

Review Article

Comparison between Manual Manipulation and Physical Modality for Treatment and Prevention of Complex Regional Pain Syndrome in Colles Fracture: A Systematic Review

Thomas Erwin Christian Junus Huwae¹, Panji Sananta¹, Vivid Prety Anggraeni², Istan Irmansyah Irsan¹, Syaifullah Asmiragani¹, Iftinan Amalia³

¹Orthopaedic and Traumatology Specialist, Department Orthopedic and Traumatology, Faculty of Medicine, Universitas Brawijaya – Saiful Anwar General Hospital, Malang, Indonesia

²Physical Medicine and Rehabilitation Specialist, Department of Physical Medicine and Rehabilitation, Faculty of Medicine, Universitas Brawijaya – Saiful Anwar General Hospital, Malang, Indonesia

³Physical Medicine and Rehabilitation Resident, Faculty of Medicine, Universitas Brawijaya – Saiful Anwar General Hospital, Malang, Indonesia

Corresponding author: Thomas Erwin Christian Junus Huwae



This work is licensed under a Creative Commons Attribution-NonCommercial 4.0 International License

Source of support: Nil

Conflict of interest: Nil

ABSTRACT

Introductions: Multiple treatments for complex regional pain syndrome (CRPS) have been promoted, although the degrees of supporting evidence vary and are often limited. This updated review aims to critically examine the data for treating Complex Regional Pain Syndrome (CRPS) from current randomized controlled trials (RCTs) and non-RCTs.

Methods: A systematic literature search was conducted to identify all randomized controlled trials and non-randomized controlled trials addressing the rehabilitation of CRPS conducted on human subjects and published in English between 2018 and 2022 using The Cochrane Library, PubMed, and ScienceDirect (Elsevier).

Results: The search yielded 6 RCTs and two non-RCTs of varying quality regarding the treatment of CRPS. 6 studies evaluate the treatment of CRPS, and two studies evaluate the prevention of CRPS.

Conclusions: In conclusion, both manual manipulation and physical modality are safe and reliable procedures that provide good pain relief and functional improvement as treatment and prevention of CRPS

Keywords: colles fracture, complex regional pain syndrome, musculoskeletal manipulations, physical therapy modality

INTRODUCTION

Complex regional pain syndrome (CRPS) is a persistent pain disorder that affects a limb and is characterized by trophic alterations, edema, vasomotor abnormalities, and allodynia. It usually occurs following an accident or trauma. The severity and duration of symptoms can vary. The International Association for the Study of Pain (IASP) proposed a division in the classification of pain into two categories: type I, which arises from non-neurological traumatic damage, also known as reflex sympathetic dystrophy (RSD) or Sudeck's atrophy. Type 1 CRPS is diagnosed if the previous symptoms occur from soft tissue injury without confirmed nerve injury in the

affected limb. Type II CRPS follows well-documented nerve damage characterized as causalgia. Type 1 CRPS is a frequently documented consequence of distal radius fractures (DRFs).^{1,2}

Complex regional pain syndrome (CRPS) is caused by various mechanisms, which include afferent mechanisms (such as inflammation and disturbances in endothelial vasomotor function), efferent mechanisms (such as central sensitization leading to sensory, autonomic, and motor disturbances), and central mechanisms (involving cortical reorganization and psychological factors).³ The upper extremity is where CRPS is most common, occurring 4–6 weeks after a mild injury, fracture, immobility, stroke, or surgery. 10% to 16% of cases have been observed to have spontaneous CRPS. The pathophysiological interactions between peripheral and central processes are thought to underlie the mechanisms underlying CRPS. The affected person's sympathetic reflexes during the early stages. Due to these disruptions, the nociceptive neurons become excessively sensitive to certain hormones and neurotransmitters, which can enhance the blood vessel's vulnerability to those substances. At the same time, decreased oxygenation (hypoxia) may occur, changing the pH of the tissue (acidosis).

CRPS also demonstrates a significant increase in proinflammatory proteins, which are believed to be vital in initiating and maintaining CRPS. The diagnosis of CRPS was erroneous and based on various competing, little-accepted diagnostic criteria. It was believed that by publishing consensus-based diagnostic criteria for CRPS in 1994, the IASP would establish a global clinical treatment and research benchmark. After validation studies indicated problems with these diagnostic criteria's lack of specificity and potential for overdiagnosis, a global effort was begun to develop and validate CRPS diagnostic criteria with high sensitivity and superior specificity. In 2012, the resulting criteria (commonly called the Budapest criteria) were adopted as the IASP's official diagnostic standards for CRPS.^{1,2}

The primary treatment for CRPS is the use of physical therapeutics. In treating CRPS, the standard order of rehabilitation is followed, beginning with pain and edema control, then a range of motion, strengthening, and finally, function. Physical modalities alone may make pain management difficult. Nonetheless, physical modalities should serve as the initial line of defense. Before and after a therapy session or exercise, contrast baths, Fluidotherapy, transcutaneous electrical nerve stimulation (TENS), and desensitization may be utilized.^{2,3}

Despite challenges with nomenclature and identification, progress is being made in collecting and synthesizing data to support individualized management. Even though manual manipulation and physical modality are central to clinical guidelines and care pathways, several articles emphasize medical management and provide inadequate direction for occupational and physical therapists who are likely to encounter these patients referred for rehabilitation. Over several years, comprehensive summaries of data, including narrative and systematic research, have been created to address the rehabilitation of CRPS. Nevertheless, writers may perceive these resources as deficient in (1) the precise information required to make a clinical assessment of the potential effectiveness of these interventions for their clients and (2) practical guidelines on how to implement and tailor the treatment. This review aims to investigate these inconsistencies in the literature and to consolidate the published data about the progression of CRPS treatment between manual manipulation and physical modality.^{2,3}

METHOD

We systematically evaluated the literature using a PRISMA checklist and algorithm per the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) criteria. A literature search was performed using the appropriate MeSH terms and text words: (complex regional pain syndrome) AND (fracture)) OR (colles

fracture)) AND (rehabilitation)) OR (manual therapy)) OR (modality)) AND (pain)) OR (functional)). The Cochrane Library, PubMed, and ScienceDirect (Elsevier) were queried to locate RCTs and non-RCTs on human subjects and published in English between 2018 and 2022. Only English-language articles were included. Biomechanical studies, animal or carcass studies, technical notes, letters to the editor, and instructional courses were excluded. Two authors independently evaluated each publication's abstract. When no conclusion could be made regarding the inclusion or exclusion of an article based on the abstract, the entire text was downloaded. In the absence of an abstract, the article was omitted. In addition, we examined the reference lists of each selected article to find research that may have been overlooked during the initial computerized search. The review author independently chose and evaluated the papers and documented the selection procedure sufficiently to produce a comprehensive PRISMA flow diagram. The review focused on randomized clinical trial articles. The characteristics of the patients are (1) Individuals who have been confirmed to have complex regional pain syndrome; (2) trials included upper extremity and or lower extremity; (3) outcome measures for either pain and edema and function and range of motion. The main result is reduced pain scores. Secondary outcomes involve a range of motion, muscle strength evaluated by a handheld dynamometer, physical functional score determined by the 6-minute walk test, and quality of life measured by physical and mental ratings. The methodological quality of each study was assessed using the Physiotherapy Evidence Database (PEDro) tool for randomized controlled trials (RCTs) and the Downs and Black (D&B) evaluation tool for non-RCTs. The PEDro scale consists of 11 items that assess the external validity (question 1) and internal validity (questions 2-11). Higher ratings indicate a greater level of methodological quality. Specifically, ratings between 9 and 11 are considered exceptional, ratings between 6 and 8 are considered good, ratings between 4 and 5 are considered acceptable, and a grade of 4 is considered low. The D&B tool has a maximum score of 28 and consists of 27 items that assess reporting, external and internal validity (bias), and internal validity (confounding). The Downs and Black score ranges were categorized as follows: extraordinary (26–28), decent (20–25), fair (15–19), and awful (14). To be eligible for inclusion, papers had to demonstrate original research describing a rehabilitation intervention for patients with CRPS and propose a proposed response. Manuscripts were declined if they consisted of single-case studies or did not emphasize rehabilitation substantially. The study was omitted if the publication was older than five years.

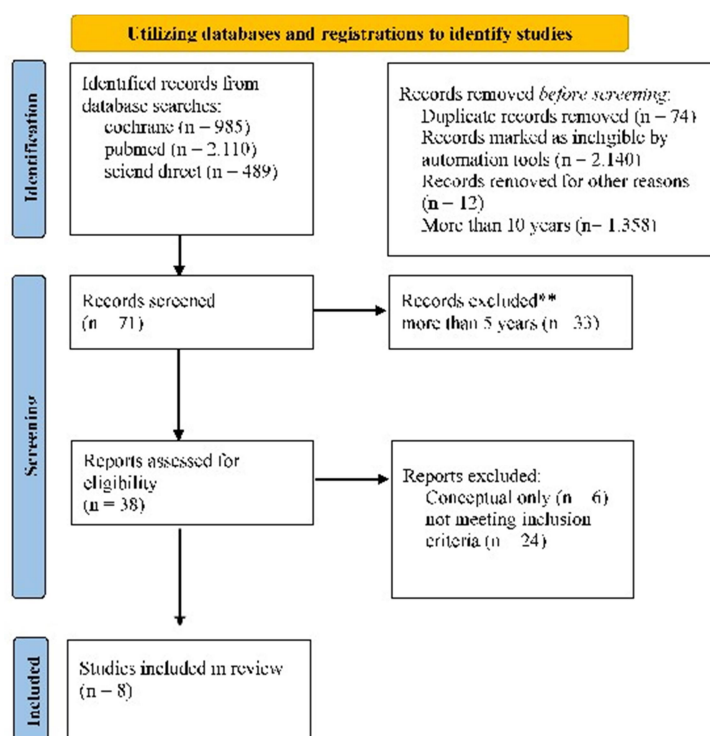


Figure 1. Flowchart of PRISMA. During the initial search, 3,584 studies were identified, and 71 were chosen based on their abstracts. In the end, we included eight articles in our systematic review.

RESULTS

A total of 3,584 research was found at the beginning of the search, and 71 articles were selected for abstract review. After the abstract screening, the eligibility of eight full-text manuscripts was evaluated (see Fig. 1 for the study flow diagram). Disagreements between raters were settled through dialogue. This generated a total of 49 papers for review. Each article was analyzed to determine (1) the research type and quality of evidence, (2) the utility of the material, (3) the risk of bias as measured by the PEDro scale and the Downs and Black Quality Assessment; and (4) the treatment program components for therapeutic action. From these papers, we determined that six were randomized controlled trials and two were not. The sample sizes of the research included in the analysis were often limited, ranging from n=20 to n=60 for treatment studies and n=50 to n=66 for prevention studies. Each non-RCT study's methodological quality was scored using the full version of the Downs and Black evaluation tool, with scale ratings ranging from 0 to 28 and an average score of 15.5%. (Table 1). For RCT, PEDro scale ratings ranging from 0 to 11 and an average score of 5.7/11 were utilized (Table 2).

Table 1. Methodological quality assessments using the Downs and Black Quality Assessment Checklist (Downs and Black 1998) (4,5)

	Reporting	External Validity	Internal Validity	Confounding and Selection Bias	Power	Total
Lebon, et al. ⁴	8/11	2/3	5/7	2/6	1/1	18/28
Gutiérrez-Espinoza, et al. ⁵	7/11	2/3	3/7	3/7	0/1	13/28

Table 2. Quality assessment based on PEDro scale of clinical trials included in the systematic review (6,11)

	Rome, et al. ⁶	Kriek, et al. ⁷	Lagueux, et al. ⁸	Lewis, et al. ⁹	Zlatkovic-Svenda, et al. ¹⁰	Mcgee, et al. ¹¹
Eligibility Criteria Specified	1	1	1	1	1	1
Random Allocation	1	0	1	1	1	1
Concealed Allocation	0	1	0	0	0	1
Comparable at Baseline	1	1	1	1	1	1
Blind Subjects	0	1	0	1	0	1
Blind Therapies	0	1	0	0	0	1
Adequate Follow-up (<85%)	1	1	1	1	1	1
Intention-to-treat Analysis	1	1	1	1	1	1
Between-group Comparison	0	1	1	1	1	0
Point Estimates and Variability	0	1	1	1	1	1
PEDro Total Score	3	8	5	6	5	7

DISCUSSIONS

This study synthesizes the evidence for manual manipulation and physical modality rehabilitation therapies in CPRS. We determined conservative treatment options for CRPS. To manage this demographic group in hand therapy, we contend that no single treatment technique should be favored, and therapists shouldn't adopt every treatment strategy without considering it. By linking prospective evaluation results to interventions supported by data, our goal was to help therapists design treatments for specific clients. In doing so, we do not promote treating patients with a preference that ignores the role that the environment and other circumstances play in their health (to use terminology from the International Classification of Function). This synthesis aims to increase understanding of how addressing mechanistic components might promote the desired improvements at the participation level, which should remain a therapeutic objective. To underline this, we further subdivided the summary of therapies (Table 3) to assist clinicians in conceptualizing and implementing individualized client

approaches. We have not made prescriptive advice but have attempted to assemble information to aid in making treatment decisions at the individual level.

We advise a full assessment of indications and symptoms, individualized functional goals, and existing restrictions and barriers to therapy as the initial stage in this approach. Prior studies have revealed the lack of standardized outcome measures employed in clinical trials for CRPS. They utilize available guidelines for assessing pain, sympathetic function, disability, and quality of life—several publications in this evaluation employed holistic quality-of-life measurements. Lebon et al. and Gutiérrez-Espinoza et al. utilized QuickDASH, while PWRE and Lagueux et al. utilized the SF-12 abbreviation.^{4,5,8} Only one of the studies investigated the impact of rehabilitative therapies on psychological status, which is a significant gap in the literature. Lagueux et al. review The State-Trait Anxiety Inventory (STAI) and The Beck Depression Inventory (BDI-II) to examine psychological effects. Since certain CRPS I patients have been noted to have perplexing features and emotional and behavioral traits, psychological issues are also of interest. According to certain studies, emotional imbalance, worry, depression's somatization tendency, and lack of confidence are key characteristics of people with CRPS. It has been proposed that CRPS I have a psychological component and a psychosomatic basis.^{8,12,13}

Recent clinical practice recommendations indicate (based on expert opinion) that activity/therapy participation should be continuously graded to promote rehabilitation progress. This could be viewed as a functional increase for the damaged limb.^{4,6,7} Three trials report the management of CRPS using occupational therapy. Occupational therapy contributes to the preservation or restoration of autonomy.^{14,15} The patient will be put in situations that closely resemble their daily activities and environment, such as dressing and undressing independently at home, preparing and eating meals in the kitchen, and stimulating sensitivity, functional and general gripping, dexterity with coordinated manipulation of standard objects during simulated activities, and reintegration of the hand using divided attention exercises. (Operating cars and workstations).^{6,8,16}

In occupational therapy, complex regional pain syndrome (CRPS) is successfully treated with graded motor imagery (GMI). GMI attempts to stop the progression of acute pain into chronic pain by progressively arranging cortical activation and decreasing cortical disinhibition. The three successive strategies utilized in graded motor imagery (GMI) are left/right discrimination, explicit motor imagery, and mirror therapy. These phases improve cortical motor networks' engagement with sensory-motor processing and prevent the pain response from protecting the body.^{6,11,14}

If activity restrictions are caused by kinesophobia or fear avoidance, a gradual reintroduction to activity may be extremely suitable. However, it is important to emphasize that pain itself is a better predictor of disability than pain-related anxiety as measured by kinesiophobia, according to multiple types of research on CRPS. Kinesiophobia is an extreme, irrational, and incapacitating dread of movement and activity rooted in the apprehension of pain, injury, or re-injury. Among the community of individuals presenting with a diagnosis of CRPS, some exhibit kinesiphobic behaviors, which may result in acquired nonuse. The Tampa Scale of kinesiophobia (TSK) was utilized as one of the outcome measures by Lagueux et al. The 17-item assessment Utilizing the Tampa Scale of Kinesiophobia (TSK), fear of movement, and injury/reinjury were evaluated. Higher overall scores indicate greater beliefs about avoiding fear. The score ranges from 17 to 68.^{8,17}

We conducted our evidence synthesis based on the proposed mechanisms that explain the signs and symptoms of CPRS. We assessed each therapy modality and its purported primary mechanisms of action. However, it is

crucial to acknowledge that a single modality can have multiple mechanisms of action, and using multiple approaches simultaneously may be the most efficient approach to target a certain mechanism. Lagueux et al. utilized transcranial direct current stimulation (tDCS) as an intervention. A battery-operated stimulator that provides a constant flow of electric current was connected to sponge electrodes soaked in a saline solution containing 0.9% sodium chloride. The electrodes had dimensions of 5 by 7 centimeters and were used to deliver direct current. Anodal stimulation was applied to the primary motor cortex (M1) using the 10/20 technique for EEG electrode placement. The anode was placed over either C3 or C4, which are contralateral to the injured limb. The cathode was positioned over the supraorbital region on the other side, which is ipsilateral to the affected limb. The selection of stimulation sites and intensity levels was determined by previous studies that showed a decrease in pain associated with neuropathy. Each day for five consecutive days, a two-mA continuous current was administered for 20 minutes (30 seconds ramp up, 30 seconds ramp down) (Monday to Friday). In patients with type I chronic CRPS, there is no evidence of a significant improvement in pain reduction. It may be because fewer cognitive-emotional elements (i.e., psychogenic causes of pain or pain avoidance behaviors) or contextual factors, such as attitudes of others or work-related beliefs, were included in their procedure. Transcranial direct current stimulation (tDCS) may be a viable treatment for neuropathic pain of many sorts. The potential mechanisms by which tDCS may modulate pain involve either directly interrupting the processing of pain signals in the thalamus and primary somatosensory cortex, or activating the limbic system and its linkages to inhibitory pathways that descend from the brainstem. The tDCS may modulate the spontaneous neuronal firing rate by polarizing the resting membrane potential and altering GABAergic synaptic activity or NMDA receptor density. This program should be evaluated in additional hospital and community settings to confirm and perhaps replicate the effectiveness and efficiency of tDCS.^{8,18,19}

Stimulation of the spinal cord (SCS) has been utilized for decades. It has been shown to affect cerebrospinal fluid (CSF) protein levels and neuroprotection, showing benefits beyond the effect on neurotransmitter concentration. These CSF protein concentrations also influence immunological regulation, neuroplasticity, and nociceptive signals. Kriek et al. conclude that after SCS, T-cell activation is inhibited. VEGF and PDGFbb levels drop following SCS, possibly due to increased peripheral tissue oxygenation brought on by IP-10's reduced anti-angiogenic effect, leading to lessened endothelial dysfunction and increased blood flow. SCS enhanced vasomotor, sudomotor, and sensory indications and symptoms. The possible immunomodulatory effects of spinal cord stimulation (SCS) offer new opportunities for using neuromodulation to treat inflammatory conditions and illnesses characterized by inflammation, such as complex regional pain syndrome (CRPS).^{7,16,20}

Two studies focused on the prevention of Complex Regional Pain Syndrome (CRPS). Combining low-energy, polarised, and polychromatic light therapy with conventional therapy (cryotherapy and kinesiotherapy) seems to be a better treatment option for improving pain control and achieving a wider range of motion in patients with distal radius fracture (DRF). Additionally, this approach significantly reduces the occurrence of complex regional pain syndrome (CRPS) following DRF. Light treatment (Biopton AG) has demonstrated biostimulatory properties that result in analgesic benefits, enhanced microcirculation, and better vasomotor function¹⁶⁻¹⁸ across different situations. This light therapy device sets itself apart from others by using polarized, polychromatic, incoherent, and low-energy light. The Biopton light treatment devices emit

wavelengths ranging from 480 to 3400 nm, penetrating the skin at different depths. This stimulates and improves numerous cellular processes, resulting in positive physiological results.^{11,19,22} Mcgee et al. determined that a greater number of women with distal radius fractures (DRF) would be able to utilize graded motor imagery (GMI). This intervention strategy, which does not require any intrusive procedures or pharmaceuticals, aims to enhance the functioning and self-management of symptoms, expedite the recovery process, offer cost-effective benefits, and potentially reduce the likelihood of developing CRPS. The GMI has successfully reduced the incidence of impairment, sensorimotor dysfunction, and CRPS in women with DRF.^{11,22,23}

LIMITATIONS

This literary analysis discovered numerous deficiencies. Three research papers reached a consensus on a diagnostic criterion, while most other investigations either utilized their diagnostic criteria or failed to describe them. Researchers have made significant efforts to establish a shared vocabulary (such as 'complex regional pain syndrome') and standardized diagnostic criteria (such as the IASP criteria or 'Budapest criteria'). However, no study published since then has utilized these terms or criteria. To further research in the field, it is imperative to employ a consistent diagnostic definition for Complex Regional Pain Syndrome (CRPS) and implement a systematic set of assessment methodologies to evaluate the indications and symptoms of CRPS. The second main finding of this study indicates that the research is affected by many forms of bias, and more rigorous investigations are needed to fully comprehend the effects of CRPS. Initially, a limited number of studies had samples that accurately represented the whole CRPS community, and many of them did not adequately describe their methods for recruiting participants. Several studies encountered substantial attrition rates or poor response rates. This becomes particularly troublesome when there is a clear disparity between individuals who engage in an activity and those who do not. The individuals who have been cured may have a lower inclination to engage in a subsequent investigation compared to people who are nonetheless encountering symptoms and are therefore enthusiastic about contributing to research on their illness. Future studies should address and overcome obstacles that prevent individuals from participating, to ensure the proper recruitment and retention of participants. Additional research constraints encompassed the absence of appropriate statistical analysis and the utilization of disparate evaluation methodologies.

CONCLUSION

In conclusion, manual manipulation and physical modalities are safe and dependable techniques for effective pain alleviation and functional improvement, such as CRPS treatment and prevention.

REFERENCES

1. Villa, M.G., Rittig-Rasmussen, B., Mikkelsen, L.M.S. and Poulsen, A.G., 2019. Complex regional pain Syndrome (vol 26C, pg 223, 2016). *MUSCULOSKELETAL SCIENCE AND PRACTICE*, 43, pp.127-127.
2. Gong, H., Zhao, G., Liu, Y., and Lu, Z., 2022. Determinants of complex regional pain syndrome type I in patients with scaphoid waist fracture-a multicenter prospective observational study. *BMC Musculoskeletal Disorders*, 23(1), pp.1-8.
3. Żyluk, A. and Puchalski, P., 2018. Effectiveness of complex regional pain syndrome treatment: A systematic review. *Neurologia i Neurochirurgia Polska*, 52(3), pp.326-333.

4. Lebon, J., Rongières, M., Aprédoaci, C., Delclaux, S. and Mansat, P., 2017. Physical therapy under hypnosis for the treatment of patients with type 1 complex regional pain syndrome of the hand and wrist: retrospective study of 20 cases. *Hand Surgery and Rehabilitation*, 36(3), pp.215-221.
5. Gutiérrez-Espinoza, H., Tabach-Apratriz, A. and Oyanadel-Maldonado, M., 2019. Physical therapy in patients with complex regional pain syndrome type I after distal radius fracture: a case series. *Journal of Physical Therapy Science*, 31(4), pp.403-407.
6. Rome, L., 2016. The place of occupational therapy in rehabilitation strategies of complex regional pain syndrome: comparative study of 60 cases. *Hand Surgery and Rehabilitation*, 35(5), pp.355-362.
7. Kriek, N., Schreurs, M.W., Groeneweg, J.G., Dik, W.A., Tjiang, G.C., Gültuna, I., Stronks, D.L. and Huygen, F.J., 2018. Spinal cord stimulation in patients with complex regional pain syndrome: a possible target for immunomodulation?. *Neuromodulation: Technology at the Neural Interface*, 21(1), pp.77-86.
8. Lagueux, Émilie, Michaël Bernier, Patricia Bourgault, Kevin Whittingstall, Catherine Mercier, Guillaume Léonard, Sarah Laroche, and Yannick Tousignant-Laflamme. "The effectiveness of transcranial direct current stimulation as an add-on modality to graded motor imagery for treatment of complex regional pain syndrome." *The Clinical Journal of Pain* 34, no. 2 (2018): 145-154.
9. Lewis, J.S., Newport, R., Taylor, G., Smith, M. and McCabe, C.S., 2021. Visual illusions modulate body perception disturbance and pain in Complex Regional Pain Syndrome: A randomized trial. *European Journal of Pain*, 25(7), pp.1551-1563.
10. Zlatkovic-Svenda, M.I., Leitner, C., Lazovic, B. and Petrovic, D.M., 2019. Complex regional pain syndrome (sudeck atrophy) prevention possibility and accelerated recovery in patients with distal radius at the typical site fracture using polarized, polychromatic light therapy. *Photobiomodulation, Photomedicine, and Laser Surgery*, 37(4), pp.233-239.
11. McGee, C., Skye, J. and Van Heest, A., 2018. Graded motor imagery for women at risk for developing type I CRPS following closed treatment of distal radius fractures: a randomized comparative effectiveness trial protocol. *BMC Musculoskeletal Disorders*, 19(1), pp.1-13.
12. Farzad, M., Layeghi, F., Hosseini, A., Dianat, A., Ahrari, N., Rassafiani, M. and Mirzaei, H., 2018. Investigate the effect of psychological factors in development of complex regional pain syndrome type I in patients with fracture of the distal radius: a prospective study. *The Journal of Hand Surgery (Asian-Pacific Volume)*, 23(04), pp.554-561.
13. Halicka, M., Vittersø, A.D., Proulx, M.J. and Bultitude, J.H., 2020. Pain reduction by inducing sensory-motor adaptation in Complex Regional Pain Syndrome (CRPS PRISMA): protocol for a double-blind randomized controlled trial. *BMC neurology*, 20(1), pp.1-24.
14. Dilek, B., Ayhan, C., Yagci, G. and Yakut, Y., 2018. Effectiveness of the graded motor imagery to improve hand function in patients with distal radius fracture: A randomized controlled trial. *Journal of Hand Therapy*, 31(1), pp.2-9.
15. Millrose, M., Gesslein, M., Kim, S., Ottersbach, C., Eisenschenk, A. and Asmus, A., 2020. Results of a special interdisciplinary hand therapy program for work-related injuries. *Hand Surgery and Rehabilitation*, 39(6), pp.575-579.

16. Taylor, S.S., Noor, N., Urits, I., Paladini, A., Sadhu, M.S., Gibb, C., Carlson, T., Myrcik, D., Varrassi, G. and Viswanath, O., 2021. Complex regional pain syndrome: a comprehensive review. *Pain and therapy*, 10(2), pp.875-892.
17. Imai, R., Osumi, M., Ishigaki, T. and Morioka, S., 2018. Relationship between pain and hesitation during movement initiation after distal radius fracture surgery: A preliminary study. *Hand surgery and rehabilitation*, 37(3), pp.167-170.
18. Yang, S. and Chang, M.C., 2021. Transcranial Direct Current Stimulation for the Management of Neuropathic Pain: A Narrative Review. *Pain Physician*, 24(6), p.E771.
19. Pinto, C.B., Costa, B.T., Duarte, D. and Fregni, F., 2018. Transcranial direct current stimulation as a therapeutic tool for chronic pain. *The journal of ECT*, 34(3), p.e36.
20. Kessler, A., Yoo, M. and Calisoff, R., 2020. Complex regional pain syndrome: An updated comprehensive review. *NeuroRehabilitation*, 47(3), pp.253-264.
21. Gulyar, S.A., 2018. Accents of the human body electromagnetic balance regulation system. *Photobiology and Photomedicine*, 24, pp.52-68.
22. Harden, R.N., McCabe, C.S., Goebel, A., Massey, M., Suvar, T., Grieve, S. and Bruehl, S., 2022. Complex Regional Pain Syndrome: Practical Diagnostic and Treatment Guidelines. *Pain Medicine*, 23(Supplement_1), pp.S1-S53.
23. Groenveld, T., Boersma, E., Blokhuis, T., Bloemers, F. and Frölke, J.P., Decreasing incidence of complex regional pain syndrome in the Netherlands: a multicenter study. *Practice variation and uncertainties in non-operative treatment*, p.85.

Table 3. Study Interventions and Outcomes

Author	Title	Setting, location, publication year	Sample and study design	Control	Intervention	Diagnostic criteria used	Outcome	Duration of treatment
Rome et al	The place of occupational therapy in rehabilitation strategies of complex regional pain syndrome: Comparative study of 60 cases	CRPS of the hand, Centre hospitalier d'Ardèche Méridionale, avenue Paul-Ribeyre, 07600 Vals-les-bains, France, 2015	Comparative study, Retrospective study, (n= 60)	underwent PT only	underwent PT and OT (stimulate sensitivity, functional and general gripping, dexterity with coordinated manipulation of standard objects during simulated activities, reintegration of the hand using divided attention exercises, develop compensation strategies (relateralization, dressing/undressing)	unable to validate	OT combined with PT brings a real benefit in restoring the essential activities of daily life and reduced pain (VAS)	24–32 months
Lebon et al	Physical therapy under hypnosis for the treatment of patients with type 1 complex regional pain syndrome of the hand and wrist: Retrospective study of 20 cases	Patients with CRPS-1 of the hand and/or wrist, orthopedic and trauma surgery department of a French University hospital, 2017	Retrospective study, (N= 20)	No control group	induction phase that allowed the patient to dissociate and protect themselves from pain, treatment phase pain-relieving modalities, lymphatic drainage massage and passive mobilization of the wrist and fingers in all	International Association for the Study of Pain (IASP) criteria described by Merskey	Physical therapy under hypnosis appears to be an effective treatment for CRPS-1 at the wrist and hand no matter the etiology,	6 weeks

					directions. hypnotherapist and physical therapist. Between the PT-H sessions, patients participated in a standard rehabilitation program with three sessions per week that combined painrelieving modalities, contrast baths, and gradual increase of the range of motion below the pain threshold.	in 1994, as modified by Harden in 2007	improvement in pain (daytime and nighttime VAS, analgesic consumption), stiffness (finger and wrist ROM) and strength (pinch and grip). Better functional scores (QuickDASH, PWRE, SHV)	
Kriek et al	Spinal Cord Stimulation in Patients With Complex Regional Pain Syndrome: A Possible Target for Immunomodulation?	Albert Schweitzer Hospital, Sliedrecht, The Netherlands, 2017	multicenter randomized double-blind and placebo-controlled trial (N= 43)	Healthy (unaffected) side two-week trial stimulation period with 40 Hz standard tonic SCS.	the affected side two-week trial stimulation period with 40 Hz standard tonic SCS.	IASP criteria	The sensory signs, symptoms, and phenotype improved SCS in CRPS patients attenuates T-cell activation, improves peripheral tissue oxygenation	10 weeks

							and decreases antiangiogenic activity which results in diminished endothelial dysfunction and improved bloodflow	
Lagueux et al	The effectiveness of transcranial direct current stimulation as an add-on modality to graded motor imagery for treatment of complex regional pain syndrome: A randomized proof of concept study	Centre hospitalier universitaire de Sherbrooke and the Hôpital Charles-Le Moyne (Québec, Canada), 2017	randomized parallel single blind design (N= 22)	GMI + sham tDCS	GMI + active tDCS	Budapest Research Criteria	no added value of tDCS combined with GMI treatments for reducing pain in patients with chronic CRPS	10 weeks;
Lewis et al	Visual illusions modulate body perception disturbance and pain in Complex Regional Pain Syndrome: A randomized trial	Royal National Hospital for Rheumatic Diseases, Royal United Hospitals Bath NHS Trust, Bath, UK, 2021	blinded randomized controlled trial (N= 45)	conducted within the MIRAGE system (image was not actually visually altered)	conducted within the MIRAGE system	Budapest clinical diagnostic criteria	significantly reduced body perception disturbance, improved liking and increased perceived lightness of the affected hand.	4 weeks

							There was also a significant decrease in pain	
Gutiérrez - Espinoza et al	Physical therapy in patients with complex regional pain syndrome type I after distal radius fracture: a case series	Physical therapy department at the Clinical Hospital San Borja Arriaran, Chile. 2019	case series (N= 54)	No control group	hydrotherapy, manual therapy, and exercises	Budapest criteria	Improves the function and reduces the pain	6 weeks
Zlatković-Svenda et al	Complex Regional Pain Syndrome (Sudeck Atrophy) Prevention Possibility and Accelerated Recovery in Patients with Distal Radius at the Typical Site Fracture Using Polarized, Polychromatic Light Therapy	Belgrade City Institute of Gerontology, Serbia. 2018	prospective study, randomized controlled (n = 52)	nonsteroid anti-inflammatory drugs, exercises, and cryotherapy on the wrist and dorsal side of the hand	nonsteroid anti-inflammatory drugs, exercises, and cryotherapy on the wrist and dorsal side of the hand + Bioptron (polarized, polychromatic, noncoherent, low-energy radiation) light in addition (intervention)	main criteria for CRPS were chronic, intensive pain of the hand, limited range of movement, with or without diffuse swelling of the hand, and changes in skin	low-energy, polarized, and polychromatic light therapy combined with conventional therapy (cryotherapy and kinesiotherapy) in patients with DRF appears a better choice and treatment option for pain control improvement and a range of motion	15 days

						temperature	achievement; it also significantly reduces CRPS occurrence after DRF	
Mcgee et al	Graded motor imagery for women at risk for developing type I CRPS following closed treatment of distal radius fractures: a randomized comparative effectiveness trial protocol	2018	randomized comparative effectiveness trial (N=66)	SOC only (a combination of clinic and home-based programming to address hand, elbow and shoulder motion as well as edema control)	a modified GMI program (mGMI) + standard of care (SOC) (a combination of clinic and home-based programming to address hand, elbow and shoulder motion as well as edema control)	Budapest CRPS Criteria	reduced risks associated with CRPS development, sensorimotor dysfunction, and subsequent disability	6 weeks