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SCRAMBLER THERAPY FOR THE TREATMENT OF CHRONIC NEUROPATHIC PAIN IN ATYPICAL PARKINSONIAN DISORDERS: A CASE SERIES

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Background: Chronic pain is a common and distressing symptom associated with atypical parkinsonian disorders (APD); however, current pain treatment methods are often unsatisfactory. Scrambler therapy (ST), a noninvasive method of cutaneous electroanalgesia, can be an effective modality in treating chronic neuropathic pain in APD.

Case Report: We reviewed 7 consecutive patients with APD (2 with multiple system atrophy, 5 with corticobasal syndrome) who received ST to treat severe, refractory neuropathic pain. After ST treatment, reported pain scores were significantly reduced in all 7 patients, often to 0/10. Pain relief was immediate and lasted from weeks to months, and in 2 cases, up to 2 years. No adverse effects related to ST were reported.

Conclusions: ST appears to be highly effective in providing immediate and sustained pain relief and thus may represent a novel, noninvasive pain treatment modality in APD. Future prospective studies are warranted to further assess its efficacy.

Key words: Atypical parkinsonian disorders, scrambler therapy, chronic pain, central pain, quality of life, case series

BACKGROUND

Atypical parkinsonian disorders (APD) are a group of neurodegenerative diseases that affect the central nervous system and include multiple system atrophy (MSA), progressive supranuclear palsy (PSP), corticobasal syndrome (CBS), and dementia with Lewy bodies (DLB). These disorders present with parkinsonism (bradykinesia, rigidity, resting tremor, postural instability) along with other features, such as autonomic dysfunction or cerebellar symptoms in MSA (1); asymmetric dystonia, myoclonus, apraxia, alien limb phenomenon, and cortical sensory loss in CBS (2); vertical gaze palsy and early postural instability in PSP (3); and early-onset fluctuating cognition, visual hallucinations, and rapid eye movement sleep behavior disorder in DLB (4).

Centrally mediated pain is one of the most common nonmotor symptoms in APD. It is present in over two-thirds of APD patients and highest in MSA compared to CBS and PSP (5-8). Pain is a distressing and debilitating symptom that increases in severity with disease progression and significantly impairs quality of life (6,9). While the mechanism of central pain in APD is not fully understood, studies (10) suggest that neurodegeneration of structures involved in descending pain modulatory pathways, such as dopaminergic pathways in the basal ganglia, may contribute.

Chronic pain is often underrecognized and undertreated in patients with APD (5). There is currently

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no gold standard for pain management in APD, but commonly used medications include nonsteroidal anti-inflammatory drugs (NSAIDs), acetaminophen, opioids, antidepressants, antiepileptics, muscle relaxants, and botulinum toxin injections (11). However, use of these pharmacologic agents is often unsatisfactory due to limited therapeutic benefit or intolerance of adverse effects. Deep brain stimulation and spinal cord stimulation have shown effective pain control in Parkinson's disease (12,13), but these are costly and invasive interventions that lack evidence of benefit in APD. Thus, there is a need for more effective and noninvasive pain treatment modalities for patients with APD.

Scrambler therapy (ST) is a noninvasive method of cutaneous electroanalgesia that was approved by the US Food and Drug Administration in 2009 for the treatment of acute, chronic, and postoperative pain (14). Through electrodes placed on the skin near sites of pain, ST applies electrical stimulation to peripheral nerve C fibers. The goal of this neuromodulatory therapy is to replace endogenous "pain" information with synthetic "non-pain" information. Through this process, ST is theorized to modulate maladaptive pain pathways and reduce central sensitization (14-17). ST has been used to effectively treat refractory neuropathic pain, including chemotherapy-induced peripheral neuropathy (18) and central pain associated with central poststroke pain syndrome (19,20), transverse myelitis (21), and neuromyelitis optica spectrum disorder (22). In addition, ST has a highly favorable safety profile with minimal adverse effects (23).

The use of ST for pain management in APD has begun to be studied only recently. We previously reported results of ST treatment in one patient with MSA (24) and 3 patients with CBS (25), all of whom experienced complete and long-lasting pain relief. Here, we review our experience with ST treatment in 7 consecutive APD patients (2 with MSA and 5 with CBS) to further evaluate its effectiveness.

METHODS

Study Patients

A total of 7 patients with a clinical diagnosis of APD and associated chronic neuropathic pain were referred from the movement disorders clinic for ST treatment at our medical center between April 2021 and December 2023 (Table).

ST Administration

ST was administered with the Calmare® MC5-A ST device (Competitive Technologies, Inc., Fairfield, CT). Each treatment session was conducted in the clinic by an experienced provider. Pairs of electrodes were placed on the skin above and below the site of pain, along the affected dermatome. If the pain extended to the end/tip of the extremity, the set of electrodes was placed above the site of pain on the affected dermatome. Up to 5 pairs of electrodes could be used. Figure 1shows the placement of electrodes in a patient receiving ST. Once the device was activated, the stimulation intensity was increased until a maximal tolerable threshold was reached. Pain level was assessed and, if necessary, the stimulation intensity and electrode placement were adjusted to achieve the desired analgesic effect. Each treatment session lasted 35-40 minutes. The number of ST sessions was tailored to each patient depending on the duration of response to treatment and return of pain symptoms requiring retreatment.

Pain Assessment

Patients were asked to rate their pain level on the 11-point Numeric Rating Scale (NRS-11, 0-10) at baseline and before and after each ST session. Of note, some patients were not experiencing pain at the time of ST treatment due to their pain being intermittent or worse at night.

Data Collection

The data used for this study had already been documented in the patients' medical records as part of their clinical care during ST treatment. We performed a retrospective chart review and collected data regarding demographics (age, gender, race/ethnicity), diagnosis, pain characteristics, ST treatment timeline, pain scores, duration of pain relief, and adverse events (Table).

Ethical Considerations

This study was approved by the Institutional Review Board of Johns Hopkins (IRB#: 00422287). The IRB waived the need to obtain consent for the collection and analysis of retrospectively obtained and anonymized data for this noninterventional study.

RESULTS

A total of 7 patients with a clinical diagnosis of APD received ST treatment for chronic neuropathic pain. Of the 7 APD patients, 2 had probable MSA and 5 had

Table 1. Results of ST treatment in 7 APD patients.

Patient #	Diagnosis	Pain Location/ Character	ST Treatment Timeline	Pain NRS-11 Pre (0-10)	Pain NRS-11 Post (0-10)	Duration of Pain Relief
1 63 yo man	MSA-P	Electric shock-like pain and muscle spasms from bilateral shoulders down to hands and from low back down to feet. Intermittent, worse at night. Required hourly massage at night from hired caretaker.	Five sessions over 3 wk, then retreated at local ST center after 6 wk.	Average 5, worst 10.	0.	One week of pain relief after initial few sessions, then 6 wk of complete pain relief after retreatment. Referred to another provider in nearby state and again obtained pain relief until death.
2 74 yo woman	CBS	Cramping pain from right side of neck down to hand with electric shock-like pain in right hand. Intermittent, worse at night.	Three monthly sessions, then 3 sessions 1 mo later, then 2 sessions 1 mo later.	Average 3-4, worst 8.	0-1.	One to two weeks of pain relief after each set of sessions. Since last session, over 2 y pain-free until death.
3 75 yo woman	CBS/PSP	Intermittent neuropathic pain in neck, right shoulder/arm, and left arm. Numbness and dystonia in right foot.	Three sessions over 3 d, then 3 sessions 1 y later.	Average 5, worst 10.	0.	One year of pain relief after initial set of sessions. After repeat sessions, pain relief lasted 7 mo up until death.
4 70 yo man	CBS	Intermittent neuropathic pain in neck, bilateral arms, and right hip. Numbness in right leg.	Three sessions over 3 d, then 3 sessions 6 mo later, then 4 monthly sessions 1.5 y later.	Average 6-8, worst 10.	0-2.	Six months of pain relief after initial set of sessions, then 10 mo of pain relief after retreatment, and 3 mo of pain relief after most recent session.
5 75 yo man	CBS	Pain in thoracic and lumbar spine shooting down legs.	Four sessions over 2 wk.	2 at rest, 10 with movement.	0 at rest, 0.5 with movement.	Pain-free for > 2 y and ongoing. Two years after treatment stopped all their medications for CBS and their symptoms improved. Still pain free. Final diagnosis unclear.
6 69 yo woman	CBS/PSP	Electric shock-like pain from right shoulder down to hand.	Four sessions over 2 wk, then 2 sessions 1 mo later.	Average 7, worst 9.	0 in arm/ hand, 3 in thumb.	Pain relief for 1 y until death.
7 55 yo man	MSA-C Syn-One positive	Stabbing pain in bilateral arms and legs. Vibration in lower legs.	Ten sessions over 1 mo, then 1 session 1 mo later, then 4 sessions 3 mo later.	Average 4, worst 10.	0-2.	Pain relief ongoing at 2 y with maximum recorded pain at 4/10.

Abbreviations: MSA-P: Multiple system atrophy, parkinsonian type; MSA-C: Multiple system atrophy, cerebellar; CBS: Corticobasal syndrome; PSP: Progressive supranuclear palsy; Syn-One: A specific and sensitive test for synucleinopathies; ST: Scrambler therapy; NRS-11: Numeric Rating scale (0-10) for pain intensity, 0 = no pain and 10 = worst pain; Pain NRS-11 pre: Reported NRS-11 pain score at baseline prior to ST treatment; Pain NRS-11 post: Reported NRS-11 pain score after all ST treatments were completed; yo: year old; d: day; wk: week; mo: month; y: year.

probable CBS; 2 patients with CBS had definite PSP on autopsy (PSP pathology is a frequent etiology of CBS, which is a clinical syndrome with heterogeneous pathological underpinnings). Their pain was typically neuropathic in nature, described as "electric shock-like" or "stabbing." For some CBS patients with limb dystonia, dystonic pain from muscle spasms further exacerbated their overall pain. All patients had tried multiple pharmacologic agents to alleviate their pain with varying degrees of success, most commonly NSAIDs, acetaminophen, gabapentinoids, benzodiazepines, muscle relaxants, opioids, and botulinum toxin injections. One patient had trialed a spinal cord stimulator that was then removed one year later due to inadequate

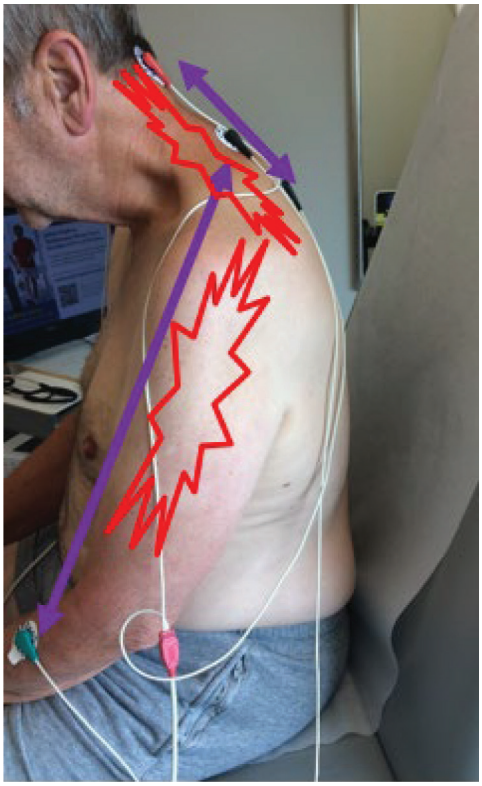

Fig. 1. Example of ST electrode placement near the patient's site of pain along the C6 dermatome.

pain relief. Severe, uncontrolled pain led to significant impairments in quality of life, such as disrupted sleep, limited mobility and function, and depressed mood.

The results of ST treatment are shown in the Table. After receiving ST, all patients experienced a significant reduction in pain levels from their baseline, with post-treatment pain scores often reduced to 0/10 on the 11-point NRS-11. Figure 2 shows the pre- and post-ST treatment pain scores in Patient 3 as an example. Graphs for all other patients are shown in Supplementary Figs. S1-S6. All patients experienced immediate pain relief with a duration ranging from weeks to months. Notably, Patient 3 experienced complete pain relief for up to one year until death, Patient 2 had over 2 years pain-free until death, and Patient 7 has had over 2 years and ongoing of pain relief. Following retreatment with ST after pain eventually returned, all patients had resumption of pain relief, and some patients benefited from increased duration of pain relief. Due to pain relief, some patients experienced improved quality of sleep, increased mobility and function of limbs, and improved ability to walk. Patient 4 experienced resolution of their previously severe alien limb phenomenon. Patient 5 was able to discontinue all prior pain medications. No adverse effects from ST treatment were observed or reported.

DISCUSSION

In this study, we reviewed a series of 7 consecutive APD patients who received ST to treat chronic neuropathic pain. Notably, pain scores for all patients were significantly reduced from baseline following ST treatment. All patients experienced immediate and sustained relief of their severe, refractory pain that significantly impaired quality of life. There were no adverse effects related to ST administration. Thus, ST may play a novel role in more effective chronic pain management in APD moving forward, thereby addressing this important unmet need.

These findings lend further support to prior case reports (24,25) that used ST to effectively treat MSA and CBS pain. Consistent with these case reports, our findings demonstrate complete or near-complete pain relief with ST in all our APD patients. In addition, due to our study's longer follow-up period, we were able to observe analgesic effects lasting for several months or more in 5 of 7 patients, with the longest durations being one and two years. Taken together, our study adds to the growing body of literature demonstrating the effectiveness of ST in APD as well as other centrally mediated pain syndromes (19-22).

ST treats neuropathic pain by stimulating peripheral nerve C fibers and replacing endogenous "pain" information with synthetic "non-pain" information, with each set of electrodes acting as an artificial nerve. The electrical stimulus on the skin can activate particular sodium-calcium channels to produce action potentials and sensations perceived not as pain but something else; patients state it feels like they are being bitten by tiny electrical ants. The long-term effect of ST is thought to involve modulation of maladaptive pain processing pathways, thereby reducing central sensitization and alleviating pain (14-17). In a recent study (26) using ST to treat chronic pain in burn patients, ST appeared to modulate central sensitization by reducing cerebral blood flow to frontal areas involved in pain processing and redistributing normal blood flow to the frontal inhibitory regions. One study (27) showed good control of chronic low back pain with ST compared to sham treatment and improved pain tolerance on quantitative

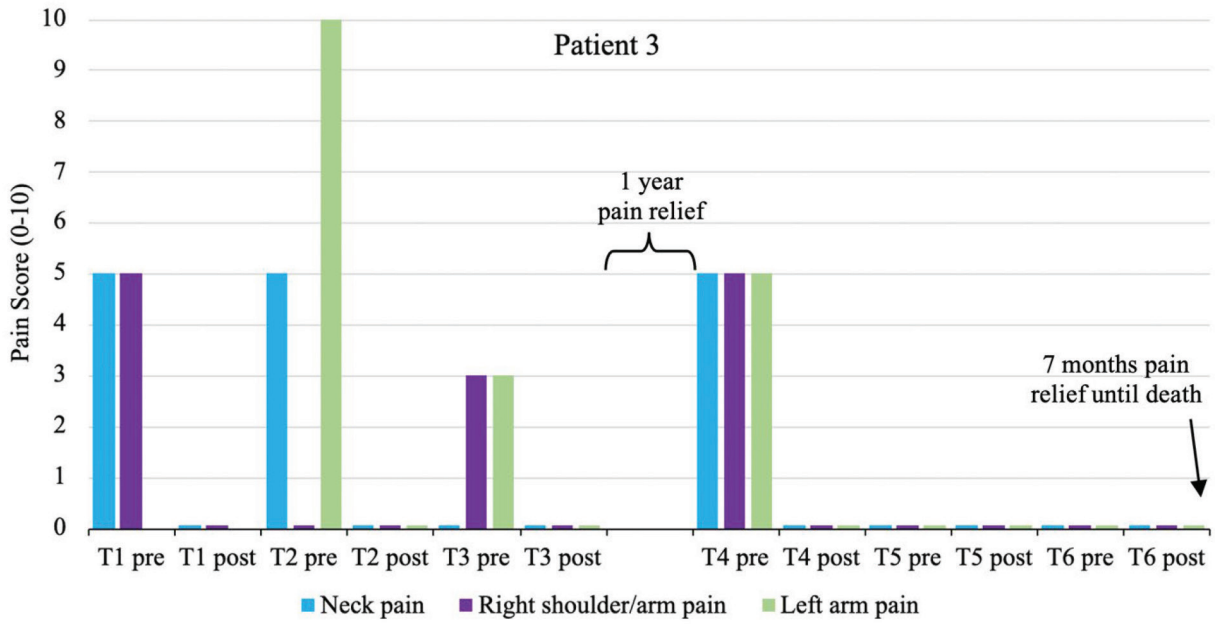

Fig. 2. Pain scores (on the 0-10 numeric rating scale) prior to (pre) and after (post) each scrambler therapy session for Patient 3. Pain locations included neck (blue), right shoulder/arm (purple), and left arm (green). Treatments T1-T3 (over three consecutive days) reduced pain scores to 0/10. Of note, left arm pain was not assessed until Treatment 2. After 1 year of pain relief, pain returned and treatments T4-T6 were given (over three consecutive days) resulting in 7 additional months of pain relief until death.

neurosensory testing. Notably, they found differential serum RNA expression of 10 genes associated with pain, such as nerve growth factor and glial-derived nerve factors, suggesting resetting of the neuroinflammatory system (27). Another study (28) found that differential responses to ST depend on neuropathic pain phenotypes, with more favorable treatment outcomes in patients with paroxysmal rather than persistent pain. Interestingly, this finding was reflected in our study in which a majority of our patients had paroxysmal pain, suggesting that ST may be particularly effective in treating this phenotype of neuropathic pain.

All patients in our study had tried various pharmacologic agents with unsatisfactory results due to inadequate pain control or intolerable adverse effects. Our observation that all these patients had an immediate response (within 30 minutes) to ST with significant and durable pain relief suggests that ST may be a particularly useful approach to treating severe, drug-refractory neuropathic pain (29). ST may be especially favored in situations where nonpharmacologic and noninvasive pain treatment methods are preferred to avoid adding to the already high symptom burden in APD. Overall, ST is noninvasive, provides immediate and long-lasting pain relief, has minimal adverse effects (23), can reduce pain medication usage, and thus is a highly favorable pain treatment modality.

There were several limitations to this study. First, the generalizability of the results is limited by the small sample size due to the relative rarity of APD. Second, because there was no control group we cannot exclude potential contribution from a placebo effect. However, the degree and duration of pain relief experienced by these patients would be highly unlikely to be attributed to the placebo effect alone, given that all of these patients were suffering from severe, debilitating pain refractory to multiple medications for several years prior to ST treatment.

ST has clear potential to reduce pain and improve quality of life for patients with APD. These initial findings warrant further investigation through future prospective, controlled trials with larger sample sizes. In addition, more research is needed to further elucidate the pathophysiology of pain in APD and among the different APD subtypes, the mechanism by which ST modulates central pain processing, and the factors underlying differential treatment responses to ST.

CONCLUSIONS

Chronic pain is a common and underrecognized nonmotor symptom in APD for which few effective treatments exist. The findings of this study demonstrate that ST can provide near-immediate, complete, and long-lasting pain relief for APD patients. ST may represent a novel and highly effective noninvasive approach to chronic pain management in APD. Future prospective studies are warranted to further evaluate its efficacy.

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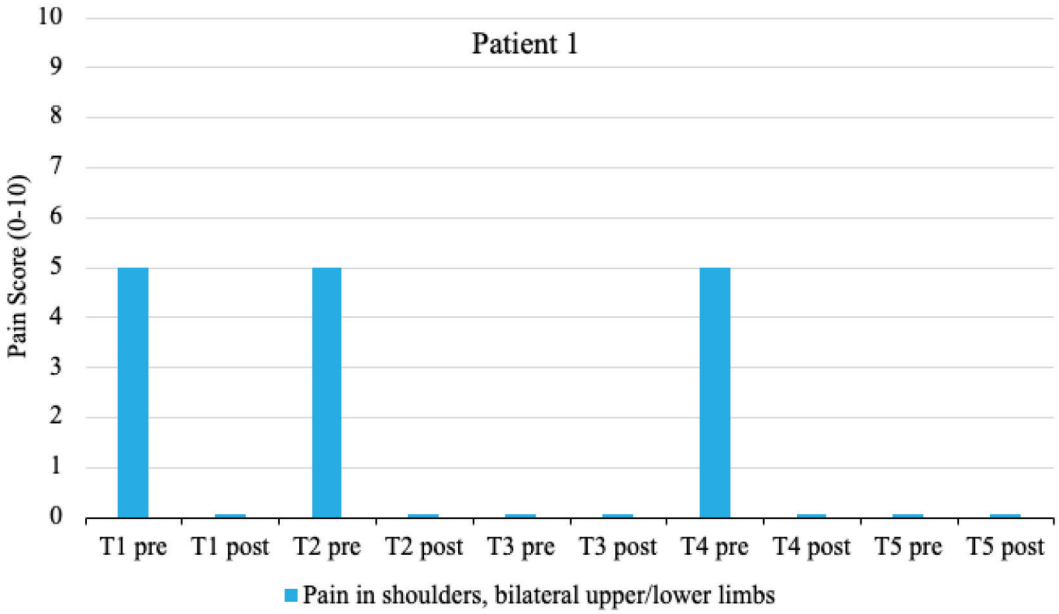
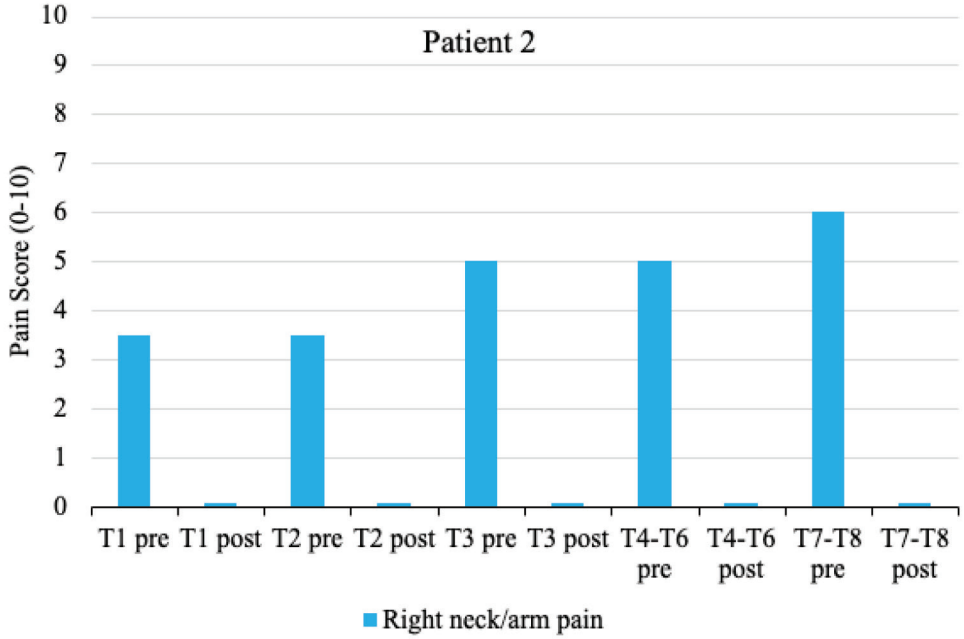
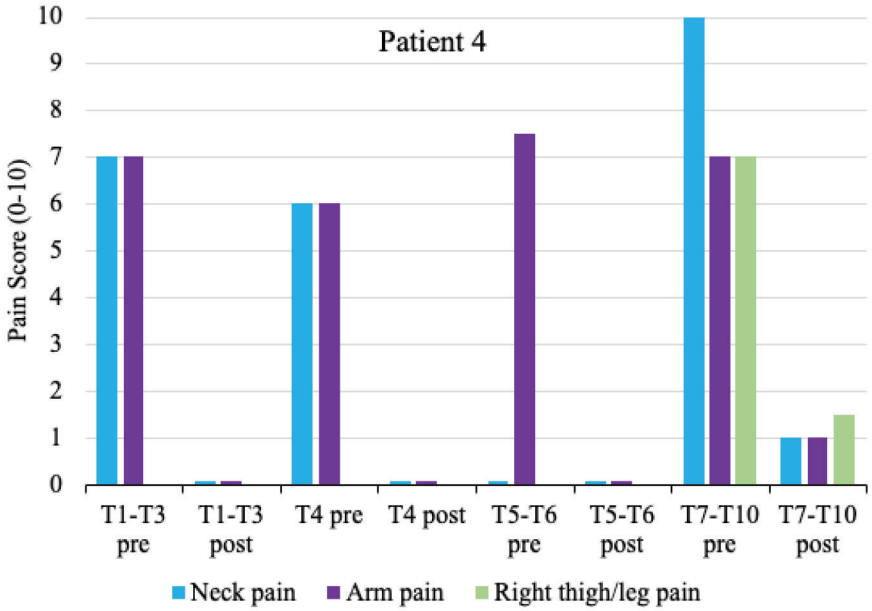


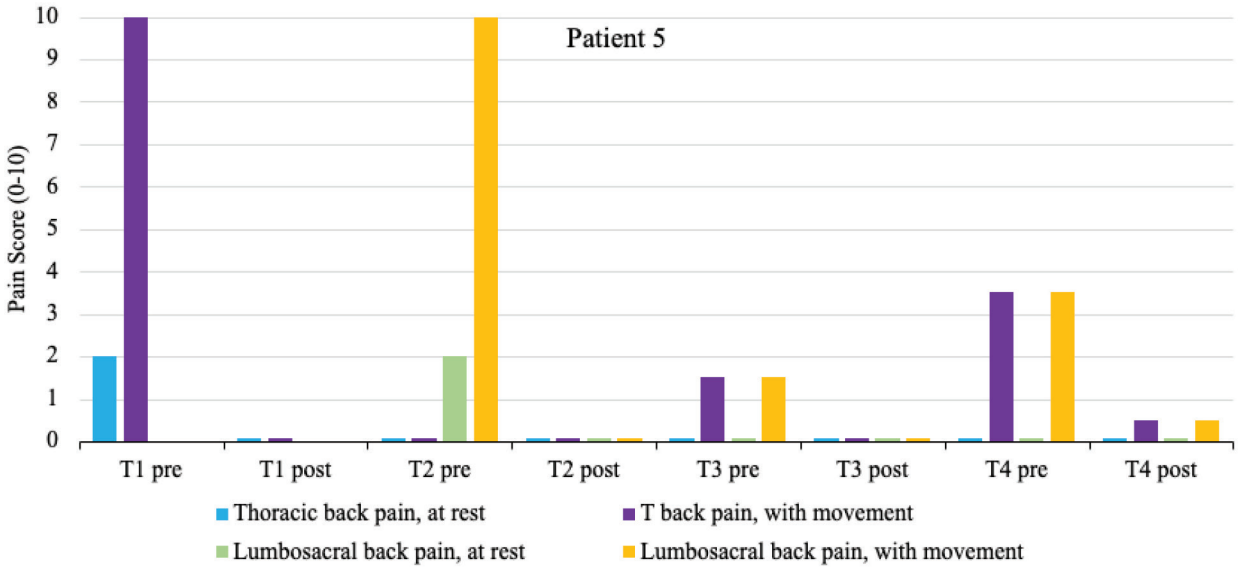
Supplemental Fig. 1. Pre- and post-ST treatment pain scores for Patient 1. Five ST treatments (T1-T5) were given over 3 weeks. Treatments 1 and 2 each resulted in 0/10 pain for a few days. After treatment 3, pain relief lasted one week. Treatments 4-5 (done over 2 consecutive days) prolonged pain relief for 6 weeks. The patient was referred to another provider in a nearby state and reported again obtaining pain relief until death.



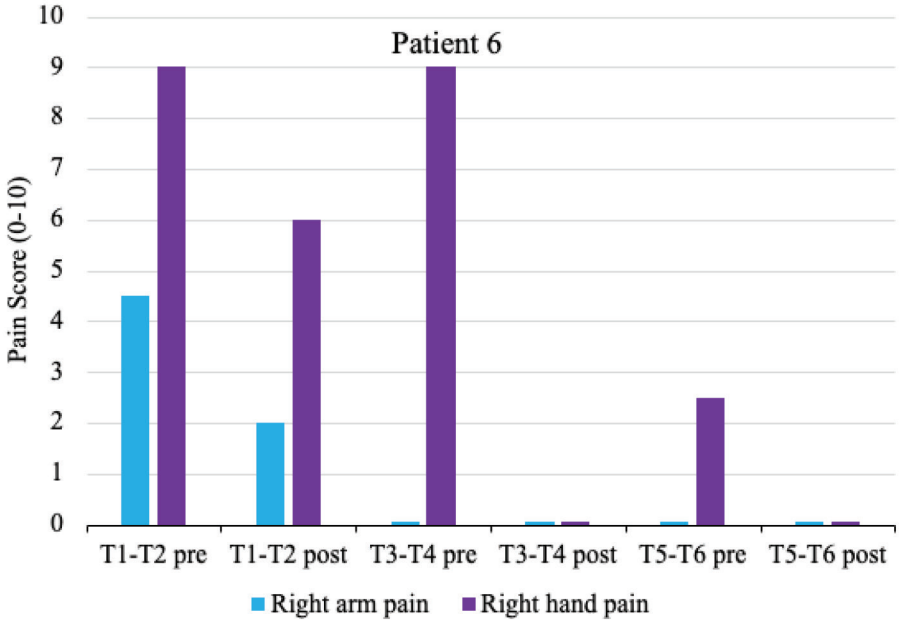
Supplemental Fig. 2. Pre- and post-ST treatment pain scores for Patient 2. Treatments 1-3 were monthly sessions each resulting in 0/10 pain for one to 2 weeks. Treatments 4-6 were given one month later (over 3 consecutive days) with pain relief lasting one week. Treatments 7-8 were given another month later with pain relief lasting 2 years until death.



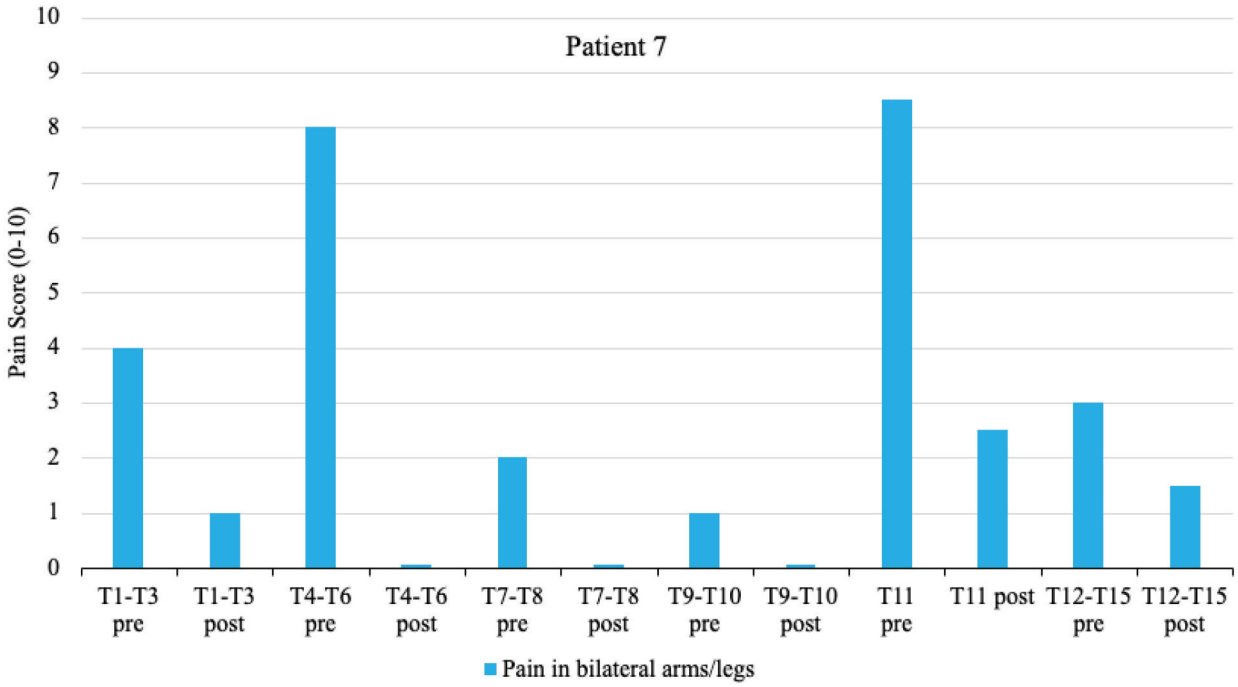
Supplemental Fig. 3. Pre- and post-ST treatment pain scores for Patient 4. After treatments 1-3 (over three consecutive days), neck and arm pain improved to 0/10 and lasted 6 months. Retreatment (treatment 4) restored pain relief. Treatments 5-6 (over 2 consecutive days) were given one month later and again restored pain relief. After 1.5 years pain-free, neck/arm pain returned along with new right leg pain. Treatments 7-10 (monthly sessions) reduced pain scores to 1-2/10.



Supplemental Fig. 4. Pre- and post-ST treatment pain scores for Patient 5. Four ST treatments were given over 2 weeks. Lumbosacral back pain was not treated until treatment 2. Pain was reduced to 0-1/10, and the patient has been pain-free for 2 years and ongoing.



Supplemental Fig. 5. Pre- and post-ST treatment pain scores for Patient 6. After treatments 1-2 (over 2 consecutive days), arm pain reduced to 2/10 (and later 0/10) and hand pain improved from 9/10 to 6/10. Treatments 3-4 (over 2 consecutive days) one week later further improved hand pain to 0/10. After treatments 5-6 (over 2 consecutive days) one month later, the patient was pain-free for one year until death.



Supplemental Fig. 6. Pre- and post-ST treatment pain scores for Patient 7. A total of 10 treatments were given over one month with pain scores reduced to 0-1/10 after each set of sessions. Pain recurred one month later at which time treatment 11 was given with pain improvement to 2-3/10. Treatments 12-15 were administered three months later with pain score reduction to 1-2/10.