

A Novel Surgical Approach to Treating Complex Regional Pain Syndrome: Three Case Reports

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1. Introduction

Complex regional pain syndrome (CRPS) is a multifaceted, chronic pain condition often affecting one of the limbs and is believed to be a result of an aberrant response to tissue injury. Symptoms are diverse, including disproportionate pain, sensory and motor disturbances, and varying degrees of autonomic dysfunction [1]. Current management strategies involve a multidisciplinary approach, including pharmacological treatments, physical therapy, and neuromodulation, but these have shown limited efficacy and considerable side effects [2,3]. The condition is hypothesized to be due to a combination of inflammation, central and peripheral sensitization, and sympathetic nervous system dysregulation [4].

We introduce three case reports that illustrate a novel surgical technique for treating CRPS. These innovative procedures represent a significant shift in current treatment paradigms, offering hope for a condition that has often been refractory to conventional therapeutic approaches. This report aims to detail this new surgical procedure, its execution, and outcomes in the context of a patient case, with the objective of contributing to the evolving body of knowledge on effective interventions for CRPS.

2. Case Presentation 1

A 63-year-old male sustained an injury in 2015, involving a pressurized injection of diesel fuel into his left hand. He presented to the hospital with intense pain on the palmar side of the hand, redness, localized heat, and limited mobility. He was treated

surgically by irrigation and debridement of the injury site in his thenar eminence.

However, approximately two months later, the patient returned with swelling in the same area, hypersensitivity to touch, and an inability to move his thumb. Notably, there were no discharges or signs of systemic infection. He was treated with antibiotics and underwent carpal tunnel release surgery, after which he was discharged. Post-surgery, he experienced limitations in thumb mobility and numbness along the ulnar aspect. Few months later, he had a revision for median nerve neurolysis but with no positive impact. As the patient experienced progressive worsening of symptoms, he was diagnosed with Complex Regional Pain Syndrome (CRPS).

Various treatments, such as occupational therapy, pressure gloves, silicone sheeting for scars, and multiple pain relief medications, including oxytocin, gabapentin, and amitriptyline were attempted. Despite these interventions, the patient's pain worsened over the years, and signs of intense hand guarding became evident. A trial of medical cannabis also failed to provide significant improvement. The patient was treated with electrical stimulation to the brachial plexus with minor improvement of his pain and the device was removed later because of technical issues. At some point the patient was offered amputation to the limb. Seven years following the injury the patient came to our clinic for consult. As he had no use of his hand, and what bothered him the most was that he could not hold his grandchildren, he was offered a nerve transfer procedure with full neurectomy for median nerve.

2.1. Surgical Intervention

Given the refractory nature of the patient's CRPS, a decision was made to pursue a surgical solution. The surgery was performed under brachial regional anesthesia. The initial step involved making a forearm distal S-shaped incision. This incision was chosen for its ability to provide adequate exposure while minimizing the risk of scar contracture and subsequent complications. Upon reaching the median nerve in the distal third of the forearm it was sectioned! The proximal part was transferred beneath the flexor mass and was neurotized to the anterior interosseus nerve after it was isolated and tracked to its branching inside the pronator quadratus muscle as described for other Targeted Muscle Reinnervation (TMR) procedures [5]. The neurotization was protected with a commercial nerve wrap (NeuraGen® Nerve Guide) aimed at reducing the risk of adhesion formation, which could limit nerve mobility and functionality, and potentially contribute to recurring or increased pain. The distal part of the median nerve was dissected to motor and sensory parts and both parts were neurotized to each other and the neurotization was protected with a nerve wrap. This concept of closed circuit aims at re-programming the nerve message relay system and avoids exposed sensory nerve ending even the distal part as this could be a source of pain (Figure 1). The layers of the hand were then carefully sutured together, ensuring proper alignment and finally, a plaster cast was applied to immobilize the hand, providing a stable environment for healing while limiting post-operative pain and potential injury for two weeks maintaining the fingers free for movement.

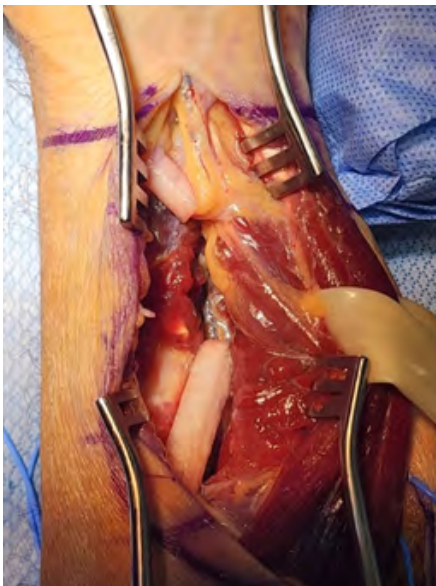


Figure 1.

2.2. Post-Operative Follow-up and Outcome

One-week post-surgery, the patient returned for his initial follow-up. He reported a noticeable reduction in his pain levels, a finding which was encouraging, given the refractory nature of his CRPS. The patient also reported feeling overall better, a subjective measure that indicated an enhancement in his quality of life. The

decrease in pain allowed a comprehensive examination of the hand to be performed. This was previously not possible due to the patient's extreme sensitivity to touch and intense hand guarding. The patient could make a fist (Figure 2) and it was possible to touch him freely with no surge of immense pain (Figure 3).

Over the following six months, His pain levels continued to decrease, and he reported improved sleep patterns. Importantly, the patient's reliance on pain medications was drastically reduced postoperatively. Before the surgery, he had been on a regimen of multiple medications, including oxytocin, gabapentin, and amitriptyline, all of which had been unable to control his pain effectively. Furthermore, the patient reported improved hand function. The resolution of hand guarding and reduction in pain facilitated better use of his hand, a critical component of his overall recovery. The patients declared that he could hold his grandchildren for the first time in years. The patient complained that losing sensation in his thumb and index makes him diligent when dealing with hot stuff because of the fear of injury. He was advised to keep eye control when dealing with hot and cold apparatus.

The patient is scheduled now to undergo a surgery to transfer the common digital nerve for fourth web space to the common digital nerve to the first web space to help restore the critical sensation of this area.



Figure 2 and 3.

3. Case Presentation 2

A 50-year-old male patient was admitted to orthopedic department following a laceration to his left wrist in 2021. He had exploratory surgery which demonstrated full laceration of FDS-2 and median nerve with partial laceration. All lacerations were sutured including the median nerve.

Following the surgery, he was diagnosed with CRPS and was treated in pain clinic with a battery of medications according to the local protocol. His hand was swollen with swan neck deformity in all fingers except thumb with no use of his hand and no independence with basic activities. It was not possible to touch his hand as that

would illicit an enormous pain (Figure 4). The patient was treated with occupational therapy with an attempt for de-sensitization but eventually he was dependent on pain medications. Later he was treated with electrical nerve stimulation with an electrode inserted to brachial plexus. The procedure although lowered the pain VAS score it did not relieve his pain completely and the hand still was non-functional.

The patient came to our clinic after a year and a half and was offered a nerve transfer procedure to alleviate his pain. The concept was to do a proximal median nerve neurectomy and transfer the proximal median nerve to the anterior interosseus nerve to re-innervate the FPL+FDP-2 and to get a pain-relieving effect as described for TMR procedures. The patient was offered a two steps procedure as the outcome of the first procedure is not fully anticipated. The second procedure involves further hand reconstruction, based on success of first procedure and willingness of the patient.



Figure 4.

3.1. Surgical Intervention

3.1.1. First Procedure: The patient had full anesthesia. Under tourniquet control, a proximal S incision was made on the proximal forearm. Pronator teres distal attachment was loosened in a step-cut fashion to facilitate exposure for median nerve.

The nerve eventually was recognized between the arterial branching of the brachial artery and the superficial head of the pronator syndrome and released including all branches up to the AIN branch on the radial aspect of the median nerve.

A neurectomy was done and the proximal part was sutured directly with the AIN with end-to-end fashion. The neurotization was protected with a nerve wrap (Fig.5). During the surgery a closed manipulation was applied to the IP joints of the fingers to break adhesions and to improve the stiffness of the fingers as they were stuck in a swan neck position for months with no motion. A nearly full passive range of motion was achieved in this fashion. After these steps the wound was irrigated and closed in layers.



Figure 5.

3.2. Post-Operative Follow-up and Outcome

Day one after the surgery the patient had full pain relief. Declaring zero pain on VAS score. it was possible to touch his hands. His fingers had some motion, but he could not do a fist and he still had swan neck deformity. The patient was satisfied.

Immediately he was enrolled on a plan for occupational therapy to keep his fingers supple after the closed manipulation.

After two months of therapy, the patient asked to do a surgery to fix his deformed fingers.

4. Second Procedure

After 3 months of the index surgery, the patient was scrubbed again to do a FDS tenodesis to correct swan-neck deformity. Under tourniquet, digits 2 to 5 were approached separately with Brunner approach. One FDS slip was recognized under A3 pulley, was cut proximally as possible at A1 level, and looped around A2 and sutured to itself, forcing the PIP into flexion (Figure 6). Next a Brunner incision was done in hypothenar region and the common digital nerve for fourth web space was recognized. The same was done in thenar region and the common digital nerve was exposed for first web space. Then a nerve transfer was utilized transferring the ulnar common digital nerve proximally to the median common digital nerve distally to restore critical sensation for thumb and index (Figure 7).

The neurotization was protected with a nerve wrap and all wounds closed with nylon 4-0 and a covered with a soft bandage. A cast was applied for 3 weeks dorsally.



Figure 6.



Figure 7.

4.1. Post-Operative Follow-up and Outcome

A plan for immediate occupational therapy was utilized to maintain finger flexion and a customized cast by occupational therapy team was utilized.

After six months of follow-up, the patient was satisfied, was pain-free and the most important outcome is a functional hand! The patient documented himself holding a cup and opening a gate with his inflicted hand (Figure 8 and 9). Vas score was 0 and the patient has a 2-point discrimination of 6 mm in his thumb and index and able to recognize hot and cold.



Figure 8 and 9.

5. Case Presentation 3

A 34-years old female patient has had a laceration to her right thumb in 2015. She was treated and discharged for local wound care. Following the injury, the patient suffered from a radiating pain to her right hand up to the shoulder, swelling in her hand, changes in the color of the hand with occasional redness and eventually she lost function of her hand. She was diagnosed with CRPS and was treated in pain clinic for several years. She was on several pain medications including gabapentin, Seroquel, oxycodone, quetiapine, and mirtazapine. In 2022 she underwent under general anesthesia abscess drainage from her index. Following the procedure, she started to complain about deteriorating pain in her index with no ability to touch the scar and no active flexion of all fingers (Figure 10). Then she came to our clinic, and she was offered surgery that included carpal tunnel release with Centro-central nerve transfer of the thumb and index finger.

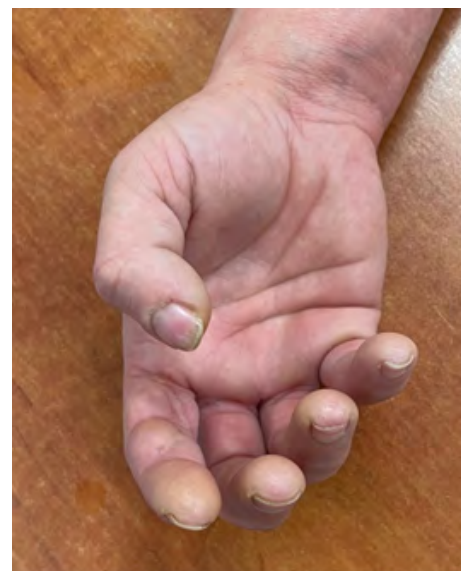


Figure 10.

5.1. Surgical Intervention

Under general anesthesia and tourniquet, the patient had carpal tunnel release with distal Brunner extension to the first web space. After gentle dissection the nerves to the thumb and index were isolated. The nerves were cut and rewired with Centro-central fashion where the proximal stumps of the digital nerves were sutured to themselves in a closed circuit and the distal stumps were sutured to their selves in the same fashion (Figure 11). The area of suturing was protected with nerve wrap to minimize axonal escape and potential positive Tinel sign. The wound was irrigated and closed primarily with 4-0 nylon. A protective splint for two weeks was utilized.



Figure 11.

5.2. Post-Operative Follow-up and Outcome

Following the surgery in the early post-operative period, the patient declared that her pain has subsided. Active flexion of the fingers was possible, and it was possible to touch her hand and her scars.

The patient started an occupational therapy regime to desensitize the wound of surgery and regain power and flexibility of fingers at the end of which her hand became functional and useful. Seven months following the surgery, the patient uses her hand to hold small and large objects and even do simple fine motor activities (Figure 12 and 13). She is content with the results and she stopped using all pain medications.



Figure 12 and 13.

6. Discussion

Complex Regional Pain Syndrome (CRPS) poses significant clinical challenges, given its complex nature, marked by disproportionate pain, sensory and motor disturbances, and autonomic dysregulation [1]. These cases serve as an example of the intricate nature of CRPS, yet it brings to light a novel surgical intervention that might pioneer new therapeutic avenues.

The surgical techniques employed in these cases are distinctly different from traditional management strategies for CRPS. Primarily, the intervention focused on the selective treatment of the sensory component of the median nerve, a targeted approach aiming to directly address the patient's pain. Notably, such selectivity is not a characteristic of previously reported conservative, surgical or invasive interventions, such as spinal cord stimulation or intrathecal drug pumps, which attempt to modulate pain but do not directly address the putative nerve dysfunction in CRPS [6-8].

We are fully aware that there are two types of CRPS where type 1 is with no apparent specific nerve injured and type 2 where there is a nerve that is injured and sometimes it is referred to as causalgia. In these cases, one case has confirmed partial laceration for the median nerve (Case 2), one case has injury to the thumb and surgical wound to the index with no obvious nerve laceration (Case 3) although it could be argued that there is probably injury to the digital nerve in the thumb that started the whole cascade. The first case discussed has no apparent nerve injury and the symptoms were not provoked immediately after injury but mainly after carpal tunnel release.

In all patients it was impossible to touch the afflicted hand. All patients needed to undergo nail trimming under sedation. This feature is important as this put them at the extreme spectrum of pain. The hallmark symptom is an extreme allodynia to touch. This contrasts with a study of del piñal in which he described 53

patients diagnosed with CRPS [9] who underwent carpal tunnel release after which, their symptoms have subsided. We acknowledge that there is a subset of patients with unrelenting pain who cannot make a fist and they answer the Budapest criteria for CRPS and could be treated with carpal tunnel release. They fall in the CRPS type 1 category. Yet, we also recognize that there is another subset of patients who also answer the Budapest criteria for CRPS, that their diagnosis has evolved after carpal tunnel release. They have dystrophic changes in their hand and non-functional hand. They also fall in CRPS type 1 category. Our first patient in this series has evolved to CRPS after carpal tunnel release. After that, he has had median nerve neurolysis. Only after median neurectomy, his severe pain and allodynia have subsided.

Post-operatively, all patients demonstrated substantial improvements, suggesting the effectiveness of this surgical intervention. The reduction in pain levels, noted within a week of surgery and maintained over the seven-month follow-up period, stands in stark contrast to the typical outcomes associated with conventional treatments [2]. Furthermore, the patient's improved sleep patterns and decreased reliance on pain medications, which are seldom achieved with other invasive procedures such as nerve blocks or sympathectomy, underscore the possible transformative effects of the surgical intervention employed [10,11]. We believe that the concept of taking off the power supply of the nerve (sensory component) and rewire it in different fashion (TMR or Centro-central) could improve CRPS symptoms. It is analogic to rebooting the system.

Still, a price is paid which is losing sensation in critical area or motor function depending on the level of neurectomy. After the neurectomy still a motor and sensory reconstruction is possible as is evident in (Case2). Using ulnar to median nerve transfer could reconstruct pinch sensation and doing the neurectomy distal as possible could spare motor function of the median nerve like FDS+AIN innervated FDP+FPL as preformed in the first case. We think that a planned staged procedures should be offered: First step is taking the pain with minimum price as possible, followed by reconstructive procedures if pain subsided. There was a learning curve in our case reports and in every patient, we learned to minimize the price. eventually in the last case we attacked the common digital nerves leaving the median nerve intact, since the area of the carpal tunnel up to distal palmar crease was touchable but the fingers were not.

In summary, these cases provide preliminary evidence for a potentially effective surgical intervention for CRPS. The surgical approach utilized here is novel, necessitating further validation through larger, controlled studies. Establishing the broader efficacy, safety, and replicability of this intervention is crucial, as has

been the case with other surgical interventions for CRPS [12]. Surgical intervention for CRPS should be strongly considered if a causative nerve can be identified. CRPS could be curable!

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