FUNCTIONAL NEUROLOGICAL DISORDER AND CHIROPRACTIC: TWO CASE REPORTS

Author

Dr David Richardson B.App.Sc.(Chiropractic)
Private Practice

Brain Based Therapies P/L

T/A Eden Chiropractic

187A Imlay Rd Eden NSW 2551, Australia.

Email: david@edenchiropractic.com.au

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Abstract

Functional Neurological Disorder (FND) is a complex condition characterised by neurological symptoms that cannot be explained by a structural or organic disease. Traditional interventions often emphasise psychological and physiotherapeutic approaches. This case series explores the efficacy of an integrative treatment combining Chiropractic care, Vestibular Rehabilitation (VR), and Sensory Motor activities in two patients diagnosed with FND.

Two patients (one female, age 15 and one male, age 48) with confirmed FND were treated. Each presented with distinct neurological complaints including motor weaknesses, sensory disturbances, and movement disorders. An individualised treatment regimen was designed for each patient combining Chiropractic Adjustments, tailored VR exercises, and specific sensory motor activities. The intervention spanned 3-36 weeks, and outcomes were evaluated based on symptom reduction and functional improvement.

Both patients achieved complete resolution. The movement disorders, such as psychogenic non-epileptic seizures, tremors and dystonia, were reported as achieving complete remission. The results of these two cases suggest that an integrative approach, melding Chiropractic care with Vestibular Rehabilitation and Sensory Motor activities, may offer a promising avenue for the management of FND. Larger controlled studies are warranted to validate these findings and to further explore the underlying mechanisms behind this synergistic therapeutic approach.

The clinical presentation and treatment course of each patient is presented, including the specific VR and Chiropractic techniques used, and report on their outcomes with discussion of the potential mechanisms by which VR and Chiropractic treatment may be effective for individuals with FND.

Introduction

The term "functional" is used to describe a category of disorders or symptoms that do not have an identifiable organic or structural cause but are associated with genuine physical or psychological impairments. These conditions are often referred to as ‘Functional disorders’ or ‘Functional Somatic syndromes’ and encompass a range of disorders with highly diverse presentations. FND is characterised by abnormal patterns of brain functioning (8,13,34). Vestibular symptoms, such as dizziness and balance problems, are a common manifestation of FND and can significantly impact an individual's quality of life.

Vestibular rehabilitation (VR) is a type of physical therapy that is used to treat individuals with vestibular disorders and can help to improve balance and reduce dizziness and other vestibular symptoms. Chiropractic treatment is another complementary therapy that is commonly used to treat a range of musculoskeletal conditions, its role in the treatment of FND is not well-established. One previous study has suggested that Chiropractic care may be a potential treatment option for individuals with FND (5), while several studies have shown the effectiveness of VR in reducing vestibular symptoms in individuals with FND (6,7). To date, there are not any published studies that have examined the use of a combination of VR and Chiropractic treatment for individuals with FND. This represents a clear gap in the literature on the treatment of FNDs, which this case series seeks to address.

This case series highlights the potential benefits of a combined approach to treatment for individuals with FND. Further research is needed to better understand the effectiveness of these treatments in this population and to identify the most effective treatment approaches for individuals with FND (10).

Patient One

P1 is a 15 y/o, right-handed female, who presented complaining of daily seizures lasting 2-6 hours for 3 years. P1 has been diagnosed with Asthma, Autism, Attention Deficit Hyperactivity Disorder, Sensory processing Disorder, Ehlers Danlos Syndrome, Epilepsy, Functional Neurological Disorder and Complex Regional Pain syndrome between 2012 and 2018. Her daily medications include Catapres, Luvox, Lyrica, Ritalin, Nasonex, Seratide and Ventolin. The seizures began in 2017 and usually present as an Oculogyric crisis being immobility, unconsciousness, whole body fine tremors with the eyes open and looking up and to the left. This was, on one occasion, observed by the author.

P1’s medical history involves multiple physicians, hospitals and clinics. She is from a single parent family and has a sibling with ADHD. Otherwise the family history was unremarkable.

Clinical Findings and Diagnostic Assessment:

1. A comprehensive Neurological examination revealed:

- Near point Convergence - 200mm (N=60mm)
- Repeated Convergence Testing showed insufficiency and dysmetria while the left eye lagged
- Corneal Reflex was diminished bilaterally
- Glabella reflex was positive
- Webers Bone Conduction was reported as Left sided
- The Gag reflex was absent bilaterally
- One Leg Standing with eyes closed was poor bilaterally (Left 4s, Right 3s)
- Dynamic Visual Acuity Test using the Snellen Chart was 3 Lines deficient.
- Cervical Joint Position Error testing was poor
- Raglans' Test was mildly positive with a diastolic variance of 12mm Hg (N<10) and the Heart Rate 21bpm (N<20)
- Pupillometry - Left Eye Latency was slow with the minimum diameter also below normal range.
- Saccadometry - The majority of P1's saccades were initiated below 150ms indicating poor neocortical control of eye movements.
- Force Plate Analysis - strong visual dependence with proprioceptive and vestibular deficits were affecting her ability to 'balance'.

Diagnosis

Functional Neurological Disorder.

Therapeutic Intervention :

- Treatment occurred in 4-5 days per session with multiple treatments of 1-3/day with home exercises between sessions, it included spinal adjustments, Sensory-Motor Integration activities, vestibular stimulation and home exercises, involving aerobic activity and coordination. (10).

- Spinal Adjustments were of the Diversified technique (High Velocity and Low Amplitude) applied to subluxations that were palpable at the time of presentation.
- Vestibular Ocular Reflex (VOR) adaption training was utilised using a Forehead mounted Laser while standing in front of a 1.2m square panel with alternating lighted targets. The patient was instructed to 'hit' the target with the laser when it illuminates. The timing of such is altered until eventually a velocity of >150°/sec is achievable, thereby readapting the VOR back to the normal range. It was performed in almost total darkness to facilitate target acquisition. (66)
- Entrainment Therapy for improving cortical network symmetry was achieved by clapping the hands together at 54Hz with audio and visual feedback.
- Vestibular Stimulation was achieved using a multi-axis rotating chair. See description following patient information.
- Peripheral Nerve Stimulator (1Hz square wave electrical activation) to the cranial nerves of XII, X, IX, VII i.e. Tongue.
- Backwards walking on a treadmill while dual tasking by juggling 3 balls.
- Collicular Remapping and Looming Techniques. (Eye movement procedures)
- Complex Movements of the limbs - Fig '8's.
- Saccade Training using a Sensory Motor Integration Reaction Timer (SMIRT) - Gap trials, Overlap trials and Anti-saccades. Described later.

Home Exercises:

- Oculomotor exercises - X2 VOR, eye rolling
- Breath pause and holding exercises
- Running 20mins/day

Treatment Timeline for P1

	Tx	Other Tx modalities	Seizure activity
Pre Tx	-	-	Daily lasting 2-6 Hours
Tx Session 1	Spinal Adjustments, Saccade Training (SMIRT). Repetitive Peripheral Somatosensory stimulation (RPSS)	B'wards walking on treadmill with juggling. VOR Adaption training Home exercises - Run 20min/day	2 days seizure free during the last 38 days
Tx Session 2 (38 days later)	As above and Multi Axis Rotation on 'The Orbital".	As above and Home Exercise to use a balance board	3 days seizure free, seizures lasting 5 hours
Tx 3 (60 days later)	As above and Multi Axis Rotation on 'The Orbital".	As above	seizures occurring every 3 days and lasting 1-1.5 Hours
Tx 4 (17 days later)	As above and Multi Axis Rotation on 'The Orbital".	Use of a weighted helmet for enhanced VOR training	Same frequency, less intense, lasting <1hr
Tx 5 (19 days later)	As above and Multi Axis Rotation on 'The Orbital".	Collicular Remapping and Looming eye movement activities	Same frequency except for 1 period of 6 concurrent days without seizures

Tx 6 (45 days later)	As above and Multi Axis Rotation on 'The Orbital" with Dual tasking.	As above with extra home iPad exercises using the Focus Builder App for Anti-saccades	4-5 days b/w seizures, lasting <45mins
Tx 7 (33 days later)	As above and Multi Axis Rotation on 'The Orbital" with Dual tasking.	As above	Seizures only at night, 1-2 per week
Tx 8 (95 days later)	As above and Multi Axis Rotation on 'The Orbital" with Dual tasking.	As above	No seizure activity, possibly some at night
Tx 9 (25 days later)	As above and Multi Axis Rotation on 'The Orbital" with Dual tasking.	As above	No seizure activity since last Tx

45 Treatments delivered in 9 sessions over a period of 9 months.

Follow-up and Outcomes

A telephone call 2 years post treatment confirmed that no further seizure activity has occurred following the aforementioned treatments and that P1 discontinued all medication over 2 years ago. It is assumed the aforementioned treatment completely resolved the seizure activity.

Patient Two

In July 2021 Patient 2 (P2), a 46 y/o right-handed builder, Caucasian, male presented with a 'vigorous' coarse bilateral distal upper limb tremor. His hands oscillating with an amplitude of approximately 200mm at around 3Hz.
Beginning in January 2021 following recovery from a loss of consciousness and hospitalisation, P2's 'seizure like' arm movements had become a daily occurrence. He could control the movement with gross actions but with rest or lack of guided activity the vigorous movements persisted until falling asleep. He concurrently suffered from business and relationship stress,

with headaches, depression and sensory aberrations as 'ants crawling under his skin' with tingling and numbness of the hands and feet. He was unable to work. His medications include Mirtazapine, Duloxetine, Propranolol.

Prior to attendance P2 had undergone extensive diagnostic investigation, including: Brain MRI (2x), MRI Spinal Cord, EEG, CT Chest, Abdomen and Pelvis. All were unremarkable and were not able to indicate a clear cause of the tremor.

Clinical Findings:

- Saccadometry - Performed initially and after 4.5 months of treatment. The initial Latency Plots show a diffuse spread of saccades from 125 - 450ms including many Saccadic Intrusions and Hypometria bilaterally. The average saccade missed the 10° target by 1.1°. In comparison, the plots taken after treatment show a Saccadic spread of only 150 - 350ms with very few Saccadic Intrusions. The average saccade missed the 10^0 by target by 0.4°.
- Force Plate Analysis - Revealed a Visual processing dysfunction, in that P2's balance paradoxically improved with his eyes closed. Proprioceptive integration failure was evident in that his balance improved while upon a perturbed surface. Vestibular compensation was occurring as when the vestibular organ was relatively isolated P2's balance was at its best. Force Plate Analysis indicated vestibular compensation for both a visual and a proprioceptive functional loss of balance ability. P2's balance age was 68.5 Years.
- Spinal assessment - Various subluxations at multiple levels.
- HR 135bpm RR 34/min HRV 44 O2 98%
- Dynamic Visual Acuity Testing - Loss of 4 lines of the Snellen Chart
- Raglans Test - Systole variation 27mm Hg (N<20)
- Diastole = N HR = N

Diagnosis:

Functional Movement Disorder

Therapeutic Intervention :

- Treatment included spinal adjustments, Sensory-Motor Integration activities, Vestibular Stimulation with home exercises and recommendations regarding lifestyle and personal stress management.

- Interactive Saccade training. This is the rapid targeting of randomly illuminated targets presented throughout the visual field.
- VOR Adaption Training - As previously mentioned.
- Entrainment Therapy - As previously described.
- Spinal Adjustments - were of the Diversified technique (High Velocity and Low Amplitude) applied to whichever subluxations that were palpable at the time of presentation.
- Vestibular Stimulation - was achieved using a Multi-Axis Rotating Chair. See Discussion.
- Home Exercises - (may seem unusual)(10) Gaze stability X2 VOR Ex
- Aerobic activity as quickly walking a 15min mile (1.6 Kms)
- Breathing Exercises - Sitting still while watching the second hand of a clock, the patient has to slowly inhale over a 5 second period and exhale over 5 seconds. Repeating for 1 minute, 3/day.

Treatment Timeline for P2

July 2021	Tx	Other Tx modalities	FMD activity
Tx 1	Spinal adjustments	none	see above
Tx 2 (4 days later)	Spinal adjustments	Home Exercises Peripheral Nerve Stimulation	unchanged
Tx 3 (1 day later)	Spinal adjustments Vestibular Stimulation Entrainment Tx	Home Exercises Peripheral Nerve Stimulation Saccade Training	slight improvement
Tx 4 (1 day later)	Spinal adjustments Vestibular Stimulation Entrainment Tx VOR Adaption Tx	Home Exercises Peripheral Nerve Stimulation Saccade Training	Fine Tremor only
Tx 5 (1 day later)	Spinal adjustments Vestibular Stimulation Entrainment Tx VOR Adaption Tx	Home Exercises Peripheral Nerve Stimulation Saccade	No Tremor

		Training	
Tx 6 (4 days later)	as above	as above	No tremor Occasional Arm twitching at night.
Tx 7 (1 day later)	as above	as above	No tremor Occasional Arm twitching at night.

Follow-up and Outcomes:

The Functional Movement Disorder of the upper limb subsided to become a 'fine' tremor within 3 treatments over 6 days. This also subsided over the next two treatments leaving only a 'twitching' of his right arm noticeable at night and gradually subsiding. One month later the 'twitching' would reoccur when encountering a stressful event. The depression and sensory symptoms abated but resurfaced from time to time over the next 18 months. No further progress was achieved. P2 stopped taking all medication shortly after treatment began. Around that time he also sought help from a counsellor but did not persevere with more than a few visits. P2's 'Balance Age' was initially 68.5 years and16 months later was 33.1 years. He is working full time.

Clinical Assessment Techniques

Several of the forms of assessment discussed above warrant a more detailed explanation.

Saccadometry

Eye motion when observing the visual environment consists of a sequence of fast eye movements called saccades. These occur around three times per second, followed by fixation periods of relative stability while observing a target object etc(56).

Saccadometry is the study and measurement of saccades, being rapid, ballistic movements of the eyes that are used to rapidly shift the focus of gaze from one object to another. It involves the use of specialised equipment to accurately measure various parameters of saccades, such as their velocity, amplitude, duration, latency, and accuracy and assist in the study of the neurological control of eye movements, brain function, and cognition.

Saccades are controlled by a complex neural network (23,55,59). Saccadometry can be used in the diagnosis and management of various neurological disorders, such as Concussion, Parkinson's disease, Multiple Sclerosis, and Huntington's disease, Progressive supranuclear palsy, and Spinocerebellar ataxia. It is also useful in the diagnosis of certain types of eye movement disorders, such as nystagmus or saccadic dysmetria(24,25,56,58). For this case series Saccadometry was used as a guide to show progress with treatment by comparing baseline measurements to normal values.(35-53,62)

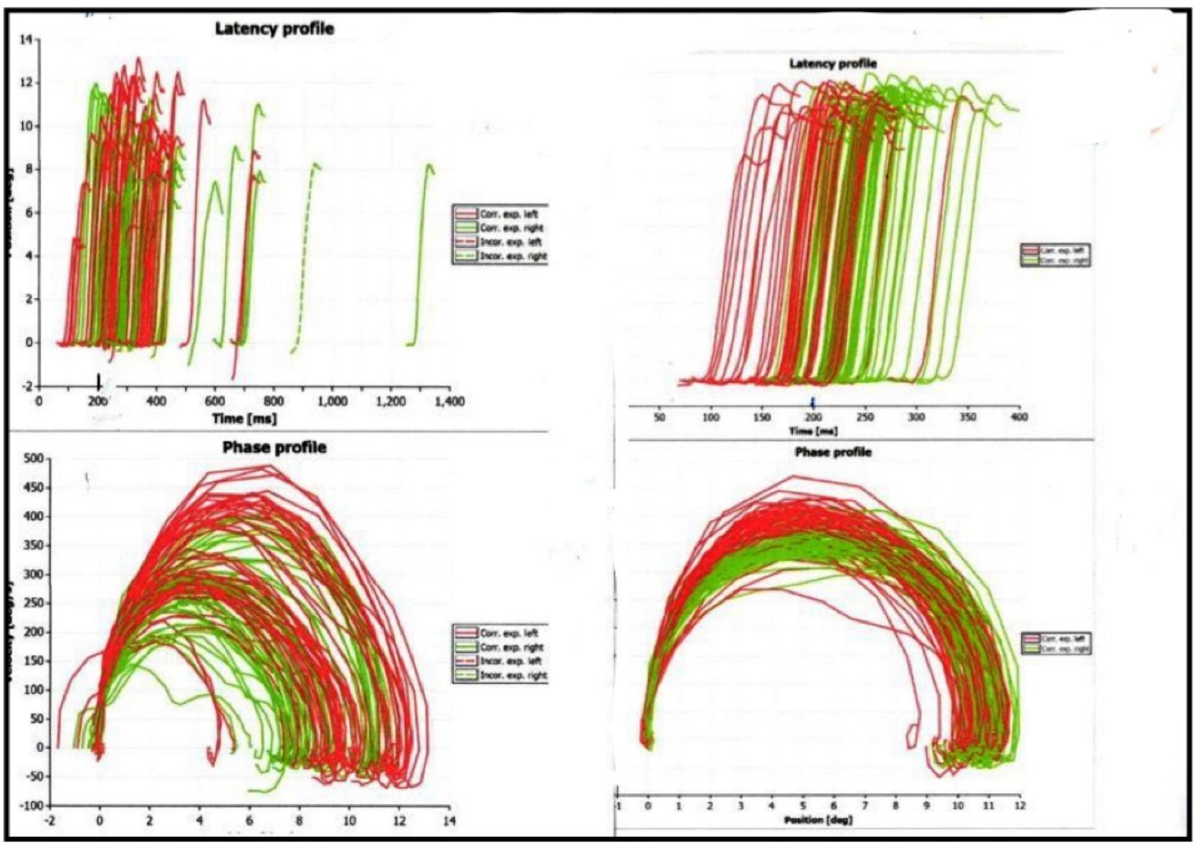


Figure 1: Pre (Left) and Post (Right) Treatment Saccadometry traces. (Patient 2)

In-depth Saccadometry interpretation is beyond the scope of this paper but readers will be able to observe a difference in the cohesion of the pre and post graphs. This represents a clear improvement in control over eye motion.

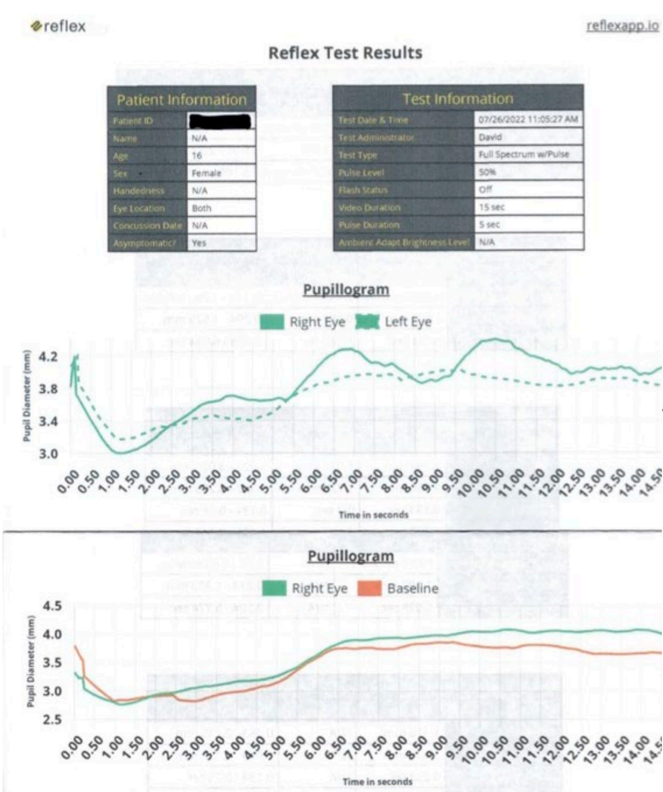
Pupillometry

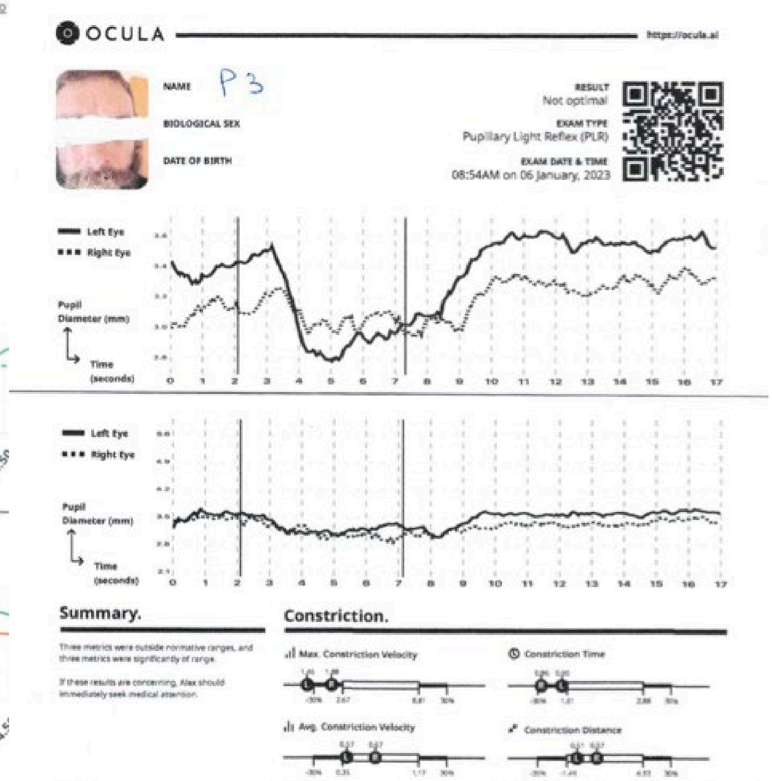
Pupillometry is the measurement of the pupil diameter and reactivity (changes in pupil size). It is conducted using a Pupillometer, a device that measures the size of the pupil and its reactions to various stimuli. Pupillometry provides insights into a variety of physiological, psychological, and neurological states and is considered an accurate indicator of Autonomic Nervous System function.(25-33).

Two types of Pupillometry Phone Applications were used to collect data with this case series.

- ‘Reflex’, which measures each eye singularly.
- ‘Ocula’ which measures both eyes simultaneously.

Both Applications produce response graphs and metrics.





This type of testing is quick, easy and accurate (67,68). Which makes it lend itself to repeatedly monitoring progress, especially of the symptoms pertaining to the Autonomic Nervous System.

Force Plate Analysis

Force plate analysis is used to assess balance and postural control by measuring the shifting centre of pressure when standing still on a balance plate. This is performed with the patient's eyes open and closed and repeated on a soft surface again with eyes open and closed. This allows for a dissection of the specific balance components and their interactions. The Vestibular, Visual and Proprioceptive sensory input is normally integrated and adjusts the outgoing motor response to maintain balance, posture and gaze stabilisation. Each sensory system contributes disproportionally depending on the stability of the surface. On a firm surface with eyes open, the Proprioceptive system contributes 70% to the overall sensory input needed for balance. The visual system 10% and the Vestibular System 20%. However, standing on a soft surface, when the feet are not in contact with the solid surface ensuring the body weight is suspended, the Proprioceptive System contributes around 10% of input and the Vestibular system then contributes 70% and the Visual system 20%.
Vestibular dysfunction arising from peripheral or central components of the vestibular system may manifest as illusory self motion (dizziness/vertigo) and spatial disorientation, which in turn impairs balance (54). The Eyes Closed, Soft Surface testing almost isolates the Vestibular system except for a small amount of Proprioceptive input.
The Proprioceptive and Visual concomitants can be deduced using the same logic. This produces a mixture of results from poor balance due to a functional loss in one, two or three systems. Or 'normal' balance may be observed but due to one or two systems compensating for a third system loss. Each unique set of system loss' or compensations suggests unique rehabilitation strategies.

Therapeutic Interventions in Detail

As detailed above, both patients received complex and individualised courses of treatment, comprised of a variety of different therapeutic modalities. For readability, they are described here in detail with a much fuller description of how the treatments are conducted, as well as an explanation of their underlying rationale.

Interactive Saccade Training

Using the custom built SMIRT (Sensory Motor Integration Reaction Timer) the patient stands in front of a panel of temporarily illuminated buttons/targets. The patient repeatedly and randomly sees a lighted target in their peripheral vision and reacts to this by quickly reaching to the target and pushing the target button. This combination of activities make the CNS perform at a high level requiring peripheral and central vision, gross and fine motor movements and demands exquisite coordination (60,61,62). The selective timing of the lighted targets enable different combinations to predominantly enhance performance of the cortex or brain stem eye movement command generators. Accuracy and average speed are recorded to gauge improvement from treatment. The equipment is custom built and is programmed to match and challenge the users ability. Theoretically, it can be adjusted to predominantly stimulate the Neocortex with an 'Overlap Stimulus' or the brain stem using a 'Gap Stimulus', which was utilised with this case series.

This equipment is also used in it's "Anti-saccade" mode, where the user has to respond to an illuminated target by activating the target button diametrically opposite the illuminated target. This protocol requires 'a double take' of the frontal cortex to achieve it correctly and quickly. That being, the reflexive saccade to the lighted target must be inhibited, the corresponding position calculated and subsequently acted upon. This integrates the asymmetric tonic neck reflex, helps correct a maladapted vestibulo- ocular reflex and or a deficient cervical-ocular reflex, consequently improves hand- eye coordination, basal ganglionic pathways and frontal lobe efficiency. Potentially, leading to improved cognition and self control over unwanted habituation, i.e. behaviours.

VOR Adaption training

Vestibulo-ocular Reflex (VOR) adaptation training is a type of rehabilitation exercise designed to improve the function of the Vestibulo-ocular reflex. The VOR is a critical neurological mechanism that stabilises vision during head movements by producing eye movements in the opposite direction of head movement, thus maintaining the image on the centre of the visual field. When the VOR is impaired due to injury, disease, or aging, it can lead to symptoms like dizziness, vertigo, and balance problems.

The VOR is very important for keeping the brain supplied with visual information to build a clear picture of the environment (57). When the information is hazy, the brain makes less accurate judgements for movement through the environment. Which could mean banging an elbow when going through a familiar doorway, or spilling a drink, tripping or being clumsy.

The VOR uses information from the inner ear (vestibular labyrinth) to generate eye movements that allow the eyes to fixate upon an object during head movements. With severe dysfunction, it is impossible to read signs or even recognise faces while just walking. A dysfunctional VOR can also cause blurred vision. There are Vertical, Horizontal, Angular and Translational VOR Reflexes. During rotation of the head, the VOR can stabilise the eyes accurately even with rapid movements, mainly because the VOR pathway is relatively short and very fast. Precisely because it is so quick, (6ms) the VOR must be intrinsically accurate; on this timescale, vision is too slow to be useful to use for feedback. The brain has to be fast and automatic. Consequently, many diseases, injuries and traumas will adversely affect the functioning of the VOR. It is likely to be a contributing problem with many chronic conditions (author's opinion).

When the VOR becomes dysfunctional the brain neuroplastically adapts to the dysfunction and it becomes a "maladapted VOR." This can persist for our entire lives being a detrimental influence to attaining rich and vibrant maps of our external world.

VOR Adaption Training is achieved by relearning how to accurately and quickly find visual targets. For this case series we used a lighted panel with computer generated targets. The patient wore a Laser headpiece to rapidly follow the randomly generated ever changing targets. Initially the times are set to whatever is achievable and this is increased as the ability to perform the activity improves.

This training aims to recalibrate or enhance the effectiveness of the VOR. The goal is to reduce symptoms of vestibular dysfunction by training away the mismatch between head movement and the corresponding eye movement. The training also included:

- Gaze Stabilisation Exercises: These involve maintaining focus on a target while moving the head. This practice can be varied in speed and complexity depending on the patient's progress.

- Dynamic Visual Acuity Training: This involves reading or recognising objects while the head is in rapid motion, which can help improve the ability to see clearly during movement.

Advanced stages of VOR adaptation training might integrate head movements with walking or other body movements to enhance overall vestibular function eg.head shaking while walking.

Entrainment Therapy

Entrainment therapy refers to a therapeutic approach that involves synchronising biological rhythms with external stimuli. This synchronisation can be achieved through various forms, such as movement with light or sound cueing. The goal is to entrain poorly regulated neurological processes. and is thought to achieve this by improving the synchronisation of various brain networks.

There are many ways to entrain the nervous system but all involve some sort of rhythmic activity. For this case series we used a computer-based program developed in the USA, which measures efficiency and effectiveness of repeated movements synchronised by an audio stimuli while clapping the hands together. The Neocortex and Basal Ganglia are heavily involved in the sensory motor integration and modulation of the networks affected by repetition of movement as a response to a stimuli (59).

Optimal interaction with our environment requires processing and relaying sensory information synchronously and precisely. This is particularly important for complex movement, cognition, emotional control, learning and behaviour.

The brain has a strong tendency to make movements automatic, i.e. riding a bike, learning to drive. Learning a new movement begins with difficulty and quickly builds ‘muscle memory’. The brain does this to free up processing power for new possibilities. It is efficient for the brain to make repetitive movements automatic i.e. ‘habituated’, which is why habits are hard to break!
The better the brain is at doing this habituation, the more efficient it can be with learning. Entrainment therapy builds to create a brain that is a fast learner. Dancing is a very good entrainment therapy!

Vestibular Stimulation

Vestibular stimulation refers to activities or therapies that activate the vestibular system, the part of the inner ear and brain that helps control balance and eye movements. It can help improve balance, coordination, spatial orientation and motor skills, particularly in individuals who have brain injuries, motor development delays or balance impairments. It is used to treat conditions like vertigo, dizziness, and balance disorders related to vestibular dysfunction and is a key component in sensory integration therapy. It helps in regulating the sensory system. Some studies suggest that vestibular stimulation can have a positive impact on cognitive functions and psychological well-being, reducing symptoms of anxiety and depression. It is used in various neurodevelopmental therapies for children with developmental delays, helping in the development of gross motor skills and spatial orientation.
Every head movement stimulates the vestibular system, both the peripheral organ and the central pathways. Typically, gymnastics and dancing will stimulate the whole vestibular system. The central vestibular components are reciprocally connected to many other areas of the central nervous system. Especially the cerebellum but also the hypothalamus, thalamus, extra-ocular muscles, reticular activating system, temporal and parietal lobes and spinal cord. Directly or indirectly stimulating these structures will also stimulate the vestibular system (57).
‘The Orbital’ being a Multi-Axis Rotating Chair, can be rotated in left or right Yaw, anterior or posterior Pitch with left or right lateral Roll. It has a novel feature in that it will roll in the lateral plane which is unlike any activity of daily living, making it a unique vestibular stimulation. This equipment was used extensively for both cases presented here.

Discussion

The intention of this case series is to add to the growing elucidation of a seemingly very effective treatment for FND. Both patients experienced substantial improvements in their symptoms coinciding with their course of treatment. At the very least, this flags chiropractic adjustments and vestibular rehabilitation may be considered as promising forms of treatment for FND, that are deserving of further research.

The generalisable conclusions that can be drawn from the case series are limited by the small number of cases. In particular, the combination of treatment approaches also poses currently unanswerable questions regarding how much effectiveness each element of the treatment contributes. The low number of cases, and the high number of independent variables within each, make it impossible to accurately determine the relative causal effects of each separate variable. Despite these limitations, the clear value of this case series is as a starting point for a more systematic investigation of the relationship between Chiropractic treatment, Vestibular Rehabilitation and FND.

Existing Literature

FND is a common diagnosis in Neurology clinics, encompassing 10-30% of initial presentations (10,13). It affects 4-10/100,000 adults (19), with highly varied presentations. The aetiology of FND is complex, and not fully understood (18).

FND is believed to involve a complex interplay between physical and psychological factors. Trauma, stress and psychiatric disorders are some of the most commonly recognised predisposing factors for the development of FND, but the research findings are inconsistent. The above predisposing factors are only found in a third of the adult population with functional symptoms(19). Other common co-morbid conditions are depression, anxiety, bladder and bowel dysfunction and fibromyalgia.

From the literature there is a broad consensus that FND is generally a 'brain network dysfunction'(8,13,34) with limbic dysregulation (8,6,3,13) involving sensorimotor, prefrontal areas, the Supplementary Motor Area and many other brain areas(2,13). Neuroimaging has delineated the general structures, tracts and networks that contribute to functional dystonia and functions in motor planning, although with limited precision (18,21,34). In many cases, sensory afferents are being poorly modulated which interferes with subsequent motor planning(13,21). The peripheral vestibular organ is a large afferent contributor, therefore it also plays a role in modulating the afferent input to the central nervous system.

FND may develop as a functional comorbidity along with other neurological diseases (15). Studies have estimated that 12% of neurological patients had functional symptoms coexisting with their recognised neurological conditions (11,1,19). An initiating physical event, in 74% of cases, is often involved as are triggers that exacerbate paroxysmal events in 88% of sufferers (17). Movement is the most common 'Trigger' for paroxysmal episodes of FND followed by emotional, visual, touch and auditory stimuli (17). This emphasises the afferent sensory motor involvement.

FND typically has a poor prognosis, especially for patients who receive a diagnosis later in life (18,19). There is no 'one size fit's all' therapy available, (22,10) meaning individualised therapy is required.

Specialised FND clinics are now emerging (12,13,20,22). This multidisciplinary approach to FND is discussed in the literature where several types of healthcare professionals may be involved in the care of these FND afflicted individuals. (10,13,16,18). Including Neurologists, Psychologists or Psychotherapists: Psychotherapy, especially cognitive-behavioral therapy (CBT) (22), and other forms of talking therapy are utilised. Building trust and discussing that the patient's symptoms are due to network dysfunction is considered important, rather than allowing the belief that 'it's all in their head' to dominate (22). Physical Therapists may help individuals with FND manage and improve their physical symptoms through physical therapy techniques and exercises (10,18). Occupational Therapists, Speech and Language Therapists and Rehabilitation Specialists offer individuals with FND programs that focus on physical and functional recovery (20).

Although the benefits of a multidisciplinary approach to FND are increasingly recognised; throughout the FND literature, there is little reference to Chiropractic treatment. It is clear that such approaches have not received much evaluation as potential treatments for FND. This omission is particularly glaring given the currently inconsistent and often poor outcomes that conventional treatments for FND currently offer (18). This case series represents an attempt to address this gap in the literature.

J. Stone's quote: 'it's a software problem not a hardware problem' provides a useful analogy for conceptualising FND (16,21,22). That 'software' problem may also be described as a 'disconnection between will and motivation'. Either analogy fits with a problem with 'predictive processing'(17). In that, with normal movement there is the Bereitschafts potential for estimating gravitational equilibrium before initiating a movement, the generation of the actual command, the creation of an efferent copy of the that command, followed by the monitoring of the movement with comparison to the efferent copy and subsequent correction of the movement. It can be thought that within this complex and rapid scenario the sensory motor data is corrupted at some point leading to an aberrant movement, thought or emotion. Further that 'corruption' might be a 'bias' to a brain network causing it to become dysregulated.

In particular, a decrease in self-agency has been considered in the research as possibly contributing to the seizure type FND (19). Associated with self-agency is the feeling of being able to control external events through one's own actions. This functions on a number of levels, but an individual's ability to exert conscious control over their movements represents a fundamental aspect of self-agency. When voluntary movement is not matched by its sensory feedback the mismatch has to be equilibrated and possibly affects associated brain networks and structures. In this way, it is likely sensory disequilibrium leads to motor disequilibrium.

Scientific Rationale

At present, the scientific rationale for the effectiveness of chiropractic care and Vestibular Rehabilitation to productively intervene in this condition is somewhat speculative. However, a candidate explanation is that their usefulness in treating FND symptoms derives from the way they help to reintegrate the brain networks responsible for the sensory motor system (65).

Vestibular Rehabilitation is recognised as an effective method for recovery from brain injury involving TBI, such as concussion (14). Concussion is a global injury paradigm affecting brain networks, FND is a network dysfunction paradigm (8,13,34). There is a significant overlap in the symptoms of both conditions either directly associated or as co-morbidities such as 'fogginess', poor concentration, dizziness, poor balance, poor coordination, headache, loss of consciousness, tinnitus, light headedness, confusion, vision problems, memory problems and cognitive issues, vertigo, etc.

The underlying similarities between these conditions suggests that they may benefit from similar treatments. It is likely that, just as Vestibular Rehabilitation positively affects brain network that have been injured by concussion, it will also positively affect the brain networks involved in FND. Brain networks are built from genetic expression and environmental interaction. FND is a network dysfunction. Targeted increase of the environmental or sensory activation either re-establishes the network or resynchronises it. Vestibular Rehabilitation Therapy encompasses exercises of adaption, habituation and substitution, such as Gaze stability, Vestibulo Ocular Reflex training, Cervical Ocular Reflex training, Sensory motor training, balance training, gait training, Cervical proprioceptive retraining. Spinal Adjustments also contribute to the reintegration of the sensory motor system (63). From the aforementioned cases it can be seen that a multimodal approach to the correction of FND is likely to be a successful model.

Conclusion

Chiropractic treatment can be considered as a particular type of therapy for the enhancement of sensory motor activity. When combined with vestibular rehabilitation techniques the combination can be very effective for Functional Neurological Disorders.

These undoubtedly complex clinical cases do not typically respond well to any one method of treatment. It appears the combination of modalities is key to success with this cohort. Spinal Adjustments are powerful re-integrators of the sensory motor system clearly demonstrated daily by chiropractic patients reporting a high level of satisfaction (64). Vestibular Rehabilitation is also an effective adjunct to improved sensory motor integration. In combination, Chiropractors are well positioned to help this debilitated cohort of FND.

Informed Consent was obtained from both patients.

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