ Clinical assessment of the suspected concussion patient in a chiropractic practice;
- ▶ Development of an interdisciplinary referral protocol and network for the concussion patient detected in a chiropractic practice;
- ▶ In-office clinical treatment and support strategies of the concussion patient attending a chiropractic practice;
- ▶ Enhancing patient and community awareness of the illness burden of undetected post concussion syndrome.

It is important to note that:

- ▶ This document is not a clinical training or certification document or manual;

...these recommendations are directed towards a chiropractor who has had not undergone concussion training within a post graduate chiropractic specialist course (e.g. Diplomate of the American Chiropractic Board [DACNB], or a sports chiropractic certification course).'



- ▶ This document outlines the steps necessary to integrate an evidence based/best practice approach to concussion management in a chiropractic clinic;
- ▶ Citation may be made of this paper in the standard ethical manner;
- ▶ It is recommended that chiropractors wishing to implement the strategies in this paper undergo clinical training in basic concussion diagnostic and treatment protocols outlined in this document in order to integrate best-practice concussion clinical strategies into their chiropractic practices; and
- ▶ I have included many references and website links in this document. There are many, many articles and websites related to the topic of concussion. I have made recommendations that I think are pertinent to this topic and are readable or watchable.

Background

- ▶ Can, and should, generalist chiropractors manage or co-manage concussion cases?
- ▶ Is it possible to translate and reduce the large amount of new neuroscience information on this topic to someone who has not undertaken post-graduate clinical neuroscience or concussion training?
- ▶ Does the scientific literature clearly inform chiropractors on how best to manage concussion in a general chiropractic clinic?
- ▶ Is there a clear set of concussion practice guidelines that would satisfy all chiropractic practice philosophies?
- ▶ Chiropractors practise within varying national regulatory scope of practice parameters; how does this influence their management of concussion?

These are just some of the questions that faced me as I sat down to write this paper.

Not long before being asked to contribute this piece a fellow chiropractor (and friend) reached out to me after he had recently experienced a recreational sports-related traumatic brain injury. He had undergone a successful clinical rehabilitation program for Post Concussion Syndrome (PCS) at my clinic. He had never undertaken a post-graduate chiropractic clinical neuroscience course, and confessed that he had not formally kept up with neuroscience since graduating as a chiropractor some 30 years before.

His brain injury had led him to a deep personal interest in catching up with neuroscience of chiropractic. He is a passionate chiropractor, and over his long career he had observed many of his subluxated patients undergoing remarkable brain-based neurological changes in response to his spinal adjustments. However, he had never been the subject of these brain changes. He quickly realised that the neuroscience of concussion was an overwhelming topic.

Following his recovery, he decided to include concussion management into his general chiropractic clinic in Auckland, New Zealand. He wanted to know how best to integrate the evidence-based management of PCS into his practice without undergoing formal post-graduate clinical neuroscience training. He was also intent on satisfying legislative and professional healthcare regulations in his country of practice (New Zealand) We spent many hours exploring the empirical observations and epistemological assertions that underpinned his intention to include post-concussion support in his chiropractic practice.

Here are four statements/claims that best summarise the empirical observations of my chiropractic colleague during our discussions. I feel they provide a starting point for this paper.

- ▶ Chiropractors may miss signs and symptoms of undiagnosed concussion.
- ▶ Chiropractors should routinely screen their patients for concussion.
- ▶ A high percentage of concussion patients may have cervical spine trauma related to their head injury.
- ▶ Chiropractic post-concussion treatment outcomes may be enhanced by chiropractic spinal adjustments, management of activities of daily living and tailored home-based rehabilitation.

I provided him with some evidence-based, best practice advice on how to identify and manage concussion patients within a general chiropractic practice in New Zealand.

These recommendations were directed towards a chiropractor who has had not undergone concussion training within a post graduate chiropractic specialist course (e.g Diplomate of the American Chiropractic Board [DACNB], or a sports chiropractic certification course)

This is an expansion on those recommendations. I have used him as my muse and have included examples of National Concussion Guidelines that he faced as a chiropractor in New Zealand. He had been through the 'official' medical concussion rehabilitation system in New Zealand (which, by the way, is highly evidence-based, extensive and generous) and was aware of how a registered chiropractor might fit into such a system. The country in which you are practicing may or may not have the same chiropractic registration legislation and national rehabilitation system as New Zealand. If not, it would be something to which your national chiropractic association might aspire.

My colleague is a busy generalist chiropractor and I imagine you, the reader, to be the same. I have written this paper with the busy generalist chiropractor in mind. I have included clinical management strategies that do not require extra hands-on clinical training. But, as you will see, I strongly recommend that you eventually (sooner than later) embark on formal clinical training in this area. Your concussion patients deserve your best clinical effort.

As you read this paper, please remember that:

- ▶ the neuroscience upon which clinical concussion models are based is massive!; the neuroscience concussion knowledge base is expanding exponentially every year. It is even more difficult to keep up with the scientific research underpinning clinical approaches to concussion;
- ▶ the subjects of traumatic brain injury/mild traumatic brain injury/concussion are huge and confusing; concussion due to sporting injuries (Sports Related Concussion-SRC) are often separated from concussion due to activities of daily living (mild Traumatic Brain Injury-mTBI) in the scientific literature. Concussion knowledge models (pathophysiology, cognitive/social, etc.) and subsequent clinical guidelines change regularly. The 1st International Conference on Concussion in Sport was held in Vienna in 2001. The 5th conference was held in Berlin in 2016 (1) and the next (6th), at the time of writing, is in Paris in late 2020. Over the ensuing 20 years, the amount of published literature produced by these conferences alone has been immense. It appears that no-one can cover it all; I certainly can't. Diagnostic and treatment models are expanding rapidly, as are the technologies that underpin them. These too are difficult to keep up with;
- ▶ Keep in mind that concussion is an 'emotional' health-care topic that has generated much political and policy discussion over the past 20 years. I am sure you have seen many media presentations on the impact of concussion in society. Some of these presentations have

sensationalised concussion, often presenting information that is discordant with concussion science;

- ▶ Sports Related Concussion (SRC) is changing the way people participate in contact sport; sports administrators are struggling to maintain participation rates as they attempt to reduce or eliminate head injuries. The recognition that mild Traumatic Brain Injury (mTBI) can result from a head injury incurred in a motor vehicle accident, or a paediatric or geriatric fall has changed the way we interact and play with each other. In contrast, it has been suggested that some patients have 'nocebo' responses to the vast amount of negative concussion information in the public domain (2);
- ▶ There is ample evidence that the human brain undergoes significant adverse changes following any sort of head injury, and recovery is dependent on many factors including age, gender, type of injury, the health status of the patient at the time of injury amongst others (3);
- ▶ The aim of this paper is to explore the concussion literature and provide some clinical direction for the general chiropractor who has no post graduate concussion training and wishes to integrate concussion management into his or her general chiropractic practice.

Definitions & Epidemiology

Epidemiology of Head Trauma (mTBI/Concussion)

- ▶ mTBI appears to be common (4)
- ▶ Not everyone with mTBI seeks medical care (5)
- ▶ The true global population incidence of mTBI may exceed 600 per 100,000 people annually (approximately 46 million people worldwide every year), with most cases being due to falls or motor vehicle collisions (6)

As you can imagine, a detailed discussion of the pathophysiology of concussion, as fascinating as it is, is beyond the scope of this paper (for further reading please see : Satarasingh et al 2019. Unifying Pathophysiological Explanations for Sports-Related Concussion and Concussion Protocol Management: Literature Review. Journal of Experimental Neuroscience, 13)

Secondly, you will more than likely be dealing with other health professionals who specialise in this area; it is important that we are all on the same page in regards to concussion definitions and vernacular.

You may be surprised to discover that there is a confusing range of definitions related to traumatic brain injury/concussion when the published literature is searched. For example, if your patient has experienced a sports related concussion (SRC) much of the confusion is often related to the type of sport the concussed patient plays. It is agreed that mild traumatic brain injury/concussion is usually the result of an impulsive force transmitted to the head. In this section I will focus on the definitions of: "mild traumatic brain injury"; "concussion"; "sports related concussion"; "post concussion syndrome (PCS) " and "post concussion disorder (PCD)".

Definition of mild Traumatic Brain Injury (mTBI)

Mild Traumatic Brain Injury (mTBI) is a term commonly used to describe concussive injuries to the brain from (mostly head) injuries. Concussion is considered by many to be a subset of mTBI (7). mTBI is typically a result of motor vehicle accidents (MVA), falls, adult head injuries, paediatric/adolescent head injuries and sports related head and body impact injuries.

Chiropractors consult a range of patients who have experienced these head injury categories and may be well placed to contribute to recovery from persistent post mTBI symptoms (8).

There appears to be no universally accepted definition of mTBI. However, the definition devised by The American Congress of Rehabilitation Medicine (ACRM) has been continuously quoted in the literature for almost thirty years (9).

Note, you will see the following definition involves the Glasgow Coma Scale. For a full description of the Glasgow Coma Scale, and how to conduct a structured examination please go to: <https://www.glasgowcomascale.org/>

The ACRM defines mTBI as:

an *'acute brain injury resulting from mechanical energy to the head from external physical forces,'* with any of the following symptoms:

1. Loss of consciousness (LOC) not exceeding 30 min;
2. Post-traumatic amnesia (PTA) of no more than 24 h;
3. A score of 13-15 on the Glasgow Coma Scale (GCS) after 30 min post injury (or upon presentation), and
4. An (unspecified) period of confusion (feeling dazed, disoriented, and confused), or other transient neurologic abnormalities such as focal signs or seizures

Definition of Concussion

The most commonly used definition of concussion is based on a consensus statement issued at the 4th International Conference on Concussion in Sport (ICCS) (7) and it states that a concussion is:

'the rapid onset of short-lived impairment of neurological function that resolves spontaneously...caused either by a direct blow to the head, face, neck or elsewhere on the body with an 'impulsive' force transmitted to the head.'

Let's first look at the word 'concussion'. A quick online dictionary search (<https://www.lexico.com/en/definition/concussion>) reveals is derived from the Latin *concutere*, which means to *'dash together, shake'*. In a general sense, it refers to a violent shock from something like a heavy blow. There is a high consensus amongst dictionary editors as to the meaning of the word, in a general sense.

Obtaining a medical definition of concussion is something entirely different. If you spend a good amount of time researching the medical definition, you will quickly see that there is much tension amongst experts when attempting to define concussion (10). The concept of concussion is not universally agreed upon. There are variable symptoms, no definitive anatomical locale, unknown pathology and variable models of pathophysiology. Also, remember that the definition of concussion has certainly been dominated by the sports concussion researchers and clinicians.

In fact, many committees of health and neuroscience experts have spent many hundreds of hours attempting to define the clinical meaning of the term.

It should not be surprising to you to know that, according to many researchers in the field, this definition alone is not actually good enough. It appears that there is some consensus in that there

are different concussion categories and conditions due to neurological impairment subsequent to an impulsive body impact injury.

Lumba-Brown et al (11) recently assembled eleven experts to explore and characterise the 5 concussion subtypes (cognitive, oculo-motor, headache/migraine, vestibular, anxiety/mood) and 2 concussion associated conditions (sleep disturbance, cervical strain) that had been defined in the concussion literature in the previous seven years.

Definition of Sports Related Concussion (SRC)

Sport Related Concussion (SRC) is a common type of concussion seen in chiropractic practices. McCrory et al (1) included a definition of sports related concussion in their summary of the 5th International Consensus Conference on Concussion in Sport in Berlin in 2016. You can view the complete online publication here: <https://bjsm.bmj.com/content/51/11/838>

You can see Dr Paul McCrory (one of the world's foremost experts on concussion) deliver a lecture on the state of sports concussion in 2016 (just before the Berlin conference) at this site. He has some interesting comments!: <https://www.youtube.com/watch?v=oPrpTj2Edp8>

Definition of Post Concussion Syndrome (PCS)

It has been suggested that approximately 6-7 % of people who suffer a concussion episode may experience persistent neurological symptoms for many months or years afterwards (12). Significant differences of opinion about the aetiology of post concussion symptoms have existed in the scientific literature over the past thirty years. This has led to academic tension when attempting to create an operational definition of post concussion disorders. Chiropractors most probably manage patients with post concussion presentations and knowingly, or unknowingly, make positive contributions to these patients' recovery.

The two most commonly used definitions of Post Concussion Syndrome (PCS) are as follows:

1. PCS-International Classification of Diseases, Tenth Revision (ICD-10):
 - a. the presence of three or more of the following symptoms that must be present within the first month post-injury including: headache, dizziness, fatigue, irritability, insomnia, and concentration or memory difficulty.
2. PCS-The Diagnostic and Statistics Manual (DSM-IV):
 - a. cognitive deficits in attention or memory, and
 - b. at least three or more symptoms including; headache, dizziness, fatigue, irritability, apathy, personality change, or sleep or affective disturbance for at least 3 months.

It is worthwhile noting that Ellis (13) suggests that there is little agreement between these definitions in clinical practice and that the ICD-10 definition is six times more sensitive than the DSM definition.

Definition of Post Concussion Disorder (PCD)

Ellis et al (14) explored a Post Concussion Disorder classification system. They proposed that *“the symptoms and impairments reported by patients in the post-concussion recovery period form symptom ‘clusters’ that point to operational post-concussion disorder (PCDs) that can be identified by salient features of patient history, physical examination and aerobic treadmill testing”*.

They listed 3 main PCD categories:

1. Physiological PCD

2. Vestibulo-ocular PCD

3. Cervical PCD

This PCD classification system has provided translatable clinical assessment and treatment models that we can use in clinical practice. We shall be looking at these categories much more closely later in this paper.

Persistent Post-Concussion Symptoms (A Functional Definition of PCS)

Polinder et al (15) suggested a different definition of PCS. They noted that in 10–25% of mTBI patients, post-concussion symptoms persist over time, which is often referred to as post-concussion syndrome (PCS). They also questioned whether the ICD/DSM classifications of PCS was adequate in defining PCS as a reliably identifiable, unique syndrome. They suggest the term post-concussion symptoms to describe symptoms following mTBI and refer to persistent post-concussion symptoms when these persist for at least 3 months after TBI.

Evidence Supporting Concussion Management in a General Chiropractic Practice

As previously mentioned, there is a large body of published scientific literature on the topic of concussion. A selective literature search was undertaken with the above four statements of my chiropractic colleague in mind. The focus of the search was management of concussion in a general chiropractic practice. The search did not screen articles based on strength of evidence. It was performed with a sense of enquiry as to how chiropractors in general practice approach a concussion patient.

Searches were performed within the *Medline* and the *Index to Chiropractic Literature* Databases and included the following 'chiropractic' MeSH terms: 'chiropractic' AND; 'concussion'; 'post concussion syndrome'; 'cervical spine' and 'concussion'; 'concussion management'; 'concussion screening'; 'mild traumatic brain injury', 'sports chiropractic' and 'concussion'; 'treatment/concussion' amongst others. Articles were downloaded, read and reviewed.

There are thousands of articles addressing many aspects of concussion. Overall, however, there are few published articles addressing the topic of chiropractic and concussion.

Further specific key words were included with concussion such as : 'SCAT', 'physio/physical therapy'; 'MVA'; 'falls'; non-sports related concussion', 'balance', 'posture', 'cognition', 'autonomic' amongst others. I have included references in this article that complement clinical topics that I have addressed.

Claim 1: Chiropractors may miss signs and symptoms of undiagnosed concussion.

It is difficult to substantiate this claim. At the time of writing this paper, there were no published epidemiological studies verifying numbers of post concussion patients attending generalist chiropractic clinics. There are a number of case reports documenting chiropractic treatment of patients who have experienced concussion (16, 17, 18, 19, 20, 21, 22, 23, 24).

Chiropractors may be increasingly engaging with patients who have suffered sport-related and non sport-related head injuries (such as falls) (17, 20, 23, 25, 26, 27). It does appear that groups representing chiropractors who have undertaken post-graduate sports injuries training have a greater interest in concussion (25, 28, 29). A survey of sports-certified chiropractors felt that only those health-care providers with training in concussion should manage concussion patients (30). Taylor et al conducted a survey of generalist chiropractors' concussion knowledge. The results led Taylor to concluded that the generalist chiropractors who responded may have had a mismatch between confidence in diagnosing and management post concussion patients and actual knowledge of the topic (31). It has also been suggested that there may be an under-reporting of the prevalence of concussion-mTBI across health care practices, including general chiropractic practice (31, 32).

It has also been repeatedly highlighted that patients (or parents of patients) may not report a history of head injury when presenting to their health-care practitioner (33, 34, 35, 36, 37, 38, 39, 40). It is possible that chiropractors and their patients may be unaware that presenting symptoms and examination findings may be related to a post head injury concussion, though the actual number of missed cases is unknown.

Claim 2: Chiropractors should routinely screen their patients for concussion.

The published 'concussion literature' confirms that early identification of concussion and implementation of concussion management strategies may result in a decreased chance of post concussion syndrome, and improve post head injury quality of life outcomes (41, 42, 43, 44, 45, 46, 47). A number of chiropractic authors have included screening measures in reports and reviews (18, 19, 20, 21, 22, 23, 24, 48, 49). A few published case reports have detailed effective chiropractic management of post concussion cases using pre and post concussion assessment tools (17, 20, 48). It is reasonable to conclude that more effective chiropractic management of post concussion patients may be implemented when the chiropractor is able to identify [screen] and educate patients at their initial presentation and recommend appropriate clinical intervention or referral to more qualified health professionals.

Claim 3: A high percentage of concussion patients may have cervical spine trauma related to their head injury.

The published literature strongly supports the notion that there is a relationship between concussion and cervical spine injury. There is also consensus amongst concussion experts that there are a number of types of post concussion disorders (PCD) including Cervicogenic PCD (50, 51). It appears that chiropractic patients with post concussion issues may present with primary cervical spine pain/dysfunction related to head injury trauma. Cervicogenic PCD may explain persistent post concussion symptoms experienced by chiropractic patients. It might further explain why post concussion patients' symptoms appear to be relieved by chiropractic spinal adjustment therapy (14, 51). More importantly, patients commonly present to chiropractors with neck pain, visual disturbances, headaches, dizziness and balance disorders which are all symptoms of traumatic and non traumatic neck pain, concussion and Cervicogenic PCD (15, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64).

Claim 4: Chiropractic Treatment, activities of daily living (ADL) management and rehabilitation may improve outcomes amongst post concussion chiropractic patients.

The scientific literature supports this observation. A multimodal approach to post concussion management, including manual therapy treatment (i.e chiropractic) and post concussion lifestyle advice (exercise, return to play, cognitive load, nutritional advice, counselling, sleep advice, neuroscience education, balance and oculomotor rehabilitation) have been found to significantly reduce the chances of post concussion syndrome, as well as expedite the recovery of those suffering PCS (3, 15, 20, 48, 51, 59, 65, 66, 67, 68, 69, 70, 71, 72). As noted earlier, there have been case study reports exploring sole chiropractic adjustment therapy of the post-concussion patient, however, it is difficult to ascertain exactly what concussion symptoms resolved, and to what to degree.

Screening for Concussion in a Chiropractic Practice

Concussion Awareness in Your Practice

This section outlines evidence-based strategies to promote concussion awareness amongst chiropractors and patients/families in chiropractic practices.

It appears that there is a lack of recognition of concussion as a consequence of head injury amongst chiropractors, patients and their families (29, 35, 40, 73, 74, 75, 76, 77, 78, 79, 80, 81). A lack of recognition of concussion in practice points to a lack of preparedness for screening.

To improve concussion awareness amongst PATIENTS AND THEIR FAMILIES

- ▶ Display patient information regarding the impact of head injury on chiropractic care within general view in the clinic;
- ▶ Display concussion awareness information on the clinic website;
- ▶ Create awareness of head injury/concussion amongst patients and their families who are actively engaged in contact sports;
- ▶ Create awareness of head injury/concussion amongst patients and their families who engage in recreational activities with high prevalence of head injury (horse riding, gymnastics, wave boarding, snow skiing, skateboarding); and
- ▶ Create awareness of head injury/concussion amongst patients and their families who are susceptible to falls (paediatric, geriatric)

Chiropractic practice concussion screening should therefore include a “practice attitude” before all else. Could the patient in front of you be suffering from concussion? (This is different to being overly concerned that all patients presenting to you might be experiencing concussion) Does this patient complain of symptoms related to concussion? Do they engage in recreational, sport or work activities that have a high incidence of concussion? Are they in an age group that might experience head injuries? Have they recently been involved in a motor vehicle accident?

The literature review revealed two articles by Craton et al. (50) and Ellis et al (82) that provide a detailed explanation of concussion and post concussion syndrome, including pathophysiological mechanisms underpinning the symptoms and signs of concussion. It is not the role of this paper to undertake a detailed neuroscience explanation of concussion. However, these articles have provided a basis for possible directions chiropractors might take when considering concussion screening.

Clinical Management of the Concussion Patient in Chiropractic Practice

Recommendations for Generalist Chiropractor Concussion Clinical Upskilling

I strongly recommend clinical upskilling to provide appropriate chiropractic clinical support to concussion patients in practice. This section discusses the rationale behind my recommendations. It has been previously noted that I make an assumption that the first aim of a chiropractor is to triage a patient for possible post concussion symptoms or post concussion syndrome (PCS).

I have outlined (below) an evidence-based clinical algorithm that will provide chiropractors with an opportunity to refer the patient, if necessary, or provide evidence-based chiropractic clinical support for the cervical or vestibular-ocular post concussion syndrome patient in practice.

The research literature contains many evidence based clinical ‘tool-boxes’ and therapy protocols that can be implemented by those who wish to practise within statutory practice guidelines (24, 35, 62, 63, 64, 68, 72, 76, 83, 84, 85, 86, 87, 88, 89, 90).

Many of these clinical examination and treatment protocols require the therapist to perform reasonably complex neurological test and therapies. I have selected a number of evidence-based ‘low-tech’, low-cost concussion assessment and therapeutic protocols that can be easily integrated into general chiropractic practice.

I recommend that a chiropractor’s clinical skill-set for concussion support requires:

1. clinical diagnostic and therapeutic skills gained in chiropractic undergraduate training combined with

2. clinical diagnostic and therapeutic skills most likely not encountered in undergraduate training.

It is strongly recommended that any general chiropractor (i.e. chiropractors without certified post-graduate neurology or applied clinical neuroscience training) undertake some form of clinical up-skilling in order to competently examine and support a concussion patient in chiropractic practice.

A list of concussion clinical examinations, therapies and tools that can be integrated into a general chiropractic practice with clinical upskilling is provided in the Appendices of this document.

Accepting a patient with a suspected mTBI/concussion

It is assumed at this point in the clinical journey of a concussion patient that the chiropractor is aware that the patient has experienced a head impact injury and the symptoms the patient is experiencing is related to that impact. I also assume that you have not had any significant training in concussion management. I suggest it is time for you to go to a short, online concussion information course.

There are many free, reputable short courses covering the basics of concussion. I recommend 'The Concussion Awareness Training Tool (CATT)'. It includes a good general information course (2 hours) for health professionals and a fabulous resource pool. It also provides you with continuing education certification. CATT is based upon the established principles of the Consensus Statement on Concussion in Sport. <https://catonline.com/medical-professional-course/>

It is clear from the scientific literature that the concussed patient may experience significant adverse neurological changes due to decreased brain function across all age groups and equally between genders (92, 93). The concussed patient may be much more sensitive to 'normal levels' of sensory input (light, sound, olfactory, gravity), including proprioceptive input provided by the chiropractic adjustment (94).

It is also clear from the scientific literature that the chiropractic adjustment alters brain function by increasing afferent input to post synaptic centres in the central nervous system (95, 96, 97, 98, 99). As previously mentioned, published case reports have detailed a chiropractic adjustment regime titrated against observable and measurable reduction of CNS signs and symptoms (19, 21, 24, 49). In my experience, the guesstimated chiropractic adjustment can be as adverse as beneficial to the concussed patient.

The research evidence concludes that a multimodal approach to concussion management is more appropriate than a single modality approach (100). Recent recommendations regarding exercise rehabilitation for concussion patients are quite sophisticated (101).

- ▶ 'Would your practice philosophy integrate, evidence-informed, best-practice concussion management'
- ▶ 'Do you have the time to conduct a focussed concussion history/examination, or not?'
- ▶ 'Do you have the clinical resources to treat concussion in a best practice, evidence-informed manner?'
- ▶ 'What is the physiological and clinical basis of your concussion treatment and how will you measure concussion recovery?'

These are serious questions, and I feel the reader needs to have a deep think about the answers, your concussed patient deserves it.

The range of practice philosophies and treatment techniques within the chiropractic profession has been our strength and weakness. There are published survey reports that suggest generalist chiropractors think they know more about concussion than they actually do. There are chiropractors within our profession that feel a concussed patient should not be treated by someone without concussion training. And it goes without saying that there are those outside our profession that feel chiropractors should never be involved in concussion management.

If you have a practice epistemology that is focussed primarily on the identification and non-titrated removal of subluxations via the chiropractic adjustment, I recommend that you exercise extreme care when treating the concussed patient. The process of subluxation removal by chiropractic adjustment therapy can have powerfully beneficial as well as potential adverse effects on the concussion patient as can many other therapeutic interventions (102, 103).

Are you aware of your National Health System's approach to Concussion Management?

It is recommended that chiropractors be aware of the clinical reasoning pathway underpinning a concussion patient's entry into any government-provided Concussion Services system. It is assumed that an important reason for assessment of the concussion patient by a chiropractor is to facilitate rapid entry into these systems where they are in place, for example in New Zealand. Direct primary management of a concussion patient by a chiropractor at this stage may or may not be within the scope of chiropractic practice where eligibility for concussion management is predicated upon a medical practitioner's diagnosis. Below is a graphic taken from the New Zealand Accident Commission website. It outlines criteria for entry into the Concussion Service. This provides a template for both patients and practitioners within the New Zealand health service. You can access this document at: <https://www.acc.co.nz/assets/provider/cbc89ef665/acc883a-concussion-service-criteria.pdf>

To improve concussion awareness amongst CHIROPRACTORS

- ▶ Pathophysiology underpins the concussion event. For a detailed discussion please read Ellis et al (91) ;
- ▶ Include specific questions addressing head injury on all new patient intake forms;
- ▶ Establish a protocol of periodic enquiry regarding head injury of regular patients;
- ▶ Enquire about signs of concussion in patients involved in a motor vehicle accident;
- ▶ Enquire about head injury of all patients presenting with sudden onset neck pain; headache, head pain, balance disturbance or dizziness, or upper limb injury;
- ▶ Consider including one of the many focussed concussion screening tools (such as the SCAT5, a comprehensive screening tool) into their practice protocols; and
- ▶ Design referral letter protocols. These will facilitate early referral into a national concussion service.

Concussion service criteria

Who can access the service?

The client must have...	Comment
had an injury in the last 12 months; AND	Clients whose injury is over 12 months ago usually require more support than this service can provide. Clients with more complex needs can be referred directly to ACC to access more comprehensive assessments and therapy.
an accepted current ACC claim; AND	The referral will not be progressed until the claim has been accepted. This service should not be used for medical follow up or where the client is at medical risk. An ACC45 can be sent with the referral form. Note: Where the covered injury is not for a traumatic brain injury the medical referrer should either confirm the diagnosis or request the diagnosis to be investigated.
been diagnosed with mild or moderate TBI or post concussion syndrome; AND	GPs & Emergency Departments (EDs) should apply the criteria for classifying the severity of TBI as described in ACC's <i>Traumatic Brain Injury: Diagnosis, Acute Management and Rehabilitation Best Practice Guide July 2006</i> . See note above
continued signs and symptoms of brain injury with a significant impact on level of functioning that requires investigation and treatment, such as: <ul style="list-style-type: none"> • mood changes • difficulty concentrating • visual disturbances • memory problems • balance issues • nausea • fatigue • headaches • muscular aches, AND 	The signs and symptoms indicate the need for <ol style="list-style-type: none"> 1. A clinical referral 2. Rehabilitation therapy
additional risk factors such as (and/or): <ul style="list-style-type: none"> • the inability to work or attend school for more than one week • second or subsequent MTBI within 6 months • post traumatic amnesia lasting more than 12 hours • requirement to operate machinery or 	These factors indicate the need for early rehabilitation intervention. The list is not exhaustive. It's intended that clients who are likely to recover without rehabilitation support are not referred to the Concussion Service.

Consideration Points for the Chiropractor managing concussion

- ▶ There are many clinical algorithms for the general chiropractor regarding the *focussed* clinical assessment of the concussion patient (13, 46, 50, 62, 76, 84, 85, 104-108)
- ▶ You may be required to provide return to play (recreational including activities such as jogging and bike riding), return to work or return to school advice.
- ▶ Communicate regularly with other participating HCPs.
- ▶ Differentiate common post-concussion symptoms such as neck pain, headache, dizziness, postural instability from normal musculoskeletal conditions.
- ▶ Be aware of physiological post concussion symptoms, and be prepared to recommend referral to a qualified medical practitioner for further concussion assessment and co-management.
- ▶ Be aware of autonomic dysfunction at this stage (nausea, cardiovascular symptoms, high brainstem signs)
- ▶ The chiropractic adjustment imparts metabolic load on the patient's CNS
- ▶ Be aware of Post Concussion Syndrome
- ▶ See the infographic below from Ellis, Leddy and Willer detailing a multi-disciplinary approach to concussion to concussion (91)

Concussion Biomarkers

The topic of concussion biomarkers is 'hot' at the time of writing this document (2020) Presently there are no definitive biomarkers for the presence of concussion. A range of concussion clinical tests have been developed (blood tests, body fluid tests, diagnostic imaging, autonomic testing, ocular tests, EEG, balance tests, questionnaires, computer assessments) that may suggest the presence of mTBI, but none have proved their worth beyond doubt (109-111).

There are concerns about distinguishing the difference between the physiological and biochemical consequences of cellular metabolic load and fatigue noted with extreme athletic effort during sporting activities and those noted following a head injury (112). Administration and interpretation of almost all of these tests require specialist centres.

There are a number of validated concussion assessment tasks and questionnaire tools that can be implemented into your chiropractic clinic with minimum training (a few hours). We will have a look at those below.

Best practice recommendations for the clinical identification of concussion is through focused clinical history and examination, rather than a full neurological screening (62, 113). We will look at concussion history and examination recommendations in a later section.

SCAT 5

("Sport Concussion Assessment Tool - 5th Edition" 2017)

Medical concussion and sporting organisation groups recommend certain protocols when conducting a sideline assessment of a head injury. The Sports Concussion Assessment Test (SCAT) is the most commonly recommended sideline assessment of concussion. The SCAT has undergone various iterations over a number of years. At present the SCAT 5 is the most current version. SCAT5 comprises a combination of Glasgow Coma Scale scoring, an evaluation of cognitive and sensorimotor functions, a physical examination, the Standardized Assessment of Concussion and the Balance Error Scoring System scales.

Many patients in a chiropractic clinic who have experienced a head injury, may not have done so by playing sport. In fact, falls are the most common cause of concussion in the general population. Paediatric and elderly patients are particularly susceptible to falls-based concussions. Chiropractors may consult with patients who have experienced head or neck trauma that lead to post concussive symptoms (eg, a MVA).

Ideally the SCAT5 should first performed as a baseline assessment against which a post concussion assessment can be compared. If you have a patient cohort that plays contact sports (adolescents, for example) then you can easily administer the SCAT5 to those patients prior to the commencement of a sports season, and re-administer if you, the patient, or patient's family suspects a concussive event has occurred.

You are able to download the SCAT5 at the following site: <https://bjism.bmj.com/content/bjsports/51/11/851.full.pdf>

There is a good YouTube video with Sports Physician, Dr Louis Holtzhausen outlining how to score the SCAT5 at https://www.youtube.com/watch?v=gNoadxx37_E

You can download the childscat5 at: <https://bjism.bmj.com/content/bjsports/51/11/862.full.pdf>

You can read information about scoring the ChildSCAT5 at: <http://childscat5.cattonline.com/>

Concussion Recognition Tool 5

("Concussion Recognition Tool 5©" 2017)

The Concussion Recognition Tool has been devised for families and health professionals who are not trained in the diagnosis and management of concussion. I recommend this tool be used in clinic to promote awareness of concussion amongst chiropractic patients.

You can download the CRT5 at: <https://bjism.bmj.com/content/51/11/872>

The impact of a head injury on a person, and whether that person suffers a concussive event leading to post concussion symptoms depends on a complex interaction between somatic, psychological and social factors.

Rivermead Post Concussion Symptoms Questionnaire

The Rivermead Post Concussion Symptoms Questionnaire (RPQ) is a 16 item, self report scale to measure the severity of symptoms following a traumatic brain injury (114). A proposed modification to the RPQ has resulted in a division of items into the RPQ-3 and RPQ-13 (115). This questionnaire takes 3-5 minutes to complete. It is a reasonably reliable questionnaire for determining whether you patient is experiencing Post Concussion Syndrome.

You can download the RPQ at: http://www.tbi-impact.org/cde/mod_templates/12_F_06_Rivermead.pdf

A Paradigm for The Chiropractor's Focused Concussion Assessment

It is assumed at this point that the reader has become aware of the patient's history of head injury. The first step recommended is an evidence-based assessment the patient. The following points are included for the chiropractor who is assessing the patient in-office some days to weeks after a possible concussion event. The patient may or may not be aware they have suffered a concussion, and may or may not have previously been assessed (e.g, an emergency department). They may have had a SCAT5 assessment. These assessment points (history and examination) are for the chiropractor in his or her office, within a typically busy day. There are many concussion history forms available on line for you to access.

I have included a link below to an assessment algorithm graphic from Matuszak, J. M., McVige, J., McPherson, J., Willer, B., & Leddy, J (2016) A Practical Concussion Physical Examination Toolbox. Sports Health, 8(3), 260–269.

<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4981071/figure/fig1-1941738116641394/?report=objectonly>

In order to assist the chiropractor to conduct a focused, evidence-based, best practice clinical assessment of the concussion patient, it is recommended that a hybrid clinical approach be applied, combining two evidence based concussion assessment approaches:

1. The COACH CV algorithm outlined by Craton et al (50)
2. The clinical algorithm for assessment and management of concussion outlined by Ellis et al (91)

The chiropractor can keep these approaches in mind when assessing the patient.

COACH CV (Craton, Ali, and Lenoski 2017)

When a patient presents longer than 5 days post head injury, there are 7 Concussion Clinical Phenotypes to consider during the history and the examination. The phenotypes relevant to the chiropractic examination are highlighted.

1. Cognitive
2. Oculomotor (evidence supports chiropractor's scope of practice)
3. Affective
4. Cervical (evidence supports chiropractor's scope of practice)
5. Headaches (evidence supports chiropractor's scope of practice)
6. Cardiovascular
7. Vestibular (evidence supports chiropractor's scope of practice)

Post Concussion Syndromes (Ellis, Leddy, and Willer 2016)

Ellis outlined three post-concussion disorders and evidence-based multi-disciplinary clinical management strategies:

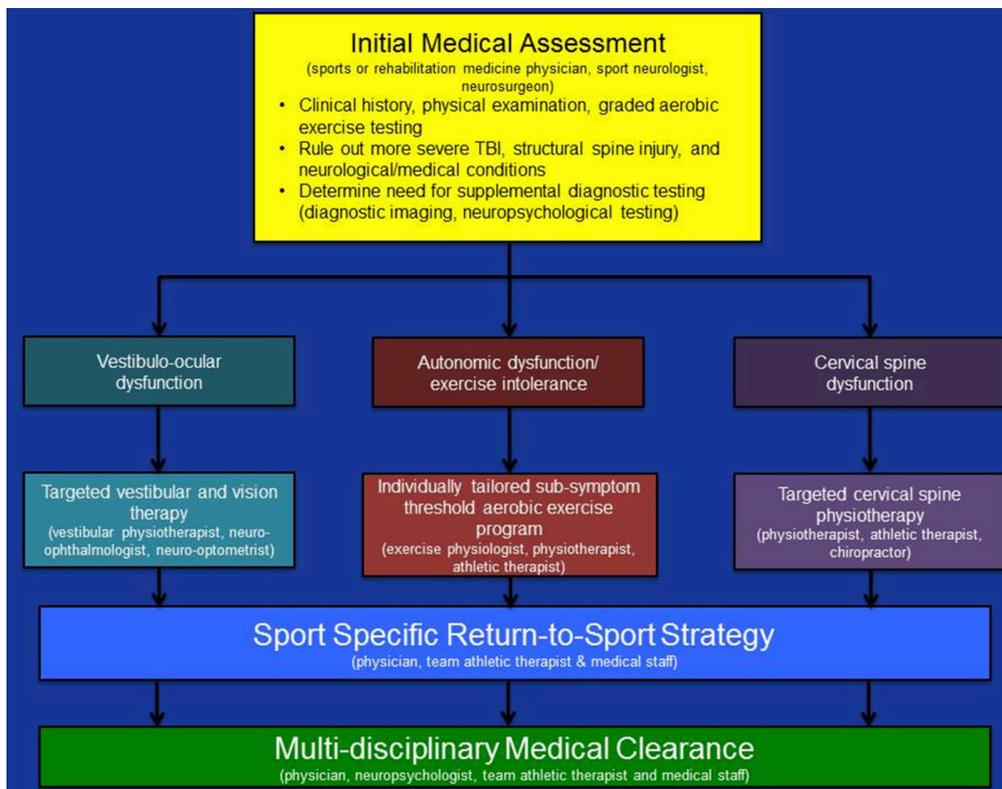
1. Pathophysiological post-concussion disorder
2. Vestibulo-ocular post-concussion disorder (suitable for integrated chiropractic therapeutic support)
3. Cervicogenic post-concussion disorder (suitable for integrated chiropractic therapeutic support)

I recommend that the evidence supports the chiropractor directing a focused history and examination of the cervical and vestibular-ocular phenotypes.

Note: If the chiropractor is concerned that the concussion is experiencing acute physiological concussion symptoms which often involve greater autonomic dysfunction, he/she should refer to an appropriate HCP or exercise physiologist for further assessment (medical practitioner, or exercise physiologist with experience with traumatic brain disorders). Physiological Post Concussion Syndrome patients will often experience onset of concussion symptoms during a graded exercise loading test (116).

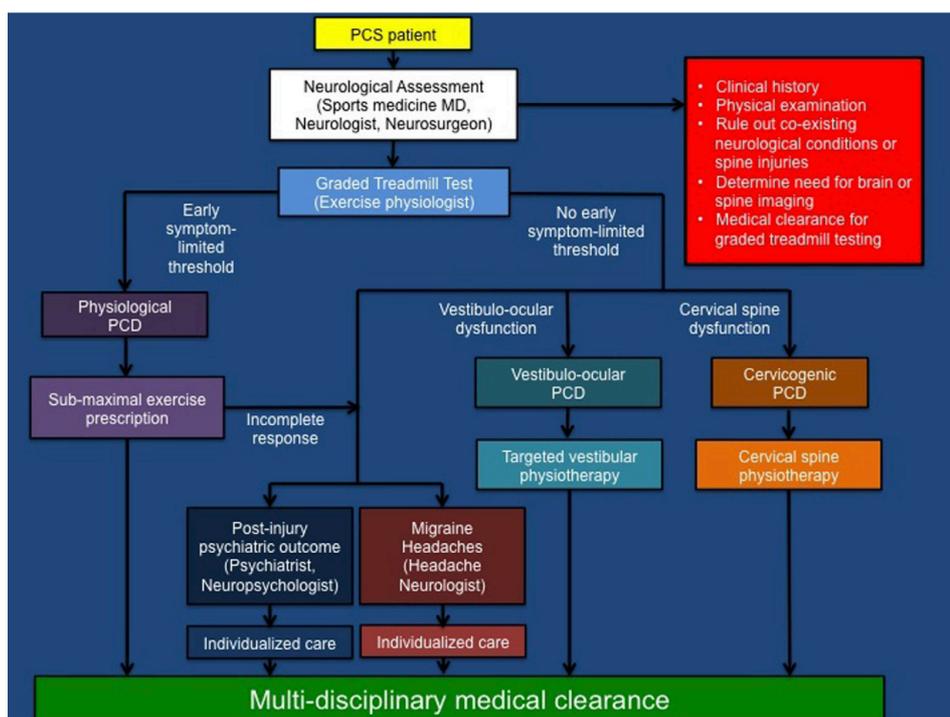
There is an overlap of many of the symptoms and tests for the two concussion phenotypes outlined here. It is assumed that once one becomes familiar with the tests and their significance, the time to effectively assess a concussion patient will be reduced.

It is assumed that a clinical judgement has been made regarding a full examination of the patient to a level of the practitioner's professional clinical competence and satisfaction. For a qualified and registered chiropractor this would include: vital sign assessment (HR, BP, RR);



standard neurological examination (including cranial nerve assessment, motor and sensory assessment); and standard peripheral and spinal orthopaedic assessment. It may or may not be decided to implement a chiropractic -orientated spinal assessment at this stage, this would be left to individual clinical judgement.

Concussion Management Ellis 2018- (117) / Post Concussion Management Ellis 2016 (91)



The General Concussion History

For concussion assessment within 2-10 days of an impact injury, clinical information obtained should include:

1. Date of Head Injury
2. Circumstances of Concussion -(Sport-related, recreational, falls-related, illness-related)
3. Assessment by medical or emergency professional
4. Diagnostic Imaging
5. Hospitalisation
6. Structural damage to head or neck
7. Loss of consciousness
8. Amnesia
9. Autonomic Dysfunction (nausea, blood pressure changes, respiration changes)
10. Affective lability
11. Agitation
12. Vestibulo-ocular symptoms
13. Cervical spine symptoms

For post concussion symptoms assessment within 2-4 weeks of an impact injury, clinical information obtained should include:

1. Headache
2. Dizziness/Postural Instability
3. Visual/visuomotor disturbances
4. Fatigue
5. Noise Intolerance
6. Irritability/lability/anxiety/depression
7. Sleep problems
8. Concentration problems
9. Memory Deficit
10. Intolerance of alcohol
11. Preoccupation with symptoms
12. Personality change
13. Apathy
14. Perceptual/motor dysfunction
15. Social cognition
16. Cervical spine dysfunction
17. Autonomic dysfunction

6e. Chiropractor's History and Examination of the Cervicogenic Post Concussion Syndrome

The evidence-based literature indicates that post concussion cervicogenic patients may experience:

Headache, neck stiffness, blurred vision, disintegration of oculomotor convergence, pursuits, saccades, optokinetic reflexes, vestibulo-ocular reflexes, cervico-colic reflexes, vestibulocervical reflexes, dizziness, vertigo, postural instability, autonomic disturbance, blurred vision.

It also indicates that manual therapy (as provided by a qualified chiropractor) combined with cervical rehabilitation may diminish some post concussion symptoms.

There is strong evidence regarding the role of the cervical spine in concussion events. It is suggested that many post concussion symptoms, and a significant part of Post Concussion Syndrome, may be related to dysafferentation of proprioceptive structures embedded in joints and soft tissue around the cervical spine that relay constant information to rostral brainstem, cerebellum, supranuclear, thalamic and cortical regions. It is further reported that treatment and rehabilitation of cervical spine dysfunction expedites recovery from post concussion syndrome (50, 51, 57, 58, 59, 60, 61, 62, 63, 64, 118, 119).

It has been suggested that brainstem and spinal cord reflexes involving both postural stability and ocular motor function are significantly impacted by cervical injury in concussion events (13, 14, 120). This occurs through cervico-colic, vestibulo-cervical, cervico-ocular reflexes. There is ample evidence that post-concussion head pain or headache may be facilitated through disinhibition of the trigemino-cervical complex, which receives significant presynaptic input from cervical structures. Many patients suffering post concussion headache may also be experiencing central sensitization of pain (83, 121).

Postural stabilising reflexes controlled by cerebellar modulation have also been found to be disrupted by cervical joint and soft tissue injury (122-126). Postural instability due to cervical joint dysfunction may lead to lumbopelvic dynamic lumbar dysfunction due to an increase in back and hip balance strategies. This may often be manifested as an increase in postural stiffness in midline spinal muscle groups. This can be assessed by postural stability testing.

Taking an evidence-based history for cervical involvement in post concussion syndrome

The following questions should be asked of a suspected cervicogenic post concussion syndrome (CGPC) patient :

1. Did you experience neck pain prior to your concussion event?
2. Since your head injury:
 - ▶ have you experienced pain or stiffness in your neck when you move your neck or maintain a static load position?
 - ▶ have you experienced head pain or a headache around the back of your head or the top of your neck?
 - ▶ do you feel dizzy when you move your neck?
 - ▶ do you feel unstable in your balance when you move your neck?
 - ▶ have you experienced more general spinal pain since your head injury?
 - ▶ do you feel disoriented when you move your neck?
 - ▶ do you feel nauseous when you move your neck?
 - ▶ do you feel your vision becomes unclear when you move your neck?
 - ▶ has your neck pain disturbed your sleep?
 - ▶ do you find it hard to concentrate due to your neck pain?

The Neck Disability Index (see Appendix 4)

If the chiropractor suspects cervicogenic post concussion syndrome from a focused history he/she should ask the patient to complete the Neck Disability Index (NDI) (127). This questionnaire allows one to identify domains of neck dysfunction as well as neck dysfunction severity that may be related to a concussive event. The NDI can be accessed at https://www.worksafe.qld.gov.au/_data/assets/pdf_file/0017/77021/neck-disability-index1.pdf

The NDI also provides a clinical outcome tool that will sensitively measure improvement in neck function following chiropractic support therapy.

The Central Sensitisation Inventory (see Appendix 5)

Many post concussion syndrome patients have significant pain and dizziness post head injury. Obsessing over post concussion symptoms can be a common occurrence with PCS. Central amplification of pain or body perception is a common consequence of concussion.

This central amplification of pain is known as Central Sensitization (CS) and was first described by Woolf in 1983 (121, 128, 129).

The Central Sensitization Inventory is a sensitive questionnaire instrument that indicates the degree of 'central nervous system upset' in the presenting concussion patient. Many concussion patients may have had some level of CS prior to their head injury. The CSI does not provide clues to pre-injury CS. Identifying the level of CS should provide the chiropractor with another sensitive indication of the level of chiropractic therapy that may be tolerated by the concussion patient.

Conducting an evidence-based examination for cervical involvement in post concussion syndrome

The chiropractor's cervical spine examination should follow a protocol as outlined below.

1. Observation
2. Palpation
 - a. Cervical musculature
 - i. The chiropractor should map the muscles palpated and record findings and patient responses.
 - ii. Are musculature structures overly painful to palpation?
 - iii. Does palpation of a muscle group cause dizziness?
 - iv. Does palpation of a muscle group reproduce head pain or headache?
 - b. Cervical and upper thoracic (C1-T6) facet joint capsules
 - i. The chiropractor should map the cervical and thoracic spinal joints palpated and record findings and patient responses.
 - ii. Are cervical or thoracic spinal joint structures overly painful to palpation?
 - iii. Does palpation of a cervical or thoracic spinal joint capsule cause dizziness?
 - iv. Does palpation of a cervical or thoracic spinal joint capsule reproduce head pain or headache?
3. Range of Motion Assessment
 - a. Assess and record the 6 degrees of cervical range of motion both passively (off vertical axis-supine) and actively (sitting)
 - i. Does any neck position or movement cause pain or dizziness? Provocative or dynamic neuro-functional testing of cervical spine?

The following tests are designed to assess the impact of cervical stress testing on brainstem and cord based postural, vestibular and oculomotor function. I have included only an outline of these tests. A full description is for another paper.

4. Swivel chair assessment for cervicogenic vertigo
5. Proprioceptive assessment of cervical spine joints-with laser
6. Fukuda's marching test
7. Cervical torsion smooth pursuit test
8. Cervical torsion saccadic test
9. Cervical torsion optokinetic test
10. Rombergs test
11. Rombergs-neck torsion-6 degrees test
12. Computerised Posturographic Assessment (if available)

Chiropractor's History and Examination of Vestibular-Ocular Post Concussion Syndrome -Examination in the Chiropractic Office

I recommend both a focused vestibular and oculomotor assessment of the concussion patient in practice. This has been recommended in the evidence-based literature and I feel this approach would satisfy a best practice assessment of the concussion patient as well as minimising time and cost in a busy chiropractic clinic (52, 58, 62, 120, 130, 131, 132).

Taking a focused Vestibular-ocular post concussion syndrome history

It is assumed at this stage the chiropractor has determined there is little or no involvement of the cervical spine in his/her patient's concussion, or s/he is not satisfied that the cervical spine involvement accounts for the totality of the patient's symptoms.

The following questions should be asked on the suspicion of a vestibular-ocular component to the patient's concussion.

1. Did you have eye strain or headaches due to eye movement (e.g reading or computer work) prior to your head injury?
2. Have you had eye strain or headaches due to eye movement (e.g reading or computer work) since to your head injury?
3. Are you finding it difficult to read since your head injury?
4. Are you finding it difficult to concentrate since your head injury?
5. If so, what particular eye movement causes strain or headache?
6. Did you have difficulties with close up eye activity prior to your head injury?
7. Are you struggling with close-up eye activity since your head injury? (loss of focus, headaches, profound eye watering, nausea, dizziness, fogginess)
8. Are you struggling to tolerate large crowds since your head injury?
9. Are you struggling with loud noises since your head injury?
10. Do you struggle to walk down the aisles of supermarkets since your head injury?
11. Do you struggle when people wave their hands in front of you?
12. Do you struggle to rapidly turn your head and focus on an object (eg, crossing the road)?
13. Do you struggle to read street signs while you are walking?
14. Have you experienced motion sickness since your head injury?

15. Did you have motion sickness prior to your head injury?
16. Do you get dizzy when you lie down in bed, or roll over in bed?
17. Do you get dizzy if you look up or down?
18. Do you feel unsteady walking down stairs since your head injury?
19. Do you feel unsteady when you are in large crowds?
20. Do you sometimes perceive you are moving when you know you are not moving?

Performing a focused Vestibular-ocular Post Concussion Syndrome Examination

I recommend integration of the evidence protocol outlined by Mucha (52) in order to assess concussion patients for VO post-concussion syndrome. An outline of the test is found in Appendix 6.

Videonystagmography (VNG)

Videonystagmography (VNG) is considered to be a sensitive and accurate measure of eye movement dysfunction following concussion. It also provides a sensitive measure of improvement in post concussion ocular function (24, 120, 133). These systems are expensive and require considerable technical training. I believe that they do not suit the purposes of a general chiropractic practice.

Computerised Posturography

The evidence based literature recommends use of a computerised force plate in order to sensitively assess and monitor postural stability after a head injury (55, 134, 135, 136).

I recommend the purchase of a small mobile force plate that enables both assessment and in office rehabilitation. Once again, however, these systems are expensive and require technical training; the general chiropractor would need to establish a cost-benefit analysis of purchase.

Modified Balance Error Scoring System

It is recommended that chiropractors utilise a relatively quick balance assessment protocol.

The modified BESS would be appropriate (18). This has been found to be sensitive enough for identifying and monitoring postural stability changes after concussion. It is recommended that the reader becomes up-skilled in use of this assessment. For a review of the mBESS assessment, please see the YouTube video demonstrating the SCAT5 at https://www.youtube.com/watch?v=gNoadxx37_E

Clinical Protocols for Support of the Post-Concussion Patient in a Chiropractic Practice

Once the concussion patient has been identified and examined, the chiropractor should make a decision about referring for medical opinion and diagnosis. The completed tests should guide the determination of whether the patient belongs to one of the two post concussion phenotypes amenable to chiropractic support therapy. The following recommendations are general strategies. A formal, expansive description of management/support strategies is for another paper.

Grading Your Therapeutic Strategies

Probably the most important message to come out of the evidence based literature regarding post concussion management is ensuring a 'graded' return to activity (137). This approach can be applied to all aspects of the chiropractic treatment paradigm: from your examination to your adjustment to your post adjustment advice and rehabilitation/lifestyle recommendations. Ensuring rest and good sleep in the early stages is imperative. A gradual return to life activities is based on the patient's response.

Determining Metabolic Fatigue

As previously alluded to, post concussion patients have been found to be sensitive to metabolic load and fatigue when exercising or undergoing clinical testing. Most of the significant symptoms a chiropractor should be wary of are brainstem autonomic signs. The Autonomic Nervous System (ANS) has major neural network control centres in the brainstem, which are subject to injury and damage in a concussive event (94). Autonomic dysfunction may be a major component of the immediate post concussion symptom picture, the Post Concussion Syndrome (138).

ANS dysfunction may be a release sign following chiropractic treatment (i.e autonomic dysfunction following chiropractic treatment). Patients may also report ANS fatigue when they engage in relatively light exercise (eg walking). This should be recorded and monitored. It has been noted that patients who have previously experienced motion sickness are more likely to have prolonged concussion recovery. The ability to perform such a test might be beyond the resources of the average chiropractic clinic. However, it is recommended that chiropractors clinically up-skill to be able to recognise autonomic signs of metabolic fatigue.

As previously mentioned, the Central Sensitivity Inventory (see Appendix 5) can also be used to monitor ANS sensitivity as a number of the functional domains in this questionnaire are related to ANS. This should be identified during the history and monitored throughout the treatment-rehabilitation phase (139).

The Buffalo Concussion Treadmill Test was designed to monitor ANS load during post concussion recovery (116). It has since been used in multiple studies as a basis for post concussion rehabilitation (140). A patient's heart rate is monitored when walking on a treadmill that is steadily increased in speed. The patient is asked to report when they feel exacerbations of their symptoms. Based on the heart rate (HR) attained at the level of symptom exacerbation on the treadmill, subjects perform a daily individualised sub-threshold HR progressive aerobic exercise program to the level of their symptom exacerbation.

The clinical ability to recognise and monitor subtle, soft autonomic dysfunction greatly enhances recovery following chiropractic support therapy, and minimises the possibility of adverse reactions going unnoticed or unrecognised.

The ability to perform such a test might be beyond the resources of the average chiropractic clinic. However, it is recommended that chiropractors clinically up-skill to be able to recognise autonomic signs of metabolic fatigue.

As previously mentioned, the Central Sensitivity Inventory (see Appendix 5) can also be used to monitor ANS sensitivity as a number of the functional domains in this questionnaire are related to ANS.

Duration and Frequency of In-office Treatment

It is difficult to identify treatment frequency protocols when offering chiropractic support therapy to a post-concussion patient. Experienced chiropractors are expected to be acutely aware of response times to chiropractic treatment for neck disorders. Response to post concussion care and rehabilitation is complex and multifactorial. It depends on the patient's social and occupational roles (student, athlete, mother, father, computer work, construction work, hospitality etc). The chiropractor must be prepared to 'buy-in' when providing support care. Patients may cancel appointments, not keep up exercises, not follow instructions for a variety of personally valid reasons. Try to use objective outcome measures described in earlier sections of this paper to monitor progress. The author's recommendation is to exercise conservative caution when administering chiropractic adjustments to post concussion patients.

Cervicogenic Post Concussion Syndrome patients, in my opinion, need immediate attention to cervical spine dysfunction. Frequency should be 1-2 visits per week, treatment should be low level in the first month, with emphasis on avoiding HVLA type treatments and including soft

tissue and active release therapies. Cervical rehabilitation protocols should be gradually introduced from the first treatment. The chiropractor should inform the patient of possible post-treatment adverse reactions (transient dizziness, pain, stiffness) in the early phases of treatment. Care should be taken regarding postural stability following treatment. In my clinical experience many concussion patients experience ANS dysfunction some minutes or hours after a chiropractic treatment.

ANS signs pre and post treatment should be monitored, as should ANS signs between treatments. Cervical ROM (pain and pain free) assessments, muscle tenderness and hypertonus assessments, and cervico-oculomotor assessments should be performed at every treatment.

Vestibular-ocular post concussion patients may or may not have a cervical component to their dysfunction. If they do the chiropractor should employ the strategies outlined above.

The chiropractor should also provide evidence based vestibular rehabilitation support therapy (VRT) as outlined in a number of references provided (48, 56, 59, 68, 70, 89, 94, 111).

There are a number of home support therapies that the chiropractor can include. Interactive Metronome has been demonstrated to improve outcome measures in concussion patients (142 and Appendix 5).

I recommend that chiropractors undertake clinical up-skilling in a specific chiropractic-centred support therapies post concussion syndrome cases. This includes clinical nutritional support.

Conclusion

The generalist chiropractor has a high level of undergraduate clinical training to manage a large range of neuromusculoskeletal conditions. Chiropractors are well positioned to identify and support a concussion patient, as they most probably consult with a range of patients from different walks of life who have experienced falls and neck injuries. However, consensus amongst concussion experts recommends that generalist chiropractors require a higher level of clinical training specific to concussion assessment and management. This document has outlined a range of evidence based clinical algorithms and recommendations suitable for the generalist chiropractor when confronted with a suspected concussion patient. It also provides directions for further concussion training. The author recommends that you be aware of concussion amongst patients in your practice, and that you “buy-in” when managing concussion patients. Be prepared to become part of the concussion patients “team”. No-one can treat this cases by themselves.

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Appendices

Appendix 1-Clinical Skills Training

This is a list of clinical up-skilling I recommend chiropractors to undertake in order to conduct appropriate examinations and implement clinical support strategies of the concussion patient in a chiropractic practice

Name	Skill Domain	Time
Dix-Hallpike Testing	Assessment-Vestibular	
Smooth Pursuit testing	Assessment-Oculomotor	
Saccade/Antisaccade testing	Assessment-Oculomotor	
Optokinetic Reflex testing	Assessment-Oculomotor	
Convergence testing	Assessment-Oculomotor-Autonomic	
Velocity Storage Mechanism testing	Assessment-Vestibular	
Pupil size	Assessment-Autonomic	
Consensual light reflex	Assessment-Autonomic	
Direct light reflex	Assessment-Autonomic	
Supine to Stand up Heart Rate	Assessment-Autonomic	
VOR Suppression Swivel	Assessment-Vestib-Oculomotor	
Dynamic Visual Acuity	Assessment-Vestib-Oculomotor	
Neck torsion smooth pursuit	Assessment-Vestib-Oculomotor	
Neck torsion saccade	Assessment-Vestib-Oculomotor	
Cervical joint proprioception-laser	Assessment-postural stability	
Trigeminal Sensory	Assessment-Sensory	
Cervicocollic Swivel	Assessment-Cervical-postural stability	
Rombergs testing	Assessment-Cervical-postural stability	
Rombergs-6 deg/head rotation	Assessment-Cervical-post/ stability	
Fukuda's marching test	Assessment-Vestibular-Cervical	
Dura disc testing	Assessment-Cervical-postural stability	
Gaze stabilization	Rehab-vestibular-ocular	
Gaze stabilisation with laser	Rehab-vestibular-ocular	
Gaze stab-laser on dura disc	Rehab-vestibular-ocular	

Cervico-colic-swivel	Rehab-vestibular-ocular	
VOR suppression-swivel	Rehab-vestibular-ocular	
OKN- swivel	Rehab-vestibular-ocular	
VSM dumping-stripes on swivel	Rehab-vestibular-ocular	
VSM dumping-roll-stripes	Rehab-vestibular-ocular	
Cervical Lordosis Training	Rehab-Cervical	
Supine cervical-gaze entrainment	Rehab-Cervical	
Epley Maneuver	Treatment-Vestibular	

Appendix 2-Convergence Insufficiency Symptom Survey (Borsting EJ 2003)

Convergence Insufficiency Symptom Survey (CISS)

Name: _____ Date: ___ / ___ / ___

Clinician/Assistant instructions: Pose the following questions exactly as written. If the patient responds with "yes" - please qualify with frequency choices. Do not give examples.

Patient instructions: Please answer the following questions about how your eyes feel when reading or doing close work.

Possible Subjective Symptoms	Frequency				
	Never (0)	Infrequently/ not very often (1)	Sometimes (2)	Fairly often (3)	Always (4)
1. Do your eyes feel tired when reading or doing close work?					
2. Do your eyes feel uncomfortable when reading or doing close work?					
3. Do you have headaches when reading or doing close work?					
4. Do you feel sleepy when reading or doing close work?					
5. Do you lose concentration when reading or doing close work?					
6. Do you have trouble remembering what you have read?					
7. Do you have double vision when reading or doing close work?					
8. Do you see the words move, jump, swim or appear to float on the page when reading or doing close work?					
9. Do you feel like you read slowly?					
10. Do your eyes ever hurt when reading or doing close work?					
11. Do your eyes ever feel sore when reading or doing close work?					
12. Do you feel a "pulling" feeling around your eyes when reading or doing close work?					
13. Do you notice the words blurring or coming in and out of focus when reading or doing close work?					
14. Do you lose your place while reading or doing close work?					
Total score _____	— x 0	— x 1	— x 2	— x 3	— x 4

For Children (< age 21) total score = 16 or higher is suggestive of convergence insufficiency.

For Adults total score = 21 or higher is suggestive of convergence insufficiency.

Reference: Borsting EJ, Rouse MW, Mitchell GL, et al and the CITT group. Validity and reliability of the revised convergence insufficiency symptom survey in children. Optometry and Vision Science 2003; 80(12):832-838.

Appendix 3- Neck Disability Index

(Vernon and Mior 1991; Howard Vernon 2008)

The Neck Disability Index

Patient name: _____ File# _____ Date: _____

Please read instructions:

This questionnaire has been designed to give the doctor information as to how your neck pain has affected your ability to manage everyday life. Please answer every section and mark in each section only the ONE box that applies to you. We realize that you may consider that two of the statements in any one section relate to you, but please just mark the box that most closely describes your problem.

SECTION 1-PAIN INTENSITY

- I have no pain at the moment.
- The pain is very mild at the moment.
- The pain is moderate at the moment.
- The pain is fairly severe at the moment.
- The pain is very severe at the moment.
- The pain is the worst imaginable at the moment.

SECTION 2-PERSONAL CARE (Washing, Dressing, etc.)

- I can look after myself normally, without causing extra pain.
- I can look after myself normally, but it causes extra pain.
- It is painful to look after myself and I am slow and careful.
- I need some help, but manage most of my personal care.
- I need help every day in most aspects of self care.
- I do not get dressed; I wash with difficulty and stay in bed.

SECTION 3-LIFTING

- I can lift heavy weights without extra pain.
- I can lift heavy weights, but it gives extra pain.
- Pain prevents me from lifting heavy weights off the floor, but I can manage if they are conveniently positioned, for example, on a table.
- Pain prevents me from lifting heavy weights off the floor, but I can manage light to medium weights if they are conveniently positioned.
- I can lift very light weights.
- I cannot lift or carry anything at all.

SECTION 4-READING

- I can read as much as I want to, with no pain in my neck.
- I can read as much as I want to, with slight pain in my neck.
- I can read as much as I want to, with moderate pain in my neck.
- I can't read as much as I want, because of moderate pain in my neck.
- I can hardly read at all, because of severe pain in my neck.
- I cannot read at all.

SECTION 5-HEADACHES

- I have no headaches at all.
- I have slight headaches that come infrequently.
- I have moderate headaches that come infrequently.
- I have moderate headaches that come frequently.
- I have severe headaches that come frequently.
- I have headaches almost all the time.

SECTION 6-CONCENTRATION

- I can concentrate fully when I want to, with no difficulty.
- I can concentrate fully when I want to, with slight difficulty.
- I have a fair degree of difficulty in concentrating when I want to.
- I have a lot of difficulty in concentrating when I want to.
- I have a great deal of difficulty in concentrating when I want to.
- I cannot concentrate at all.

SECTION 7-WORK

- I can do as much work as I want to.
- I can do my usual work, but no more.
- I can do most of my usual work, but no more.
- I cannot do my usual work.
- I can hardly do any work at all.
- I can't do any work at all.

SECTION 8-DRIVING

- I can drive my car without any neck pain.
- I can drive my car as long as I want, with slight pain in my neck.
- I can drive my car as long as I want, with moderate pain in my neck.
- I can't drive my car as long as I want, because of moderate pain in my neck.
- I can hardly drive at all, because of severe pain in my neck.
- I can't drive my car at all.

SECTION 9-SLEEPING

- I have no trouble sleeping.
- My sleep is slightly disturbed (less than 1 hr sleepless).
- My sleep is mildly disturbed (1-2 hrs sleepless).
- My sleep is moderately disturbed (2-3 hrs sleepless).
- My sleep is greatly disturbed (3-5 hrs sleepless).
- My sleep is completely disturbed (5-7 hrs sleepless).

SECTION 10-RECREATION

- I am able to engage in all my recreation activities, with no neck pain at all.
- I am able to engage in all my recreation activities, with some neck pain at all.
- I am able to engage in most, but not all, of my usual recreation activities, because of pain in my neck.
- I am able to engage in few of my recreation activities, because of pain in my neck.
- I can hardly do any recreation activities, because of pain in my neck.
- I can't do any recreation activities at all.

Instructions:

1. The NDI is scored in the same way as the Oswestry Disability Index.

2. Using this system, a score of 10-28% (i.e., 5-14 points) is considered by the authors to constitute mild disability; 30-48% is moderate; 50-68% is severe; 72% or more is complete.

Appendix 4- Central Sensitisation Inventory

(Neblett and Mayer 2017)

Central Sensitization Inventory

Please circle the best response to the right of each statement						
1	I feel unrefreshed when I wake up in the morning	Never	Rarely	Sometimes	Often	Always
2	My muscles feel stiff and achy	Never	Rarely	Sometimes	Often	Always
3	I have anxiety attacks	Never	Rarely	Sometimes	Often	Always
4	I grind or clench my teeth	Never	Rarely	Sometimes	Often	Always
5	I have problems with diarrhea and/or constipation	Never	Rarely	Sometimes	Often	Always
6	I need help in performing my daily activities	Never	Rarely	Sometimes	Often	Always
7	I am sensitive to bright lights	Never	Rarely	Sometimes	Often	Always
8	I get tired easily when I am physically active	Never	Rarely	Sometimes	Often	Always
9	I feel pain all over my body	Never	Rarely	Sometimes	Often	Always
10	I have headaches	Never	Rarely	Sometimes	Often	Always
11	I feel discomfort in my bladder and/or burning when I urinate	Never	Rarely	Sometimes	Often	Always
12	I do not sleep well	Never	Rarely	Sometimes	Often	Always
13	I have difficulty concentrating	Never	Rarely	Sometimes	Often	Always
14	I have skin problems such as dryness, itchiness or rashes	Never	Rarely	Sometimes	Often	Always
15	Stress makes my physical symptoms get worse	Never	Rarely	Sometimes	Often	Always
16	I feel sad or depressed	Never	Rarely	Sometimes	Often	Always
17	I have low energy	Never	Rarely	Sometimes	Often	Always
18	I have tension in my neck and shoulders	Never	Rarely	Sometimes	Often	Always
19	I have pain in my jaw	Never	Rarely	Sometimes	Often	Always
20	Certain smells, such as perfumes make me feel dizzy and nauseated	Never	Rarely	Sometimes	Often	Always
21	I have to urinate frequently	Never	Rarely	Sometimes	Often	Always
22	My legs feel uncomfortable and restless when I am trying to get to sleep of a night	Never	Rarely	Sometimes	Often	Always
23	I have difficulty remembering things	Never	Rarely	Sometimes	Often	Always
24	I suffered trauma as a child	Never	Rarely	Sometimes	Often	Always
25	I have pain in my pelvic area	Never	Rarely	Sometimes	Often	Always

Score 0-Never, 1-Rarely, 2-Sometimes, 3-Often, 4- Always Add Score out of 100

subclinical = 0 to 29; mild = 30 to 39; moderate = 40 to 49;
severe = 50 to 59; and extreme = 60 to 100.

Appendix 5- Interactive Metronome

Nelson et al. 2013 (142)



Appendix 6: Vestibular/Ocular-Motor Screening (VOMS) for Concussion

The original article outlining this examination protocol is available for free download at PubMed. You can also access two supplementary downloads that outline the testing procedures and provide instructional diagrams. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4209316/>

Here is a summary of the tests involved

Vestibular/Ocular Motor Test:	Not Tested	Headache 0-10	Dizziness 0-10	Nausea 0-10	Fogginess 0-10	Comments
BASELINE SYMPTOMS:	N/A					
Smooth Pursuits						
Saccades – Horizontal						
Saccades – Vertical						
Convergence (Near Point)						(Near Point in cm): Measure 1: _____ Measure 2: _____ Measure 3: _____
VOR – Horizontal						
VOR – Vertical						
Visual Motion Sensitivity Test						

Instructions

Interpretation: This test is designed for use with subjects ages 9-40. When used with patients outside this age range, interpretation may vary. Abnormal findings or provocation of symptoms with any test may indicate dysfunction – and should trigger a referral to the appropriate health care professional for more detailed assessment and management.

Equipment: Tape measure (cm); Metronome; Target w/ 14 point font print.

Baseline Symptoms

Record: Headache, Dizziness, Nausea & Fogginess on 0-10 scale prior to beginning screening

Smooth Pursuits

Test the ability to follow a slowly moving target. The patient and the examiner are seated. The examiner holds a fingertip at a distance of 3 ft. from the patient. The patient is instructed to maintain focus on the target as the examiner moves the target smoothly in the horizontal direction 1.5 ft. to the right and 1.5 ft. to the left of midline.

One repetition is complete when the target moves back and forth to the starting position, and 2 repetitions are performed. The target should be moved at a rate requiring approximately 2 seconds to go fully from left to right and 2 seconds to go fully from right to left. The test is repeated with the examiner moving the target smoothly and slowly in the vertical direction 1.5 ft. above and 1.5 ft. below midline for 2 complete repetitions up and down. Again, the target should be moved at a rate requiring approximately 2 seconds to move the eyes fully upward and 2 seconds to move fully downward.

Record: Headache, Dizziness, Nausea & Fogginess ratings after the test.

- **Saccades :**

Test the ability of the eyes to move quickly between targets. The patient and the examiner are seated.

- **Horizontal Saccades:**

The examiner holds two single points (fingertips) horizontally at a distance of 3 ft. from the patient, and 1.5 ft. to the right and 1.5 ft. to the left of midline so that the patient must gaze 30 degrees to left and 30 degrees to the right. Instruct the patient to move their eyes as quickly as possible from point to point. One repetition is complete when the eyes move back and forth to the starting position, and 10 repetitions are performed.

Record: Headache, Dizziness, Nausea & Fogginess ratings after the test.

- **Vertical Saccades:**

Repeat the test with 2 points held vertically at a distance of 3 ft. from the patient, and 1.5 feet above and 1.5 feet below midline so that the patient must gaze 30 degrees upward and 30 degrees downward. Instruct the patient to move their eyes as quickly as possible from point to point. One repetition is complete when the eyes move up and down to the starting position, and 10 repetitions are performed.

Record: Headache, Dizziness, Nausea & Fogginess ratings after the test.

- **Convergence**

Administer the Convergence Insufficiency Symptom Survey (Appendix 2)

Measure the ability to view a near target without double vision. The patient is seated and wearing corrective lenses (if needed) The examiner is seated front of the patient and observes their eye movement during this test. The patient focuses on a small target (approximately 14 point font size) at arm's length and slowly brings it toward the tip of their nose. The patient is instructed to stop moving the target when they see two distinct images or when the examiner observes an outward deviation of one eye. Blurring of the image is ignored. The distance in cm. between target and the tip of nose is measured and recorded. This is repeated a total of 3 times with measures recorded each time.

Record: Headache, Dizziness, Nausea & Fogginess ratings after the test.

Abnormal: Near Point of convergence ≥ 6 cm from the tip of the nose.

- **Vestibular-Ocular Reflex (VOR) Test:**

Assess the ability to stabilize vision as the head moves. The patient and the examiner are seated. The examiner holds a target of approximately 14 point font size in front of the patient in midline at a distance of 3 ft.

- **Horizontal VOR Test:**

The patient is asked to rotate their head horizontally while maintaining focus on the target. The head is moved at an amplitude of 20 degrees to each side and a metronome is used to ensure the speed of rotation is maintained at 180 beats/minute (one beat in each direction) One repetition is complete when the head moves back and forth to the starting position, and 10 repetitions are performed.

Record: Headache, Dizziness, Nausea and Fogginess ratings 10 sec after the test is completed.

- **Vertical VOR Test:**

The test is repeated with the patient moving their head vertically. The head is moved in an amplitude of 20 degrees up and 20 degrees down and a metronome is used to ensure the speed of movement is maintained at 180 beats/minute (one beat in each direction) One repetition is complete when the head moves up and down to the starting position, and 10 repetitions are performed.

Record: Headache, Dizziness, Nausea and Fogginess ratings after the test.

- **Visual Motion Sensitivity (VMS) Test:**

Test visual motion sensitivity and the ability to inhibit vestibular-induced eye movements using vision. The patient stands with feet shoulder width apart, facing a busy area of the clinic. The examiner stands next to and slightly behind the patient, so that the patient is guarded but the movement can be performed freely. The patient holds arm outstretched and focuses on their thumb. Maintaining focus on their thumb, the patient rotates, together as a unit, their head, eyes and trunk at an amplitude of 80 degrees to the right and 80 degrees to the left. A metronome is used to ensure the speed of rotation is maintained at 50 beats/min (one beat in each direction) One repetition is complete when the trunk rotates back and forth to the starting position, and 5 repetitions are performed.

Record: Headache, Dizziness, Nausea & Fogginess ratings after the test

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Websites/Links

Glasgow Coma Scale- <https://www.glasgowcomascale.org/>

Online Dictionary - <https://www.lexico.com/en/definition/concussion>

Dr Paul McCrory Concussion lecture- <https://www.youtube.com/watch?v=oPrpTj2Edp8>

CATT online <https://cattonline.com/medical-professional-course/>

New Zealand Accident Commission Concussion Criteria <https://www.acc.co.nz/assets/provider/cbc89ef665/acc883a-concussion-service-criteria.pdf>

Download the SCAT5: <https://bjsm.bmj.com/content/bjsports/51/11/851.full.pdf>

YouTube video -how to score the SCAT5: https://www.youtube.com/watch?v=gNoadx37_E

Download the childscat5 at:<https://bjsm.bmj.com/content/bjsports/51/11/862.full.pdf>

Scoring the ChildSCAT5 at: <http://childscat5.cattonline.com/>

Download the CRT5 at: <https://bjsm.bmj.com/content/51/11/872>.

You can download the RPQ at: http://www.tbi-impact.org/cde/mod_templates/12_F_06_Rivermead.pdf

Assessment algorithm graphic :<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4981071/figure/fig1-1941738116641394/?report=objectonly>

NDI-https://www.worksafe.qld.gov.au/__data/assets/pdf_file/0017/77021/neck-disability-index1.pdf

mBESS assessment: https://www.youtube.com/watch?v=gNoadx37_E

VOMS assessment <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4209316/>