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CLINICALEVIDENCE
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Two case reports, M46 & M58yo, of long-term stroke recovery using a sensory motor reintegration approach

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Background: Stroke-related motor and balance deficits often persist for years, yet evidence shows neuroplasticity can be rekindled long after the acute phase2,6. We present two chronic stroke cases treated with an integrated programme of manual spinal adjustments, vestibulo-ocular reflex (VOR) exercises, multi-axis whole-body rotation, reaction-time drills, quantitative EEG (QEEG) tracking, and autonomic monitoring (Ocula) delivered in a regional clinic.

Case summaries: M58, 36-months post-ischaemic stroke with gait and cognitive deficits; M46, 8-years post-cerebellar infarct with imbalance and daily headache. With multiple sessions over several months, both showed improved posturography, oculomotor metrics, reaction time, and functional independence.

Interventions for both patients: (i) high-velocity low-amplitude spinal adjustments to segments with fixations; (ii) daily home VOR × 2 and dual-task balance drills; (iii) progressive multi-axis chair rotations (yaw, pitch, roll; 30–60 deg s^{-1}; 20–60 s bouts) with concurrent cognitive tasks; (iv) reaction-time panels (overlap, gap, anti- saccade paradigms); (v) lifestyle coaching and paced aerobic activity. QEEG and smartphone pupillometry (Ocula™) guided the session intensity.

Outcomes: Both survivors demonstrated objective sensory-motor and cognitive gains well beyond the accepted twelve-month plateau.

Conclusion: These cases illustrate that chronic stroke deficits can improve when a sensory-rich, individualised, and autonomically titrated programme is applied. Multi-axis vestibular stimulation and spinal adjustments may act as potent afferent primers that amplify subsequent task-specific learning. Controlled studies are required, but clinicians should consider multimodal, data-informed approaches rather than accepting late-phase stasis. Of note is that long term treatment appears to deliver long term gains.

Indexing Terms: Chiropractic; adjustment; chronic stroke recovery; sensory motor integration; multi axis vestibular stimulation; qEEG; Pupillometry.

Introduction

Stroke is a leading cause of serious long-term disability worldwide.(1) Many stroke survivors are left with persistent motor, sensory, and balance deficits that require prolonged rehabilitation, even years after the acute event.

> *…The integration of spinal adjustments provided additional benefits that are harder to isolate but were nonetheless observed …'*

Traditional stroke rehabilitation often tapers off after the first few months, yet neuroplasticity, the brain's capacity to reorganise and form new connections, can persist well into the chronic phase of recovery. (2)

This paper presents an approach to long-term stroke recovery, emphasising sensory-motor integration and vestibular rehabilitation as central components. The approach integrates established traditional spinal manipulative methods with modern neurological rehabilitation techniques, including quantitative electroencephalography (QEEG) for brain function monitoring, reaction time training, vestibulo-ocular reflex (VOR) exercises, and advanced vestibular stimulation with multi-axis full body rotation. Autonomic nervous system function is tracked using a pupillometry application (Ocula) to ensure interventions support overall neurological health.

We illustrate how a multimodal, individualised therapy program can facilitate significant improvements, even in chronic stroke patients. In the following sections, we review relevant literature, describe the clinical methodology, and present two detailed case studies. The discussion contextualises the outcomes and insights from the cases in light of current evidence, underscoring the importance of an integrated, multidisciplinary approach for chronic neurological rehabilitation.

Background and Literature Review

Sensory–motor integration in stroke recovery

Post-stroke motor relearning depends on restoring sensory processing and sensorimotor integration (vision, proprioception, touch) rather than motor training alone, because disrupted integration is common and correlates with poorer motor outcomes. (4)

Neuroplasticity and chronic recovery

The adult brain retains capacity for experience-dependent plasticity (e.g., dendritic/synaptic change, re-mapping) well beyond the subacute phase, so targeted, task-specific practice can drive gains even in the chronic stage. (14, 17).

Chiropractic plus neurorehabilitation

In a randomised controlled trial, 4 weeks of spinal adjustments added to usual physiotherapy improved Fugl-Meyer scores more at 4 weeks than sham + physiotherapy (difference ≈6 points), though between-group differences were not sustained at 8 weeks. Neurophysiology work in chronic stroke shows single-session spinal adjustments can increase corticomotor excitability and early sensorimotor SEP responses, suggesting short-term central effects. (17, 18)

Vestibular rehabilitation & VOR training

Across 15 RCTs (n=769), adding vestibular rehab to usual stroke care produced moderate-certainty improvements in balance (SMD ≈ 0.59) and faster Timed-Up-and-Go

(≈ −4.3 s), with the most effective protocols combining gaze-stabilisation (VOR) drills with swivel-chair/head-movement training. (8)

Multi-axis vestibular stimulation (e.g., OVAR/rotational chair)

Off-vertical-axis rotation and related chair-based paradigms deliver controlled semicircular canal/otolith stimuli that probe and train vestibular function; parameters are clinically used and correlate with vestibular test profiles in vestibulopathies. (13) Evidence in stroke is emerging, so protocols should be individualised and symptom-titrated.

Quantitative EEG (qEEG) in rehabilitation

qEEG metrics (e.g., delta/alpha ratio, brain symmetry index) reflect cortical dysfunction after stroke and show prognostic associations with impairment and outcome in systematic reviews, though consensus on best biomarkers for routine care is still evolving. (15, 23) Reaction time & cognitive-motor speed with reaction times measured in the acute stage correlate with attention and global cognition months later, supporting their use as a quick surrogate of central processing speed relevant to functional recovery. (21)

Autonomic function monitoring via pupillometry (OculaTM -smartphone App)

Smartphone-based pupillometry can capture pupillary light reflex (latency, amplitude, velocities) with clinically useful accuracy compared with reference devices and supports remote/bedside autonomic assessment; validation studies include PupilScreen and related systems. (16, 20)

Cases

Patient 1(P1)

A 58-year-old male suffered an ischemic stroke while undergoing 70 minutes of emergency CPR for a myocardial infarction. The CPR also fractured his sternum and multiple ribs. He presented 3 years post stroke complaining of a '*terrible*' loss of short term memory, fogginess of thinking, frustration, a lack of motivation and an unsteadiness with walking, insomnia, mild depression, an inability to concentrate, feelings of confusion and bewilderment.

He had difficulty with climbing stairs and could not walk a kilometre without having to stop and recover. Several years previously he suffered a Non Hodgkins Lymphoma which was treated successfully with chemotherapy. He suffered recurrent low back pain for '*many years*'. P1's family history was unremarkable except for cardiovascular disease. He was unable to work and his driving licence was cancelled.

At the time of initial evaluation in our clinic, P1 was 36 months post-stroke, essentially in a '*chronic stable*' state, but desperate to improve his life. He had a slightly wide based unsteady gait and presented with his wife holding him by the elbow.

Rehabilitation Intervention

We implemented the integrated program described earlier, customised to P1's profile:

Chiropractic Adjustments:

Given his significant balance asymmetry and a history of low back pain, we delivered manual chiropractic adjustments to all spinal areas of reduced movement (1–2 adjustments per week). Notably, P1 reported feeling less spinal pain and demonstrated a slight improvement in mobility which helped reinforce his engagement in therapy.

Multi-Axis Rotational Stimulation:

From the beginning of treatment we used the multi-axis chair. In the first session, we performed only mild horizontal rotations at 30°/sec for 30 seconds, repeatedly in each direction, with pauses in between. He was anxious but reported '*it's like my brain is waking up*'. Over subsequent sessions, we applied 30° of anterior tilt to achieve Off Vertical Axis Rotation for combined lateral canal and otolithic organ stimulation.

From there we achieved progressive introduction of anterior and then posterior pitch rotations. Within two weeks we were achieving a well tolerated combination of yaw and pitch combined and at various velocities. During these sessions, we integrated cognitive tasks and hand-eye coordination activities such as repeating every second letter of the alphabet or throwing balls at targets.

Reaction Time and Cognitive Drills:

In each clinic session P1 used the Sensory Motor Integration Reaction Trainer, his average reaction time was 0.569 with a miss rate of 70% He predominately used his dominant right hand so we encouraged using the left hand equally to drive improvement on that side. He eventually improved significantly in reaction times and accuracy with a miss rate of only 15%. This quantitative improvement mirrored subjective reports that he felt '*quicker*' in daily tasks.

Autonomic Regulation:

Throughout therapy, we monitored P1's fatigue and autonomic signs. After the more intense multi-axis rotation or taxing activities, we measured his pupil response with Ocula.

P1 was given daily exercises as a home program involving VOR x2, walking a fast mile, Supine to sitting upright repeatedly, the Peak Brain Training App and Squats. His compliance was poor.

Outcomes

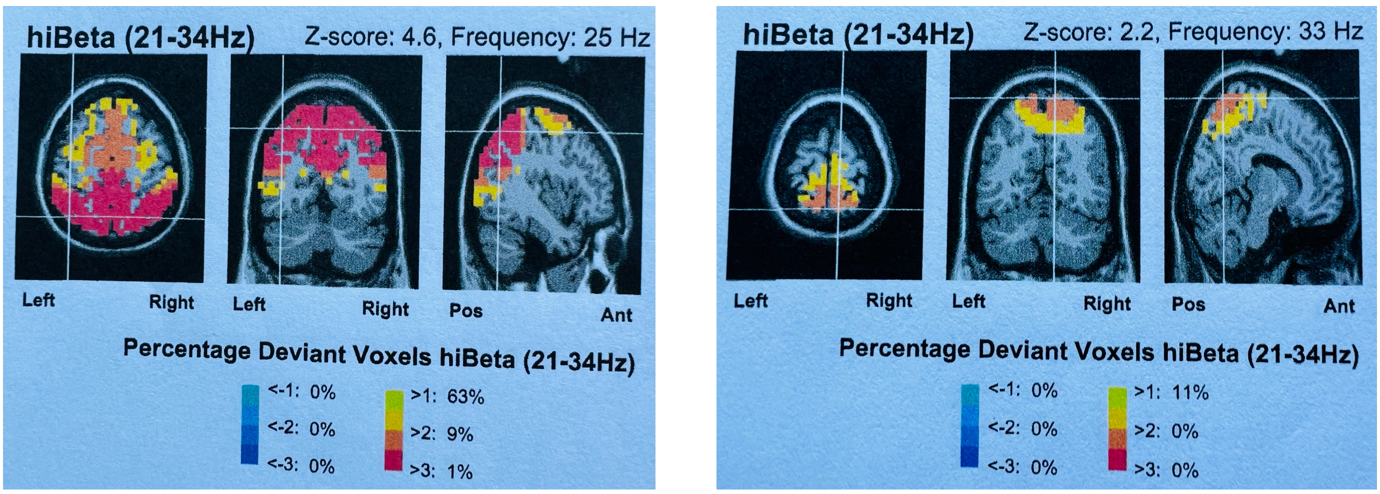
At the conclusion of 30 treatment sessions P1 demonstrated notable improvements:

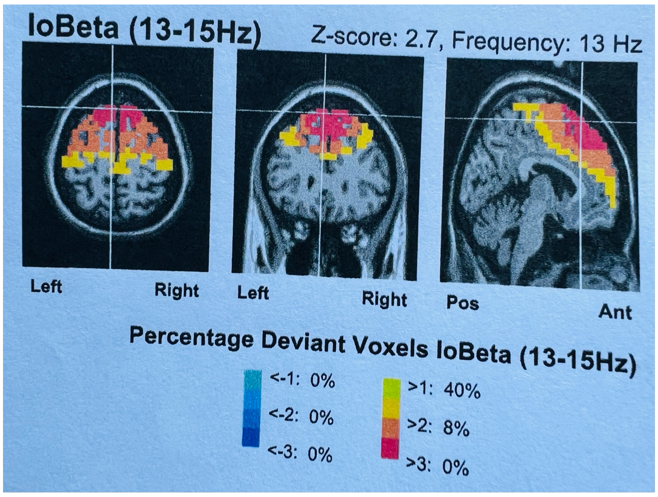
- Mini Mental State Examination Post Tx score was 25/30 consistent with normal cognitive impairment. Initially 22/30.
- UPDRS scoring 3/12. Initially 7/12.
- Entrainment accuracy (clapping 100 times to a 54Hz Beat) 58%. Initially 24%
- Ability to accurately saccade left to right was timed at 0.7secs. Initially 0.9secs.
- Time to achieve hitting a lighted targets (overlap) 0.6secs. Initially 0.9secs.
- Time to achieve hitting a target geometrically opposite a lighted target (anti saccade) was 1.2secs. Initially 2.2secs.
- Dynamic Visual Acuity testing showed 2 lines of deficit on the Snellen chart. Initially 4 lines.
- Force Plate Analysis initially showed vestibular compensation for deficient visual and proprioceptive systems. Retesting showed slight improvement.
- Initially,QEEG analysis gave a sLoretta Z score. The sLORETA Z-scores give a precise, statistical way to say ‘how far’ a client’s 3-D cortical current density at each voxel and frequency band deviates from a healthy reference group). Normal values are between +2 & -2.

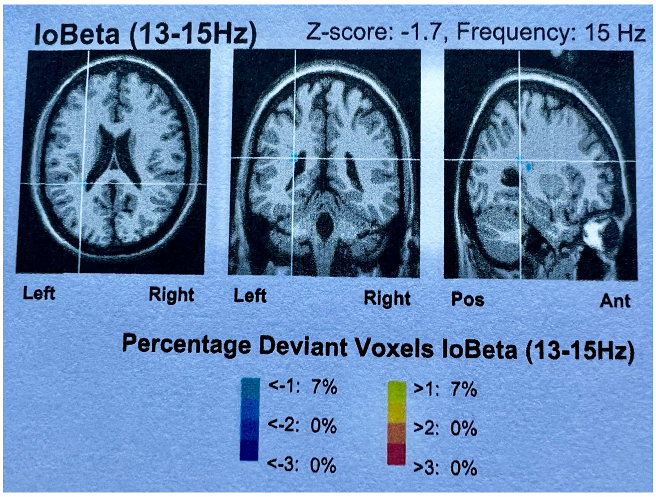
P1’s QEEG examination values were consistent with his presenting symptomatology Retest post treatment showed significant improvement.

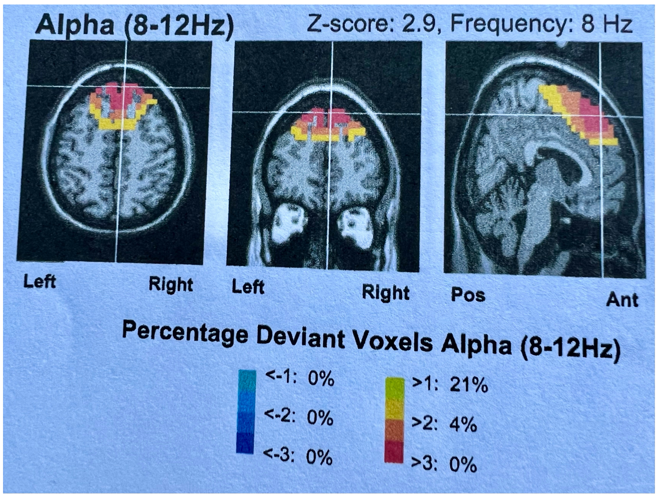
Z Scores N=-2 +2	Delta	Theta	Alpha	Lo Beta	Beta	Hi Beta	Gamma band
Pretreatment	6.4	5.6	2.9	2.7	2.5	4.6	3.6
Posttreatment	4.1	2.7	1.5	-1.7	-1.8	2.2	3.0

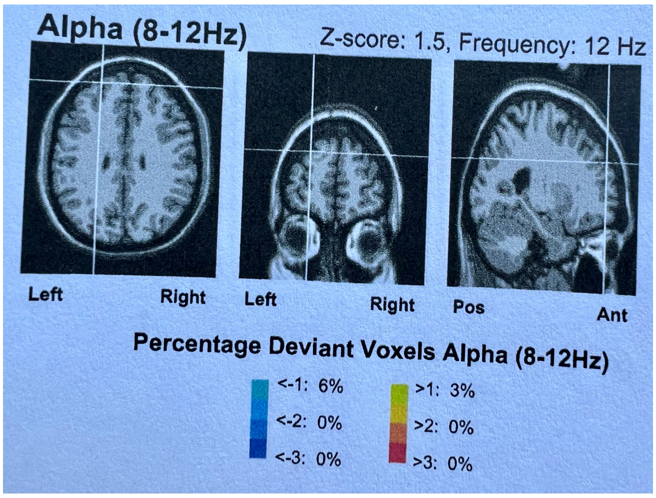
QEEG: Pre Tx on Left ,Red is bad, (Dysfunctional); Grey is good, (Normal)



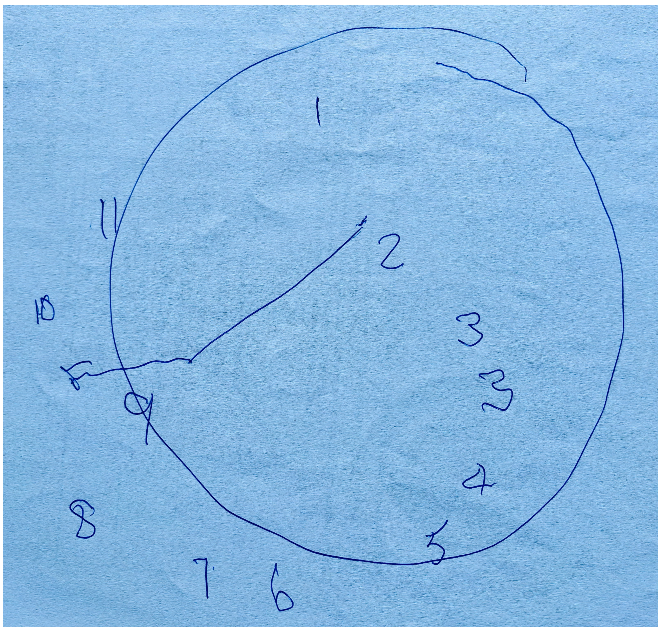


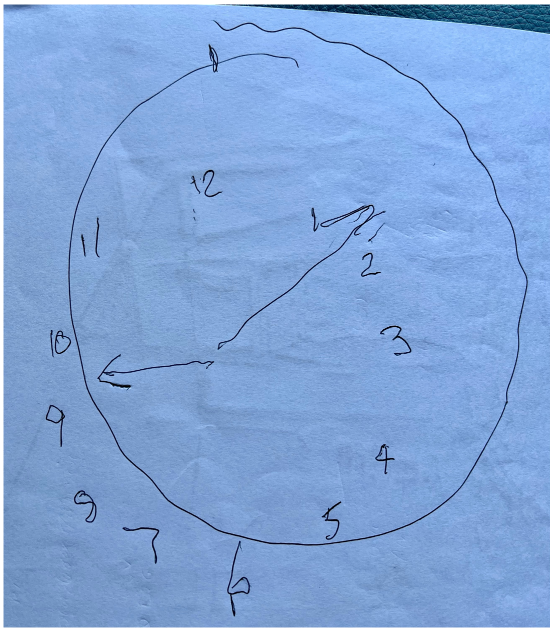






This is a small improvement in the clock face test



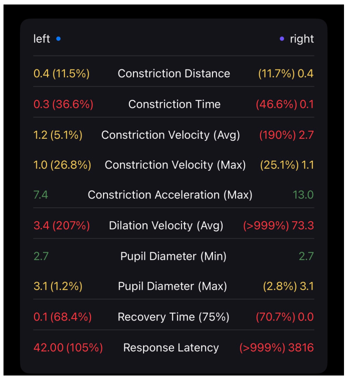


- Saccadometry showed a diffuse latency spread with large numbers of spontaneous saccades and saccadic intrusions, bilateral hypometria with the right being worse than the left. There was poor neural integration showing in the velocity profile. Post treatment showed a marginal improvement.
- Pupillometry was significant in that it measured P1's PLR '*out of range*' metrics in latency, constriction velocity and time, dilation velocity and recovery time. While normal range values were found for constriction distance, acceleration, velocity (ave and max) and pupil diameter. Post treatment only the constriction velocity was left '*out of range*'.
- Bell's Test was unremarkable 33/35 bells circled in 1.55 mins with a coherent scanning strategy.
- Dizziness Handicap Inventory was unremarkable scoring 12/100
- P1 could stand on one leg for only - left 4s right 3s.
- The Fakuda test had a marked forward drift with turning to the left and a general instability of his stepping ability.
- The subjective visual vertical white bucket test was borderline aberrant at -2.2.
- The velocity storage time constant measured by Optokinetic After Nystagmus was 64 seconds to the left and 72 seconds to the right.
- Vibration induced nystagmus was NAD.
- The Draw-A-Clock face test showed improvement but still indicated a demented state.

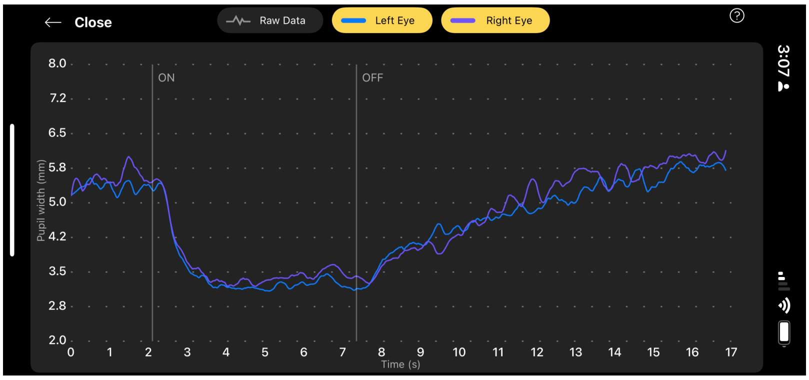
After 29 consultations he attended for his regular neurological checkup. The neurologist stated he never thought it possible but P1 had clearly improved and was permitted to have his driving licence reinstated. P1 was very happy about this.

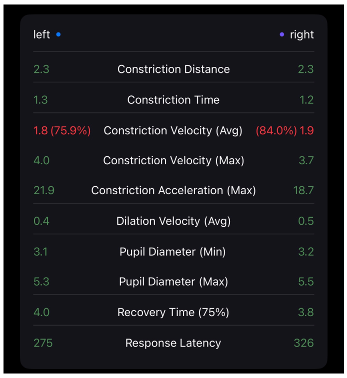
Pupilometry Results

Pre treatment above, Post treatment below.



left		right
0.4 (11.5%)	Constriction Distance	(11.7%) 0.4
0.3 (36.6%)	Constriction Time	(46.6%) 0.1
1.2 (5.1%)	Constriction Velocity (Avg)	(190%) 2.7
1.0 (26.8%)	Constriction Velocity (Max)	(25.1%) 1.1
7.4	Constriction Acceleration (Max)	13.0
3.4 (207%)	Dilation Velocity (Avg)	(>999%) 73.3
2.7	Pupil Diameter (Min)	2.7
3.1 (1.2%)	Pupil Diameter (Max)	(2.8%) 3.1
0.1 (68.4%)	Recovery Time (75%)	(70.7%) 0.0
42.00 (105%)	Response Latency	(>999%) 3816





left		right
2.3	Constriction Distance	2.3
1.3	Constriction Time	1.2
1.8 (75.9%)	Constriction Velocity (Avg)	(84.0%) 1.9
4.0	Constriction Velocity (Max)	3.7
21.9	Constriction Acceleration (Max)	18.7
0.4	Dilation Velocity (Avg)	0.5
3.1	Pupil Diameter (Min)	3.2
5.3	Pupil Diameter (Max)	5.5
4.0	Recovery Time (75%)	3.8
275	Response Latency	326

Post treatment, P1's pupillary response to light is markedly improved to near normal. Red results represent metrics 2 standard deviations from normal. Yellow one standard deviation from normal and green are within the established normal range.

Patient 2 (P2)

A right handed 46 yo male presented to the emergency department in 2011 having suffered a right cerebella infarct. Upon release from hospital he was not confident enough to drive a car for 8 months. With poor balance he was unable to ride a motorcycle and subsequently sold off his collection of antique motorbikes. Before the stroke he was an earth moving machine operator but this was no longer possible from difficulty climbing into the machine, poor balance and a diminished sense of spacial awareness. He felt unsafe when negotiating a corner and could not estimate distance.

P2 attended the clinic almost 8 years after his stroke in 2018, complaining of poor balance, foggy thinking, 7 years of constant Headache and a sore cervical spine. He suffered right eye pain post stroke, which was constant regardless of what he did in his daily living, the headache would be there upon awakening as a fronto-occipital '*pressure*' and was relieved by '*Panadol*' which he consumed daily.

A comprehensive examination was completed.

- Raglans test - unremarkable
- Right superior eyelid ptosis and photophobia was noted.
- Blood oxygen level was 92-94%
- Rhomburg's testing had a noticeable sway to the right.
- His steady standing Rhomburg Tandem stance was unachievable,
- Standing on one leg with eyes closed was only 1-2 seconds bilaterally,
- The Fakuda test was stopped at 15 secs as the unstable stepping ability was considered to potentially allow a fall. Even in the 15 seconds he turned 30° to the right.
- His Tandem walk was poor with eyes open and unachievable with eyes closed.
- Hand slapping dysdiadokokinesia was poor on the left and less than normal on the right. As was the rebound test with eyes closed using resistance to upper limb flexion.
- Gabella tap was positive.
- Head shake nystagmus lasted 9 seconds.
- Normal gait with a tendency of veering to the right and a diminished right arm swing.
- Force plate analysis derived an age based database comparison of an overall balance age of 83 with vestibular and visual system deficit combined with proprioceptive system compensation. See Graph.
- Grip strength was normal Lt 49.8 and Right 45.1kgs.
- Pinwheel sensation of the V1, V2 and V3 dermatomes were reported as noticeably sharper on the right side of the face.
- The 'Draw a clock-face' test was performed with eyes closed to emphasise spacial awareness deficit and was markedly positive.
- Saccadometry was performed and showed a large number of spontaneous saccades at 100ms, the average velocity of the eye movements were slow and inaccurate.

- Cognitive assessment using the Cambridge Brain Sciences computer based testing revealed a poor result for response inhibition, visual partial working memory and mental rotation tasks.

The same integrated rehabilitation program described earlier was customised to P2's profile. We delivered manual spinal adjustments to all spinal areas of reduced movement weekly. Notably, P2 reported his constant headaches were relieved after a few spinal adjustments.

We began the multi-axis chair vestibular stimulation on the first visit gradually increasing the velocity, direction and duration to his tolerance on a session by session basis. He tolerated the procedure quite well with and with enthusiasm as he could see improvement from every session. Dual tasking was applied every time.

P2 used the SMIRT (Sensory Motor Integration Reaction Trainer). To begin with, his average reaction time to hitting targets was poor with a high 'miss rate'.

Ocula was used to monitor P2's fatigue and autonomic signs.

P2 was given daily exercises as a home program involving VOR x2, balancing on one one foot with eyes closed, the Peak Brain Training App and Squats (Deep knee bends). His compliance was excellent.

Outcomes

P2 reported improvement after every consultation with his headaches resolving after a few visits, within a couple of months he was able to operate machinery again. He was so impressed with the treatment he elected to continue with near weekly treatment for the following 6 years. Periodic assessments were completed and the results of the 12 month and 6 year reassessments are described.

P2 reported that his photophobia in the right eye resolved but the eye pain persists as does the ptosis of his upper eyelid.

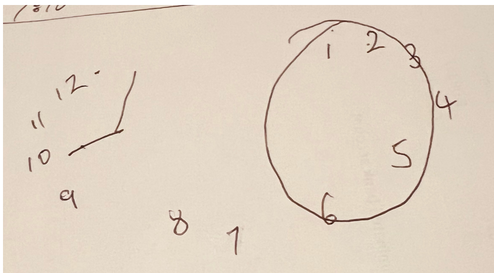
The Fakuda test resulted in a left turn of 60° but was prematurely stopped at 25seconds due to considerable stepping instability.

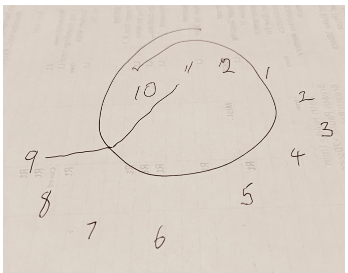
Head shake nystagmus lasted 4 seconds.

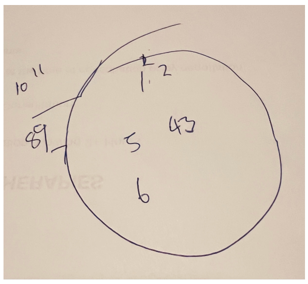
One leg standing with eyes open was Rt 7sec and Lt 6secs.

Saccadometry was improved with better metrics for target acquisition: Pre Tx Lt 7.2, Rt 7.9, post tx Lt 8.0, Rt 9.1 (N=9-11) Eye movement velocity was improved into the normal range (pre tx Lt 354, Rt 350, Post Tx Lt 446, Rt 417 (N=400-1000deg/sec), The latency profile showed a considerable improvement with far less spontaneous saccades.

The improvement in Visuospatial working memory is well correlated to the obvious progression with the 'eyes closed' draw a clock face test. These were drawn initially and at 1 and 6 years.



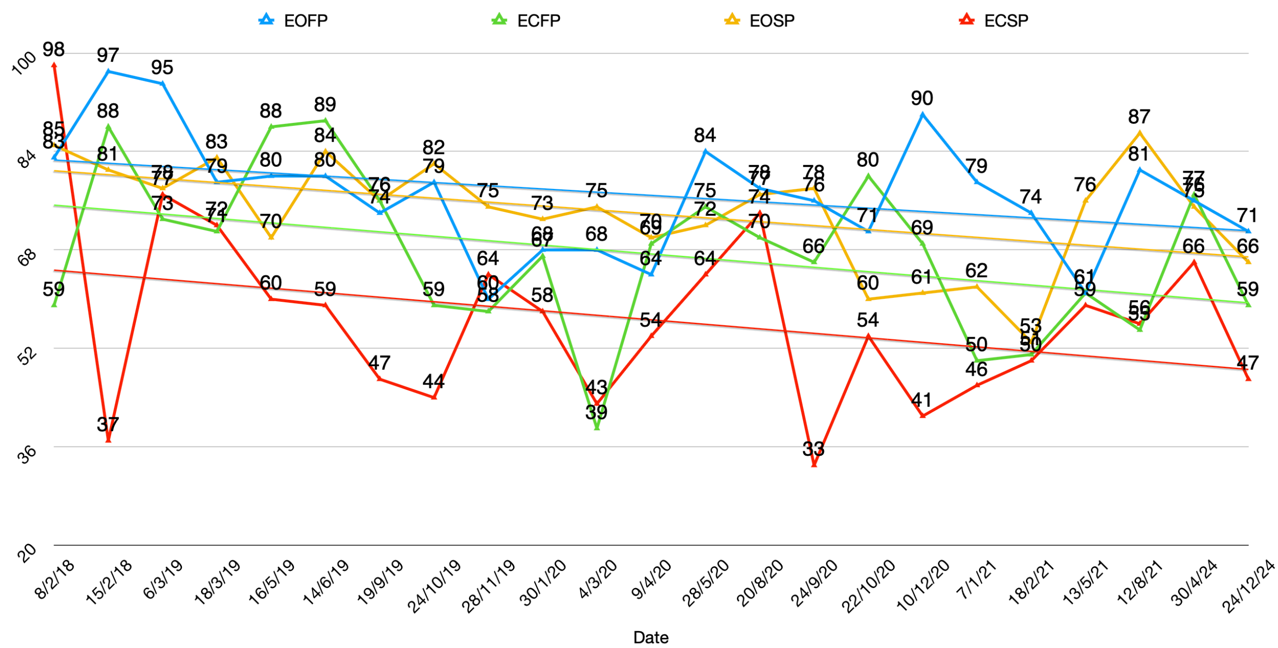




Cognitive assessment progressive results:

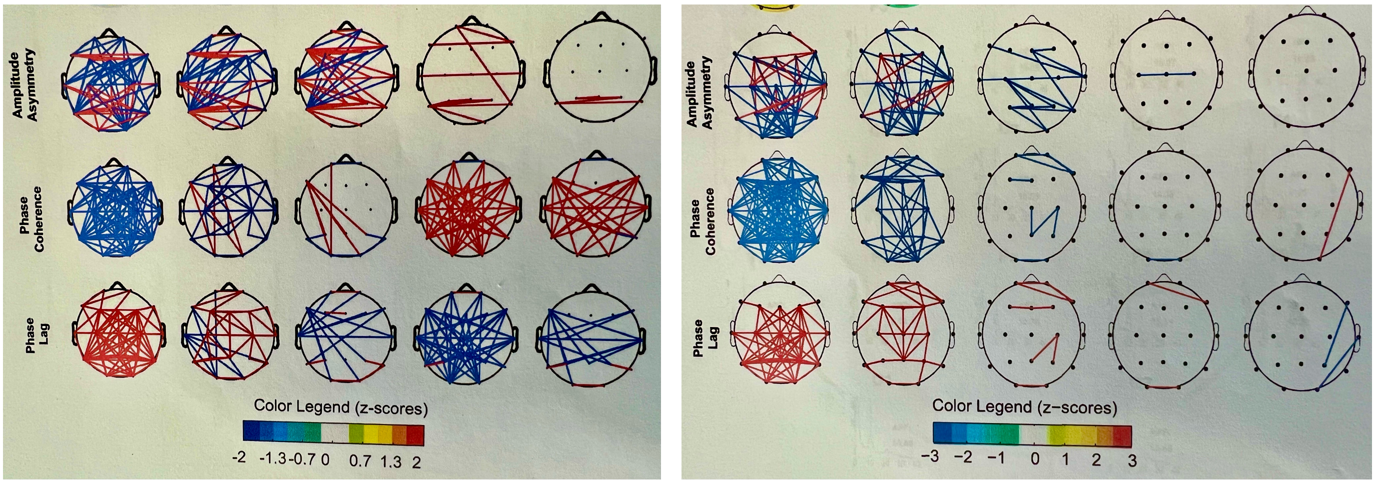
Percentile Ranking N>74	Jun 2019	Sept 2019	Dec 2019	Feb 2020
Response Inhibition	7	33	14	17
Deductive Reasoning	59	30	46	43
Planning	50	50	44	80
Verbal Reasoning	84	14	49	15
Verbal Short Term Reasoning	24	48	42	49
Working Memory	71	71	53	69
Episodic Memory	43	28	47	29
Spacial Short term Memory	34	64	59	61
Attention	57	19	39	27
Mental Rotation	8	11	52	37
Visuospatial Processing	29	65	40	27
Visuospactial Working Memory	4	21	32	59

Force plate analysis over 6 years has shown continuing improvement. Especially considering the ability to balance normally diminishes with age beyond 22 years old.



QEEG was performed 4 years apart and show improvement consistent with the other clinical results.

Z Scores N=-2 +2	Delta	Theta	Alpha	Beta	Gamma band
Year one	5.7	5.3	1.7	1.4	2.3
Year four	3.9	3.6	1.5	-1.0	1.7



These 'Mind Maps' (above) depicting Amplitude asymmetry (flags localised cortical power imbalances), Phase coherence (shows how stably two regions are functionally connected) and Phase lag (reveals the direction and speed of information transfer). The colour legend shows dark blue and red as 3 standard deviations beyond normal. Simply put, The less coloured lines the better. Early treatment is left with the 4 year follow-up on the right. A marked improvement.

Discussion

These two cases exemplify how even long after a stroke, a concerted, integrative rehabilitation effort can produce meaningful recovery. These achievements of regaining secure balance, faster reactions, and the ability to return to driving and employment, significantly enhanced their quality of life.

This case study and the described methodology highlight several key themes in long-term stroke rehabilitation. First and foremost is the importance of sensory-motor integration. Consistent with the literature, treating motor deficits in isolation is suboptimal; incorporating sensory retraining (vestibular, visual, proprioceptive feedback) accelerates and augments motor recovery(4). These two patients improvements in balance and coordination can be attributed to engaging their sensory systems (particularly the vestibular system through VOR exercises and multi-axis rotations) in tandem with motor exercises. This integrated approach likely facilitated more normal patterns of movement by restoring the brain's ability to sense body position and motion accurately and respond with appropriate motor output. It underscores the assertion that 're-establishing sensorimotor interactions' is essential for functional improvement post-stroke(3).

> Another theme is the harnessing of neuroplasticity in the chronic phase

Traditionally, many stroke patients are told that recovery plateaus after the first 6–12 months. However, as can be seen here, along with emerging research, this notion is challenged by demonstrating that significant gains are possible even years post-stroke. (2) The multi-axis vestibular stimulation provided a novel stimulus that these patients' brains had never encountered, likely activating latent neural circuits and promoting plastic reorganisation. The improvement in their QEEG metrics provides objective evidence of neuroplastic changes coinciding with clinical gains. This aligns with studies showing that interventions can shape brain oscillatory activity and network connectivity in stroke survivors, which correlates with functional improvements. (9)

It is worth noting that neuroplastic changes can be adaptive or maladaptive; our aim was to steer the plasticity in an adaptive direction by carefully calibrating the difficulty and novelty of exercises. These cases illustrate that through trial and error and close monitoring, appropriate stimulation can encourage plasticity without causing discouragement or adverse effects.

A role for the Chiropractic adjustment

The integration of spinal adjustments provided additional benefits that are harder to isolate but were nonetheless observed. While we must be cautious in attributing long-term outcomes to any single component, the contribution of Chiropractic adjustments in reducing joint restrictions and normalising afferent input likely created a more favourable environment for neural change. This is consistent with Holt et al's RCT findings where adding chiropractic adjustments improved motor scores in stroke patients at least in the short term. (9) One can theorise that manipulating the spine modulates proprioceptive signals to the cerebellum and sensorimotor cortex, thereby 'priming' the nervous system for other exercises.

Additionally, addressing biomechanical issues can reduce nociceptive inputs that might otherwise interfere with motor control. The role of the vestibular-ocular system in stroke recovery is another important discussion point. The vestibular exercises and advanced rotational therapy also likely contributed to gains in gait and balance. The meta-analysis cited earlier showed that vestibular therapy yields meaningful improvements in post-stroke gait and balance outcomes. (8) These cases reinforce this:

- by retraining the VOR and challenging the vestibular system, the patient became steadier and more confident.

The success with multi-axis rotation is particularly noteworthy. It suggests that providing the brain with rich, multi-directional vestibular input can stimulate neuroplastic responses in central vestibular pathways and their projections to other areas like the cortex and autonomic centres. This may translate into better integration of sensory information and improved spatial orientation. The anecdotal evidence from functional neurology clinics in the USA using such devices is positive, but rigorous controlled studies are still needed to quantify its efficacy. Our case adds to the clinical narrative supporting its use, at least for patients with pronounced balance and sensory integration deficits.

The monitoring of reaction time and cognitive engagement in our program proved beneficial as well. P1&P2's improved reaction times likely reflect faster information processing and motor planning. This manifested in real-life skills like driving, which require split-second decisions. Cognitive-motor training thus should be considered a staple in long-term rehab, not only for the cognitive gains but also because faster reaction time has been linked to better long-term stroke outcomes. (3) The approach described here demonstrates that integrating these cognitive drills need not detract from physical rehabilitation; in fact, it complements it by training the brain to handle complex dual-tasks. (22) It also adds an element of fun and challenge that can keep patients engaged during what is often a long and arduous recovery journey.

The use of QEEG and Ocula (autonomic monitoring) also merits discussion on how technology can augment clinical thinking. QEEG in these cases provided validation for what we observed clinically. It also can alert to issues like low arousal or excessive fatigue. For instance, if Ocula showed considerable increased dysfunction on a given day, we might deduce fatigue allowing for a more responsive treatment plan. perhaps scheduling shorter sessions. The Ocula app gave us a quantifiable handle on autonomic function, something that is otherwise gauged by more subjective measures or expensive lab equipment.

Monitoring autonomic responses ensured we did not push these patients into a state of sympathetic overdrive (which could impede learning or cause setbacks). Instead, we saw that as their fitness and neurological function improved, so did their autonomic stability, such as a smaller pupillary response latency indicating healthier reflex circuits. (12) From a broad perspective, this aligns with the understanding that the autonomic nervous system plays a crucial role in rehabilitation: a calmer, well-regulated nervous system can better engage in neuroplastic change, whereas a stressed system is more prone to maladaptive plasticity or burnout. Thus, tools like Ocula can be invaluable for tailoring therapy intensity and for providing biofeedback to patients about their own relaxation and arousal states.

Clinical Reflections

As a practitioner with four decades of experience, the author notes that the fusion of time-honoured hands-on techniques with cutting-edge technology represents the evolution of neurological rehabilitation. Early in the author's career, such detailed tracking of brain waves or pupil dynamics was not feasible in a Chiropractic setting. Now, accessible technologies empower clinicians to implement evidence-informed, objective-driven therapies.

However, technology is only as good as its integration into patient-centred care. The success outlined here was not due to a single device or exercise, but rather the careful layering of multiple interventions at a pace that could be handled, with continuous feedback and encouragement. This highlights the concept of multidimensional problems require multidimensional solutions.

A chronic stroke affects motor ability, sensory processing, cognition, mood, and autonomic function, therefore, addressing only one domain will yield incomplete results. By contrast, our comprehensive approach aimed to leave no stone unturned: every session engaged

- the balance system
- the visual system
- cognition, and even
- the subconscious autonomic responses.

In solo practice, a practitioner may need to wear multiple hats to truly embody integrative care.

It is also important to consider limitations and the need for further research. This is only a double case study, larger studies are needed to validate each component's contribution. While QEEG and pupillometry guided our care, more research is needed to establish specific biomarkers that predict which patients will benefit most from certain interventions. (9) These cases do however, support the safety of this approach: no adverse events occurred, and both patient's function only improved.

An ethical consideration is resource availability, not all patients have access to advanced equipment like the Orbital or even QEEG. Thus, a takeaway is that the principles demonstrated as multi-sensory engagement, individualised progression and objective monitoring, can still be applied in lower-tech settings. For example, if multi-axis chairs are unavailable, therapists can use physical activities or rotational exercises manually; if QEEG is not an option, a careful clinical 'neuro' exam can suffice; if Ocula is not on hand, tracking heart rate variability could be an alternative measure of autonomic function.

Conclusion

Long-term recovery from cerebral stroke, especially in cases involving both hemispheres or complex sensorimotor deficits, is challenging but attainable through a multidimensional rehabilitation strategy. This paper presented a framework that synthesises sensory-motor integration techniques, Chiropractic manual interventions, vestibular and VOR training, cognitive and reaction time exercises, and cutting-edge monitoring tools like QEEG and pupillometry. These case studies demonstrate that even years after a stroke, targeted therapy can yield significant improvements in balance, motor control, reaction speed, and overall neurological function, translating to meaningful gains in daily life independence.

The success of this approach lies in its integrative nature, addressing the whole nervous system rather than isolated impairments. Sensory systems (visual, vestibular, somatosensory) are retrained alongside motor systems to rebuild the brain's internal maps and feedback loops.

> Chiropractic adjustments and manual therapies are employed not as stand-alone cures, but as catalysts within a broader neurorehabilitative context, potentially enhancing afferent input and neuroplastic readiness.

Quantitative tools like QEEG and the Ocula app provide objective guidance and evidence of physiological change, anchoring the clinical thinking as data. Meanwhile, patient engagement is maintained through varied, stimulating activities that challenge the brain and body in tandem, embodying the principle of '*use it or lose it'* across multiple domains.

This two case study underscores the value of expanding one's therapeutic repertoire and suggests long-term stroke recovery should not be approached with resignation to plateaus. With a rigorous, sensory-rich, and personalised program, guided by both clinical expertise and technological feedback, patients can continue to make strides in their recovery years after their stroke.

The journey requires patience and creativity, but as shown, the integration of multidimensional techniques offers a promising pathway to maximising neurological recovery and improving quality of life for stroke survivors in the chronic stage.

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Note:

Written informed consent from both patients for publication of these case reports and any accompanying images is held by the author.

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