Original Manuscript

HAND
1–6

DOI: 10.1177/15589447211063578
journals.sagepub.com/home/HAN

Functional Outcomes After a Physiotherapy Program in Elderly Patients With Complex Regional Pain Syndrome Type I After Distal Radius Fracture: A Prospective Observational Study

Héctor Gutiérrez-Espinoza[1], Jonathan Zavala-González[1,2], Rodrigo Gutiérrez-Monclus[3], and Felipe Araya-Quintanilla[1]

Abstract

Background: No published prospective studies have reported the clinical effects of physiotherapy at 1-year follow-up in patients with complex regional pain syndrome type I (CRPS I) after distal radius fracture (DRF). The purpose of this study was to evaluate at 1-year follow-up the functional effects of physiotherapy program in elderly patients with CRPS I after extra-articular DRF. **Methods:** A total of 72 patients with CRPS I after DRF were prospectively recruited. All patients were treated with a 6-week supervised physiotherapy treatment. Three evaluations were performed: at the beginning, at the end of the treatment, and at 1-year follow-up. Wrist function, upper limb function, grip strength, and pain intensity were assessed with the Patient-Rated Wrist Evaluation (PRWE), Disabilities of the Arm, Shoulder, and Hand (DASH), Jamar dynamometer, and Visual Analogue Scale (VAS), respectively. **Results:** At 1-year follow-up, the PRWE showed a decrease of 21.6 points (Cohen's $d = 2.8$; 95% confidence interval [CI] = 18.6-24.6; $P < .05$); the DASH showed a decrease of 23.8 points (Cohen's $d = 2.9$; 95% CI = 20.8-26.7; $P < .05$); grip strength showed an increase of 40.6% (Cohen's $d = 5.0$; 95% CI = 43.5-37.6; $P < .05$); and the VAS showed a decrease of 2.6 cm (Cohen's $d = 1.9$; 95% CI = 2.11-3.16; $P < .05$). **Conclusion:** At 1-year follow-up, a physiotherapy program showed clinically and statistically significant results in all functional outcomes in elderly patients with CRPS I after extra-articular DRF.

Keywords: complex regional pain syndrome, distal radius fracture, functional outcomes, physiotherapy

Introduction

Distal radius fracture (DRF) is one of the most common musculoskeletal injuries.[1] Distal radius fractures in patients older than 60 years are typically treated conservatively with closed reduction and plaster cast immobilization.[2] The reported complication rates of DRF are highly variable, and complex regional pain syndrome type I (CRPS I) presents the highest levels of incidence.[3]

Complex regional pain syndrome type I is a chronic condition characterized by regional disabling pain (spontaneous or evoked); increased sensitivity to tactile stimuli, swelling, vasomotor, and sudomotor abnormality (sympathetic dysfunction); and impairment of motor function (weakness, tremor, and muscle spasms).[4] Nevertheless, the pathophysiological mechanisms underlying CRPS remain unclear.[5] Currently, an association of multiple mechanisms is proposed, such as maladaptive proinflammatory response and a disturbance in sympathetically mediated vasomotor control, together with maladaptive peripheral and central neuronal plasticity.[5]

Several clinical guidelines for the treatment of CRPS I recommend an interdisciplinary multimodal approach, comprising pharmacological and interventional pain management strategies together with physiotherapy, psychological therapy, and educational strategies.[6,7] Physiotherapy programs are considered the first-line treatment for CRPS I,

[1]Universidad de las Américas, Santiago, Chile
[2]Clinical Hospital San Borja Arriaran, Santiago, Chile
[3]Hand Team of Traumatology Institute of Santiago, Santiago, Chile

Supplemental material is available in the online version of the article.

Corresponding Author:
Héctor Gutiérrez-Espinoza, Exercise and Rehabilitation Sciences Laboratory, School of Physical Therapy, Faculty of Rehabilitation Sciences, Universidad Andres Bello, Santiago 7591538, Chile.
Email: kinehector@gmail.com

but systematic reviews have shown controversial results regarding their effectiveness in this clinical condition.[8,9]

To our knowledge, no previous prospective studies have reported the clinical effects of physiotherapy at 1-year follow-up in patients with CRPS I after DRF treated with closed reduction and cast immobilization. Thus, the main objective of this study was to evaluate at 1-year follow-up the functional effects of physiotherapy program in elderly patients with CRPS I after extra-articular DRF.

Materials and Methods

Study Design/Patients

This prospective observational study was approved by the ethics committee. Between February 2017 and February 2019, 72 elderly patients with CRPS I after extra-articular DRF were prospectively recruited. All patients were treated with closed reduction and plaster cast immobilization for a range of 6 to 8 weeks. In addition, the 3-point index was used to evaluate the displacement of the DRF.[10] After cast removal, all patients were prescribed acetaminophen (500 mg, every 8 hours, for 7 days).

The inclusion criteria for participants were: (1) being older than 60 years old with CRPS I based on the Budapest criteria[11]; and (2) accepting and signing the informed consent form. Conversely, patients with psychiatric treatment history before diagnosis with CRPS, with peripheral or central nervous system lesions affecting the upper limb, or with cardiac, pulmonary, or neurological diseases were excluded.

Interventions

All patients received supervised physiotherapy treatment consisting of 15 minutes of active wrist and hand exercises in a whirlpool at a temperature of 34°C, followed by joint mobilization applied to the radiocarpal joint. During the first 2 weeks, patients received grade II or III of the Maitland technique at a dose of 1 cycle per second for 1 minute. In the remaining 4 weeks, the sustained grade I glide Kaltenborn technique was performed in both the anteroposterior and posteroanterior directions. Finally, 3 specific exercises based on motor skill training were performed. To avoid pain and muscle fatigue, patients performed short-duration and low-intensity exercises (Supplemental Figure S1). The dose was 8 to 10 times for each exercise, maintaining the task for 5 seconds with 10 to 30 seconds of rest. The program consisted of 12 sessions, 2 times per week, for 6 weeks.[12,13]

Outcome Measures

Two blinded evaluators performed the functional outcome assessments at baseline, at the end of the 6-week intervention, and at 1-year follow-up. Both physiotherapists assessed the same number of patients.

Primary Outcome Measure

The Patient-Rated Wrist Evaluation (PRWE) questionnaire was used to assess wrist/hand pain and function.[14] The Spanish version of the PRWE showed good validity and reliability in patients with DRF.[15] A study showed that a decrease of 15 points on the PRWE questionnaire can be considered a minimal clinically important difference.[16]

Secondary Outcome Measures

The Disabilities of the Arm, Shoulder, and Hand (DASH) questionnaire was used to assess the upper limb function.[17] The transcultural adaptation to the Spanish language showed excellent results in terms of validity, reliability, and sensitivity to change.[18] A study showed that a decrease of 10 points on the DASH questionnaire can be considered a minimal clinically important difference.[19]

A Jamar dynamometer was used to assess the grip strength, and the measurements were used as recommended by the American Society of Hand Therapists.[20] The participants were evaluated while seated, with their arm placed to the side of the body; they had their shoulders in neutral position, the elbow flexed to 90°, and the forearm in neutral rotation. Then, patients were verbally instructed to make tight fists with all their strength and to hold that position for 4 seconds with their hands and then rest for 30 seconds for each set. First, the unaffected side was evaluated, and then the affected side was evaluated. In both cases, the highest value obtained from 3 attempts was recorded. An adjustment of 10% between the force of the dominant and nondominant sides was made.[21] The final result was expressed as a percentage relative to the unaffected side. This valid and reliable instrument serves as a reference standard for evaluating the gripping function in patients with DRF.[22]

The Visual Analogue Scale (VAS) was used to assess the pain intensity. The VAS has been shown to be a reliable and valid instrument to assess changes in pain intensity.[23] A study showed that a decrease of 1.4 cm on the VAS can be considered a minimal clinically important difference.[24]

Statistical Analysis

The parametric distribution of the continuous variables was checked using both the Kolmogorov-Smirnov test and the graphical procedures (normal probability plot). Descriptive statistics were used to describe the demographic and clinical characteristics of the patients and other potentially confounding variables. Continuous variables were presented as mean and standard deviation (SD), and categorical variables were presented as number and percentage. Analyses

Table 1. Baseline Characteristics of Elderly Patients With CRPS I After Extra-articular DRF.

Characteristics	Patients (n = 72)
Age, y, mean (SD)	52.8 (6.9)
Gender, No. (%)	
Female	67 (93.1)
Male	5 (6.9)
Height, m, mean (SD)	1.6 (1.8)
Weight, kg, mean (SD)	68.1 (9.1)
BMI, kg/m^2, mean (SD)	28.1 (3.1)
According to AO classification type of DRF, No. (%)	
A2	6 (8.3)
A3	48 (66.7)
B1	10 (13.9)
B2	8 (11.1)
Acceptable alignment of DRF, No. (%)	50 (69.4)
Immobilization time, wk, mean (SD)	6.3 (0.8)
Length of symptoms, wk, mean (SD)	5.8 (1.4)
Affected dominant hand, No. (%)	52 (72.2)
Comorbidities, No. (%)	
Diabetes	52 (72,2)
Smoking	29 (40.3)
Hypercholesterolemia	58 (80.6)
No. of comorbidities (diabetes, smoking, and hypercholesterolemia), No. (%)	
1	27 (37.5)
2	23 (31.9)
3	22 (30.6)
Education level, No. (%)	
Primary	22 (30.6)
Secondary	40 (55.6)
University	10 (13.9)
Physical activity level with RAPA, No. (%)	
Sedentary	16 (22.2)
Underactive	52 (72.2)
Active	4 (5.6)

Note. CRPS I = complex regional pain syndrome type I; DRF = distal radius fracture; BMI = body mass index; RAPA = rapid assessment of physical activity.

of variance were used to analyze the intragroup difference; for the difference between groups, Bonferroni post hoc correction was used. Finally, we calculated Cohen's *d* for the effect of supervised physiotherapy treatment, considering the effect to be trivial (<0.2), small (0.2-0.5), medium (0.5-0.8), or large (>0.8). The statistical significance was set at $P \leq .05$, and the analyses were performed using the software IBM SPSS 24 (SPSS Inc., Chicago, Illinois).

Results

The baseline information characteristics of the study group are shown in Table 1. Seventy patients (97.2%) were diagnosed with CRPS I between the third and fourth week after cast removal, and the patients started the supervised physiotherapy program at an average of 4.3 weeks (SD, 1.2) after the onset of symptoms. At the end of the physiotherapy program, there were no patient-informed complications associated with the treatment received, and at 1-year follow-up, there were no dropouts or withdrawals.

Table 2 shows the values of the outcomes assessed before and after the physiotherapy program and at 1-year follow-up, as well as the effect of the treatment. At the end of the treatment at 6 weeks, all variables showed a clinically and statistically significant difference ($P < .05$). At 1-year follow-up, the PRWE showed a decrease of 21.6 points (Cohen's $d = 2.8$; 95% confidence interval [CI] = 18.6-24.6; $P < .05$); the DASH showed a decrease of 23.8 points (Cohen's $d = 2.9$; 95% CI = 20.8-26.7; $P < .05$); grip strength showed an increase of 40.6% (Cohen's $d = 5.0$; 95% CI = 43.5-37.6; $P < .05$); and the VAS showed a decrease of 2.6 cm (Cohen's $d = 1.9$; 95% CI = 2.11-3.16; $P < .05$). In all outcomes assessed, the values of Cohen's *d* showed a large effect size ($d > 0.8$). Finally, to compare the results of all outcome measures with the minimum clinically important differences, the differences were clinically important and statistically significant ($P < .05$).

Discussion

This prospective study evaluated at 1-year follow-up the functional effects of a physiotherapy program in elderly patients with CRPS I after extra-articular DRF treated with closed reduction and cast immobilization. At 1-year follow-up, the physiotherapy program showed clinically important differences and statistical significance in all functional outcomes in these patients.

The incidence of CRPS after DRF varies from 1% to 37%. This range of incidence could be because of different criteria used by the authors, as there is a lack of criterion standard for diagnosing CRPS I.[25] The demographic data of the patients included in our study are similar to those described in the literature. Complex regional pain syndrome type I occurs frequently during the third and fourth week after cast removal, especially in women who report severe pain and impairment of physical quality of life.[25] Regarding the effectiveness of physiotherapy, a systematic review showed that a limited number of low-quality trials has studied various physiotherapy modalities of treatment.[9] The graded motor imagery and mirror therapy may provide clinically meaningful improvements in pain and function in people with CRPS I, although the quality of the supporting evidence is very low.[9] In addition, the effectiveness of multimodal physiotherapy, electrotherapy, and manual lymphatic drainage is generally absent or unclear.[9]

Our results do not support the findings of previous studies. A possible explanation for our results are the clinical and neurophysiological foundations of the applied

Table 2. Comparison of Results at Baseline, After Treatment, and at 1-Year Follow-up.

Outcome	Baseline, mean (SD)	At the end of treatment at 6 wk, mean (SD)	Mean difference (SD)	1-year follow-up, mean (SD)	Mean difference (SD)	Effect size (Cohen's d)	95% CI for Cohen's *d*	*P* value
PRWE	65.7 (7.6)	45.5 (7.5)	20.3 (2.5)*	23.8 (7.5)	21.6 (6.2)	2.8	18.6-24.6	.000[a]
DASH	73.0 (6.0)	48.4 (8.5)	24.8 (5.0)*	24.5 (7.6)	23.8 (5.2)	2.9	20.8-26.7	.000[a]
Grip strength	16.8 (6.2)	24.2 (7.5)	7.6 (3.2)*	64.8 (8.9)	40.6 (8.2)	5.0	43.5-37.6	.000[a]
VAS	7.2 (1.3)	4.1(1.6)	3.1 (0.5)*	1.5 (1.0)	2.6 (0.6)	1.9	2.11-3.16	.000[a]

Note. CI = confidence interval; PRWE = Patient-Rated Wrist Evaluation; DASH = Disabilities Arm Shoulder and Hand; VAS = Visual Analogue Scale.
[a]Difference at the end of treatment and 1-year follow-up.
*Statistically significant difference at baseline and after treatment: $P < .001$.

standardized physiotherapy program. All patients began with 15 minutes of active wrist and hand exercises in a whirlpool, and we used thermoneutral water immersion (34°C), which decreases the activity of the sympathetic nervous system; when combined with the effects of hydrostatic pressure, it helps reduce edema and pain perception.[26] Then, joint mobilization was used in the first 2 weeks of treatment, when pain levels are high, oscillatory techniques are better tolerated, and there is more effective pain relief and increased wrist function in patients with DRF. From week 3, when pain levels are lower, mainly at rest, sustained gliding techniques are more effective in these patients.[27]

The current evidence supports sensorimotor system alterations as the most clinically relevant impairment after DRF.[28] These deficits have been suggested to result from cortical reorganization, which would be influentially associated with persistent and recurrent pain, and have been significantly correlated with poor results in reported functionality and disability.[29] The gradual reintroduction of functional activity using therapeutic exercise with a focus on graduated corticomotor retraining is founded on the neurophysiology of motor learning.[29] The conscious and voluntary learning of specific motor skills, such as control of scapular retraction, gradual wrist prehensile activity, and subtle manual skills, requires precision, decreasing the fear of the perceived threat of pain, reducing local rigidity, and modifying the cortical representation of the musculature affected by trauma.[29]

Pain management is essential in this clinical condition, although there are no published studies that have investigated how pain interference can influence the response to physiotherapeutic treatment in elderly patients with CRPS I after extra-articular DRF. One study in patients with chronic pain showed that if the patient presents with low interference on both activity and affective interference dimensions, the probability of benefiting from the multidisciplinary treatment is good: less weight problems, regular exercising, better mood, and the most helpful psychological reactions to pain among these patients.[30] However, there are few studies that have investigated the effectiveness of physiotherapy in patients with CRPS I after DRF.[9] According to our findings, 2 clinical trials showed that graded motor imagery and mirror therapy are effectives in pain reduction and wrist function in these patients.[31,32] However, no previous prospective studies have reported the clinical effects of physiotherapy at 1-year follow-up.

This study has a few limitations. First, as it is an observational study, it does not have a control group. Second, there was no randomized sample strategy to select the patients. Third, the lack of control for confounding factors inherent in observational studies may have caused overestimation of the treatment effects. Finally, all these considerations must be examined when attempting to extrapolate the results of our study to patients younger than 60 years with CRPS I after DRF or to patients with intra-articular DRF treated surgically.

In summary, at 1-year follow-up, a physiotherapy program showed clinically and statistically significant results in all functional outcomes in elderly patients with CRPS I after extra-articular DRF. Our results must be interpreted in the context of the studied population. Future studies are needed to verify these findings in younger patients or intra-articular DRF treated surgically while controlling confounding factors that could influence functional outcomes in these patients.

Author note

Héctor Gutiérrez-Espinoza is now affiliated to Exercise and Rehabilitation Sciences Laboratory, School of Physical Therapy, Faculty of Rehabilitation Sciences, Universidad Andres Bello, Santiago 7591538, Chile.
Jonathan Zavala-González is now affiliated to Rehabilitation in Health Research Center (CIRES), Universidad de las Américas. Santiago, Chile.

Ethical Approval

The Ethics Committee of the Central Metropolitan Health Service of Chile approved the study protocol on January 4, 2017 (number 142/2017).

Statement of Human and Animal Rights

All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation

(institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008.

Statement of Informed Consent

Informed consent was obtained from all patients enrolled in this study.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

ORCID iDs

Héctor Gutiérrez-Espinoza https://orcid.org/0000-0002-4650-3426
Rodrigo Gutiérrez-Monclus https://orcid.org/0000-0001-9491-1179

References

1. Singer BR, McLauchlan GJ, Robinson CM, et al. Epidemiology of fractures in 15,000 adults: the influence of age and gender. *J Bone Joint Surg Br*. 1998;80(2):243-248.
2. Huetteman HE, Shauver MJ, Malay S, et al. Variation in the treatment of distal radius fractures in the United States: 2010 to 2015. *Plast Reconstr Surg*. 2019;143(1):159-167.
3. Turner RG, Faber KJ, Athwal GS. Complications of distal radius fractures. *Hand Clin*. 2010;26(1):85-96.
4. de Mos M, Sturkenboom MC, Huygen FJ. Current understandings on complex regional pain syndrome. *Pain Pract*. 2009;9(2):86-99.
5. Bruehl S. An update on the pathophysiology of complex regional pain syndrome. *Anesthesiology*. 2010;113(3):713-725.
6. Perez RS, Zollinger PE, Dijkstra PU, et al. Evidence based guidelines for complex regional pain syndrome type 1. *BMC Neurol*. 2010;10:20.
7. Harden RN, Oaklander AL, Burton AW, et al. Complex regional pain syndrome: practical diagnostic and treatment guidelines, 4th edition. *Pain Med*. 2013;14(2):180-229.
8. Daly AE, Bialocerkowski AE. Does evidence support physiotherapy management of adult Complex Regional Pain Syndrome Type One? A systematic review. *Eur J Pain*. 2009;13(4):339-353.
9. Smart KM, Wand BM, O'Connell NE. Physiotherapy for pain and disability in adults with complex regional pain syndrome (CRPS) types I and II. *Cochrane Database Syst Rev*. 2016;2:CD010853.
10. Alemdaroğlu KB, Iltar S, Aydoğan NH, et al. Three-point index in predicting redisplacement of extra-articular distal radial fractures in adults. *Injury*. 2010;41(2):197-203.
11. Harden NR, Bruehl S, Perez RSGM, et al. Validation of proposed diagnostic criteria (the "Budapest Criteria") for Complex Regional Pain Syndrome. *Pain*. 2010;150(2):268-274.
12. Gutiérrez-Espinoza H, Rubio-Oyarzún D, Olguín-Huerta C, et al. Supervised physical therapy vs home exercise program for patients with distal radius fracture: a single-blind randomized clinical study. *J Hand Ther*. 2017;30(3):242-252.
13. Gutiérrez-Espinoza H, Tabach-Apraiz A, Oyanadel-Maldonado M. Physical therapy in patients with complex regional pain syndrome type I after distal radius fracture: a case series. *J Phys Ther Sci*. 2019;31(4):403-407.
14. MacDermid JC. Development of a scale for patient rating of wrist pain and disability. *J Hand Ther*. 1996;9(2):178-183.
15. Alfie V, Gallucci G, Boretto J, et al. Patient-rated wrist evaluation: Spanish version and evaluation of its psychometric properties in patients with acute distal radius fracture. *J Wrist Surg*. 2017;6(3):216-219.
16. Walenkamp MM, de Muinck Keizer RJ, Goslings JC, et al. The minimum clinically important difference of the patient-rated wrist evaluation score for patients with distal radius fractures. *Clin Orthop Relat Res*. 2015;473(10):3235-3241.
17. Hudak PL, Amadio PC, Bombardier C. Development of an upper extremity outcome measure: the DASH (Disabilities of the Arm, Shoulder and Hand) [corrected]. The Upper Extremity Collaborative Group (UECG). *Am J Ind Med*. 1996;29(6):602-608.
18. Hervás MT, Navarro Collado MJ, Peiró S, et al. Spanish version of the DASH questionnaire. Cross-cultural adaptation, reliability, validity and responsiveness. *Med Clin*. 2006;127(12):441-447.
19. Franchignoni F, Vercelli S, Giordano A, et al. Minimal clinically important difference of the disabilities of the arm, shoulder and hand outcome measure (DASH) and its shortened version (QuickDASH). *J Orthop Sports Phys Ther*. 2014;44(1):30-39.
20. Richards L, Palmiter-Thomas P. Grip strength measurement: a critical review of tools, methods, and clinical utility. *Crit Rev Phys Rehabil Med*. 1996;8(1-2):87-109.
21. Crosby CA, Wehbé MA, Mawr B. Hand strength: normative values. *J Hand Surg Am*. 1994;19(4):665-670.
22. Roberts HC, Denison HJ, Martin HJ, et al. A review of the measurement of grip strength in clinical and epidemiological studies: towards a standardised approach. *Age Ageing*. 2011;40(4):423-429.
23. McCormack HM, Horne DJ, Sheather S. Clinical applications of visual analogue scales: a critical review. *Psychol Med*. 1988;18(4):1007-1019.
24. Tashjian RZ, Deloach J, Porucznik CA, et al. Minimal clinically important differences (MCID) and patient acceptable symptomatic state (PASS) for visual analog scales (VAS) measuring pain in patients treated for rotator cuff disease. *J Shoulder Elbow Surg*. 2009;18(6):927-932. doi:10.1016/j.jse.2009.03.021.
25. Jellad A, Salah S, Ben Salah Frih Z. Complex regional pain syndrome type I: incidence and risk factors in patients with fracture of the distal radius. *Arch Phys Med Rehabil*. 2014;95(3):487-492.

26. Barker AL, Talevski J, Morello RT, et al. Effectiveness of aquatic exercise for musculoskeletal conditions: a meta-analysis. *Arch Phys Med Rehabil*. 2014;95(9):1776-1786.
27. Coyle JA, Robertson VJ. Comparison of two passive mobilizing techniques following Colles' fracture: a multi-element design. *Man Ther*. 1998;3(1):34-41.
28. Valdes K, Naughton N, Algar L. Sensorimotor interventions and assessments for the hand and wrist: a scoping review. *J Hand Ther*. 2014;27(4):272-285.
29. Moseley GL, Flor H. Targeting cortical representations in the treatment of chronic pain: a review. *Neurorehabil Neural Repair*. 2012;26(6):646-652.
30. Miettinen T, Kautiainen H, Mäntyselkä P, et al. Pain interference type and level guide the assessment process in chronic pain: categorizing pain patients entering tertiary pain treatment with the Brief Pain Inventory. *PLoS ONE*. 2019;14(8):e0221437.
31. Moseley GL. Graded motor imagery is effective for long-standing complex regional pain syndrome: a randomised controlled trial. *Pain*. 2004;108(1-2):192-198.
32. Moseley GL. Is successful rehabilitation of complex regional pain syndrome due to sustained attention to the affected limb? A randomised clinical trial. *Pain*. 2005;114(1-2):54-61.