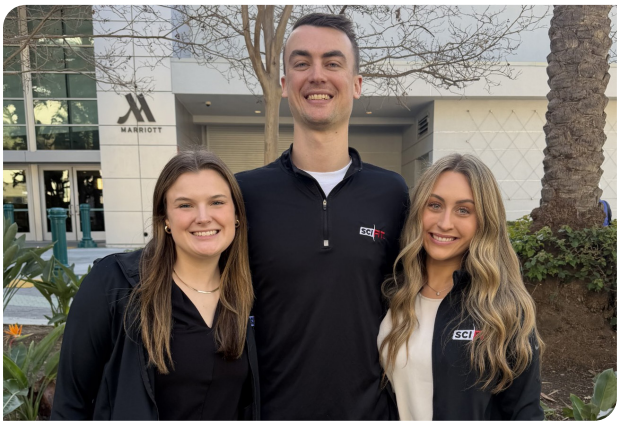
CLINICAL EXPERIENCE REPORT:

Integrating ARC^{EX} Therapy in the rehabilitation program of an individual with chronic cervical incomplete spinal cord injury



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Summary:

The patient is a 43-year-old female with a C3-C4 spinal cord injury consistent with central cord syndrome, characterized by a pronounced hypertonicity in all four extremities, significantly limiting her functional independence.

Prior to utilizing ARC^{EX} in her rehabilitation program, she was unable to perform a hand to mouth movement and relied exclusively on her head array and chin drive systems for power wheelchair mobility.

Following ARC^{EX} Therapy delivered 2 times a week for 20 weeks the patient now demonstrates meaningful improvements in hand and upper extremity motor control, allowing her to consistently operate her wheelchair's hand controls both at home and in community environments. Although forearm pronation and supination remain challenging during feeding tasks, she is now able to reliably bring her hand to her mouth during meals, reducing the level of assistance required and enhancing her overall independence.

Initial Presentation:

Demographics & Injury Profile

- *43-year-old female*
- *Neurological level of injury: C3–C4*
- *AIS classification: AIS C*
- *Time since injury: 3 years*

Overall Clinical Impression

The patient's presentation is consistent with expected impairments following a C3–C4 AIS C central cord syndrome, characterized by greater upper extremity involvement compared to lower extremity function, pervasive spasticity, reduced selective control, and compromised dynamic sitting balance. These impairments significantly restrict independence across mobility, ADLs, and participation in daily routines.

Functional Status & Assistance Needs

- *Requires total assistance for all Activities of Daily Living (ADLs) and is fully reliant on caregivers for self-care, mobility-related tasks, and environmental interactions.*
- ***Power wheelchair mobility:*** *Utilizes a chin-drive interface for independent propulsion due to severely limited up per-extremity motor control.*
- ***Feeding and drinking:*** *Unable to assist with self-feeding because of impaired fine and gross motor control and significant tone in the upper extremities.*
- ***Transfers:*** *Performs stand pivot transfers with approximately 50% assistance from a therapist or caregiver.*
- ***Bed mobility:*** *Requires 75–100% assistance for rolling, repositioning, and transitions between supine, sidelying, and sitting.*

Motor Performance & Tone

- *Manual Muscle Testing (MMT):*
    - *Biceps flexion: 3/5*
    - *Shoulder adduction: 3/5*
    - *All other tested upper-extremity muscle groups: 1/5, with movement significantly restricted secondary to hypertonicity.*
- *Presents marked spasticity in all four extremities, most pronounced in the upper extremities, consistent with a central cord syndrome pattern.*
- *Upper extremities display increased extension tone (3/5). Resting position (in wheelchair) is shoulder internal rotation, elbow extension, and finger flexion.*
- *Demonstrates limited isolated motor control, with strong co-contraction patterns and difficulty achieving selective motor activation.*
- *Exhibits impaired interlimb coordination, further limiting functional task performance.*

Sensation

- *Sensation is intact on her medial wrist, medial elbow and shoulder. Full sensation through mid-thoracic (T5 level).*
- *She is only able to perceive deep pressure on bilateral lower extremities.*

Balance & Postural Control

- *Modified Functional Reach Test:*

  (measured at acromion)
    - *Lateral reach: 0 inches*
    - *Anterior reach: 3 inches*

Trunk demonstrates global rigidity, providing some passive stability during static sitting. However, this rigidity reduces the ability to perform dynamic postural adjustments, with limited trunk dissociation and delayed or absent righting reactions. This results in decreased capacity for postural self correction during functional sitting tasks.

Goals:

Improvements in hand and upper extremity control directly support lower extremity function. Enhanced upper extremity strength, sensation and motor control contribute meaningfully to tasks such as walker management during supported ambulation and greater postural stability during standing and sit to stand transitions, particularly when relying on upper extremity support on a bar or assistive device.

Together with the patient, we established the following overall rehabilitation short- and long-term goals.

Short-term Goals:

1	*Patient will complete bilateral upper extremity flexion to shoulder height to display reduced upper extremity spasticity for increased independence in ADLs.*
2	*Patient will demonstrate improved hand and arm active range of motion for self-correction, evident by ability to maintain standing balance for 30 seconds with improved stability and righting reactions.*
3	*Patient will demonstrate improved hand and arm active range of motion for self-correction, enabling completion of 10 sit-to-stand transfers with contact guard assistance and no loss of balance.*

Long-term Goals:

1	*Patient will open left hand to grasp a small ball with 50% assistance to demonstrate improved ability to maneuver wheelchair with hand controls.*
2	*Patient will walk 30 feet with a platform walker with only 25% assistance from one person to propel device.*
3	*Patient will be able to correct balance after moderate perturbations in standing to demonstrate improved stability.*

Treatment:

ARC^{EX} Therapy was one component of the patient's broader rehabilitation plan of care, used as a targeted intervention to address upper extremity (hand) motor control, neuromuscular activation, and functional task performance. It was delivered alongside other therapeutic sessions. She currently attends our facility 2 times a week for 60 minutes. All sessions are 1:1 with a therapist to ensure individualized cueing, optimal parameter setting, and progressive therapeutic dosing.

Outside of these sessions, the patient is not enrolled in any additional formal outpatient therapies, but she maintains a structured home and caregiver supported program, including:

- *Daily standing program with caregiver assistance*
- *Floor based mobility exercises, including quadruped and tall kneeling activities*
- *Gait practice at home, performed approximately twice weekly with two-person assist*

ARC^{EX} Parameters Used:

Active electrodes are placed at C3 and C7 and the return electrodes on ASIS.

We used ARC^{EX} with a biphasic waveform, 1 ms pulse width, 30Hz frequency, and 10kHz Carrier Frequency at amplitudes between 90-110 mA for most upper extremity tasks. For some more gross motor response of upper extremities, we tried changing the waveform to Monophasic while lowering the amplitude to approximately 30-35 mA.

We primarily monitored patient reported response/sensation and palpated to ensure there was no contraction under the electrodes. As the session progressed, we typically began the session with a 25 second ramp time up to approx. 85 mA. From there we increase it slowly during the first intervention (max 5 minutes in increments of 3 mA) to the target 90-110 mA. This is the range for this client that we have found most successful; she reports a notable improvement in movement fluidity, and less assistance is required from the therapist to achieve desired tasks. Below that threshold, the patient reports feeling minimal changes and over that threshold the therapist notices contraction of the cervical musculature.

For decreased tone, we increased the frequency to approximately 100Hz (with biphasic waveform, 1ms pulse width, 10 kHz Carrier Frequency, and about 75-80 mA amplitude).

With the parameters focusing on tone management, we notice the most response distally in the hands. At these settings, the patient displays increased passive range of motion through all 5 digits and is able to achieve a flat hand position much easier. Typically, the patient will also display co-contraction through her hands with difficulty tasks; with the above parameters to decrease tone it seems to mitigate this as well leading to improved tolerance to strenuous tasks.

The patient tolerated all the parameters and settings well.

Skin condition in the sites of electrode placement was closely monitored before and after each stimulation session.

Therapeutic Interventions:

Interventions were individualized for each session based on the patient's motor control goals, functional priorities, and response to ARC^{EX}. Treatment emphasized upper extremity (hand) activation, selective motor control, and functional task practice, with postural demands adjusted to optimize engagement and carryover.

1. Fine Motor and Upper Extremity Task Training with ARC^{EX} in Unsupported Sitting

ARC^{EX} Therapy sessions incorporated high challenge, Upper Extremity focused tasks performed in unsupported or minimally supported sitting to increase proximal stability demands and promote distal motor control. Typical activities included seated edge of mat practice, with and without external trunk support, emphasizing:

- *Simulated feeding tasks (e.g., stabbing with a fork, scooping with a spoon), targeting graded grasp, wrist positioning, and functional reach*
- *Hand-to-mouth training with therapist guided movement dissociation*

- *Facilitated forearm supination and pronation to improve hand-to-mouth capability and utensil manipulation*

2. Active Assisted Gross Upper Extremity Movement Training in Standing

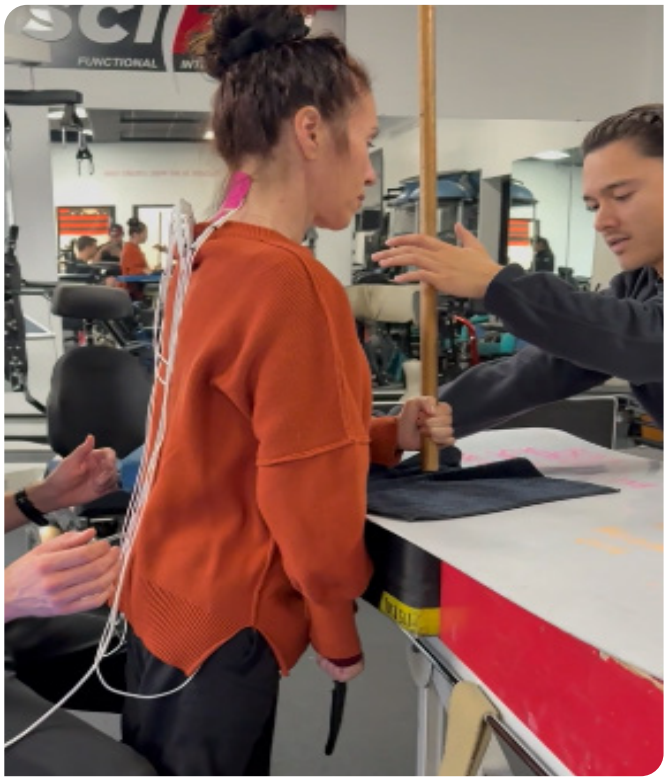
To promote proximal strengthening and enhance functional reaching, active assisted exercises were incorporated during supported standing tasks:

- *Pulley assisted shoulder activation (flexion, abduction, and external rotation) trained in both even stance and staggered stance to challenge stability while facilitating controlled upper extremity movement*
- *Table slides in standing targeting shoulder flexion and abduction with guided movement to reduce compensatory shoulder and trunk patterns*
- *Modified plantigrade pushups, progressing toward improved weightbearing tolerance, scapular stability, and triceps activation*
- *Reaching tasks within and beyond the base of support, performed in even and staggered stances to develop anticipatory postural control and functional goal-directed movement*

3. Developmental Position Training for Proximal Stability and Upper Extremity Activation

Developmental positions were integrated to optimize load through the upper extremities, increase proprioceptive input, and facilitate improved motor recruitment:

- *Quadruped activities, including triceps pushups and sustained static holds for proximal shoulder and elbow activation, trunk stabilization, and controlled weight shifting*
- *Tall kneeling exercises, featuring lateral pull downs, facilitated rows, and reaching beyond the base of support to reinforce upright postural control while training Upper Extremity pull patterns*
- *Half kneeling tasks, such as resisted open chain biceps activation and triceps facilitation with manual cueing, to enhance unilateral Upper Extremity strength and selective motor control during asymmetric postural demands*



Outcomes:

Distal improvements in hand function appeared approximately 4 weeks into our plan of care. Continued proximal improvement was noted for 10-20 weeks and is continuing to see progression during our sessions.

Alongside other improvements observed during the plan of care, the following outcomes have been achieved since initial evaluation.

	INITIAL PRESENTATION	FINAL EVALUATION
Opening left hand	*Minimal extension initiation of all fingers without assistance*	*Able to open her left hand to grasp a small ball with 50% assistance*
Independence in feeding/ drinking	*Unable to assist in feeding/drinking*	*Able to bring left hand to mouth 3/4 times displaying improved feeding and reduced extensor tone*
Wheelchair maneuvering	*Uses head array and chin drive to maneuver power wheelchair*	*Improved consistency in distal Upper Extremity (hand) function. Able to maneuver power wheelchair with hand control for one lap around gym with no assistance or cues*

Additionally, the patient reports overall increased movement with left arm at home. She reports using her hand control for everything but navigating her car ramp. She also is able to feed herself more fluidly. She reports being able to cross midline more which helps her hug her kids better and tighter.

Conclusion:

The goals reached marked important improvements in the patient's functional independence, particularly in Activities of Daily Living (ADLs) such as feeding and community mobility.

Since initiating treatment at SCI-FIT with the integration of ARC^{EX} therapy, the patient has demonstrated substantial improvements in upper-extremity motor control, which have translated directly into enhanced autonomy and participation in daily life.

She is now able to independently operate the hand control on her power wheelchair both at home and in her community, an ability she did not possess prior to this intervention. This new skill has enabled her to navigate aisles in a store, ascend ramps and adjust her path in crowded environments, reducing her reliance on the chin-drive system and significantly increasing her environmental access.

One of the most notable milestones was her ability to bring her hand to her mouth for the first time since injury, greatly improving her independence and confidence in self-feeding. While she continues to require assistance for certain components, such as food preparation and occasional stabilization when applying downward force to stab food, she can now consistently complete the hand-to-mouth motion, representing a major advancement in her functional repertoire.

Improved hand and upper-extremity control has also enhanced her participation in supported walking at home. She now requires only one assistant for stepping and balance because she can reliably advance the walker using her hands. Her increased ability to manage the walker has expanded her opportunities for upright mobility and task specific gait practice.

Testimonial:

> *Overall, my body cooperates more with the movement I am trying to do.*

Integration of ARC^{EX} Within Our Center:

At our facility we see about 60 clients a day, about a third is seen by our physical therapy staff. Throughout the whole day, 6 to 8 clients use ARC^{EX}. We have used it consistently with more than 20 individuals. For scheduling purposes, we use a separate color identifier on our schedule to show what client is using ARC^{EX}.

We typically complete a 10-session trial to see if there are any changes or improvements before deciding to continue utilizing it during our sessions.

Overall, the staff has incorporated it well into our programming. It is very easy to set up and does not add much additional configuration once the device is on.

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About Us:

Spinal Cord Injury Functional Integrated Therapy (SCI-FIT) is an activity based center consisting of 5 different locations in California and 1 in Arizona. All of our locations see clients with paralysis consisting of but not limited to Spinal Cord Injury, Traumatic Brain Injury, Cerebral Palsy, and Multiple Sclerosis. Our Dublin location offers a unique hybrid option of insurance based physical therapy and cash pay personal training to maximize plan of care duration and improve overall outcomes.

SPINAL CORD INJURY SCI FIT FUNCTIONAL INTEGRATED THERAPY™

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