

Tele-rehabilitation program in patients with distal radius fracture: a controlled clinical trial

Programa de telerrehabilitación en pacientes con fractura de radio distal: ensayo clínico controlado

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Abstract

Objective: To determine the effectiveness of tele rehabilitation versus supervised treatment in the functional recovery of patients with distal radius fracture. **Method:** A randomized clinical trial was conducted that included 91 patients with distal radius fractures grades AO23 A and AO23B, which were randomly assigned to a treatment group, the supervised rehabilitation group received for two weeks a program of 10 treatment sessions and the tele rehabilitation group received through the Moodle platform instructions to carry out the rehabilitation program. Outcome measures (functionality, active range of motion, hand grip strength, quality of life and pain) were measured at the time of admission to rehabilitation and at 1, 3 and 6 months. **Results:** In both treatment groups at 6 months, statistically significant intragroup differences in functionality were demonstrated, with no intergroup differences. **Conclusions:** At 6 months, both rehabilitation programs increase functionality, range of motion, quality of life and decrease pain, without statistically significant differences intergroup.

Keywords: Distal radius fracture. Tele rehabilitation. Physiotherapy. Functionality. Quality of life.

Resumen

Objetivo: Determinar la efectividad de la telerrehabilitación en comparación con el tratamiento supervisado en la recuperación funcional de los pacientes con fractura de radio distal. **Método:** Se realizó un ensayo clínico aleatorizado que incluyó 91 pacientes con fracturas de radio distal de grados AO23A y AO23B, los cuales se asignaron aleatoriamente a un grupo de rehabilitación supervisado que recibió durante 2 semanas un programa de 10 sesiones de tratamiento o un grupo de telerrehabilitación que mediante la plataforma de Moodle recibió instrucciones para realizar el programa de rehabilitación. Las medidas de resultado (funcionalidad, rango de movimiento activo, fuerza de prensión de la mano, calidad de vida y dolor) se midieron en el momento del ingreso a rehabilitación y a los 1, 3 y 6 meses. **Resultados:** A los 6 meses, ambos grupos de tratamiento demostraron diferencias estadísticamente significativas intragrupo en la funcionalidad, sin diferencias intergrupo. **Conclusiones:** A los 6 meses, ambos programas de rehabilitación aumentan la funcionalidad, el rango de movimiento y la calidad de vida, y disminuyen el dolor, sin diferencias estadísticamente significativas intergrupo.

Palabras clave: Fractura de radio distal. Telerrehabilitación. Fisioterapia. Funcionalidad. Calidad de vida.

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Introduction

Distal radius fractures are among the most frequent fractures worldwide. In the United States, they are the second most common upper limb fracture, with an estimated annual incidence of 643 000¹, representing 1.5% of visits to the ER for hand and forearm fractures, following fractures of the radius and ulna². In the United Kingdom, the National Health Service estimated a mean daily cost of £1375.34 per patient with surgical fixation of distal radius fracture³. In the United States, Medicare system estimated a cost of over \$170 million for the management of these fractures⁴. After a variable period of immobilization, these patients are generally referred to rehabilitation services, increasing the cost of care. The cost of hospital physical therapy is estimated at £82.03 per day, and outpatient physical therapy at £40.70³.

Despite several studies, it is still unclear which type of therapy has the most significant impact on wrist function recovery, range of motion, and strength⁵. Currently, studies show that home programs are as effective as supervised rehabilitation programs^{6,7}; however, other studies indicate the opposite⁸⁻¹⁰.

The COVID-19 pandemic has imposed new paradigms of care for distal radius fractures, now recommended to be treated as non-emergent and conservative. Therefore, it is necessary to establish rehabilitation strategies to continue treating patients without exposing them to the risk of infection. In this regard, the World Confederation for Physical Therapy has proposed the online practice of rehabilitation services (telemedicine)^{11,12}. Therefore, the aim of this study was to determine the effectiveness of telerehabilitation compared to supervised therapy in the functional recovery of patients with distal radius fractures.

Method

Approval for the study was obtained from the regional hospital local research and ethics committee no.1 (R-2020-3201-153), and all patients agreed to participate and the publication of results.

We conducted a randomized, controlled, parallel treatment trial protocol. Using computer-generated random numbers, hidden allocation was performed (sequential and sealed envelopes filled by a person unrelated to the study), administered by the project coordinator after the patients' acceptance to enter the

study. Due to the nature of the intervention, both participants and investigators alike were blinded to the intervention.

The first group received a supervised rehabilitation program and was considered the control group, receiving a 10-session program over a 2-week period, including external heat application, stretching, mobilization, strengthening, and occupational therapy focused on improving essential functions and strengthening extrinsic and intrinsic hand musculature, effectiveness in wrist mobility, and simulation of specific activities to go back to work.

Members of the second group were provided with the Moodle application on their cell phones to access the online content of the distal radius fracture rehabilitation program, where they received self-care advice and the type of exercises that should be performed. The program included hydrotherapy, mobility exercises, muscle strengthening, and activities to improve wrist and hand function, with planned objectives for 4 full weeks.

Participants in both groups received written exercise material, training, and advice on how to return to work and leisure activities. Each patient kept a weekly record of the therapy they had given administered, including the day, type, and time of their exercise development.

From November 2020 through April 2021, men and women older than 15 years with AO23 A and AO23 B type distal radius fractures were included, with prior immobilization for 6 weeks (with or without surgical fixation), with indication from the orthopedic physician to undergo rehabilitation, and who had a mobile phone and internet access.

Patients with distal radius fractures were excluded if they showed any of the following radiographic findings: > 12° tilt, > 23° radial tilt, and > 12 mm radial height. Patients with neurological problems, illiteracy, presence of pressure ulcers in the distal third of the forearm or hand that did not heal, users of orally or IV administered steroids, with preexisting arthritis or osteoarthritis of the wrist, or with a history of injury were also excluded. Participants with < 80% compliance to treatment were eliminated.

Sample size calculation

A minimum clinically important difference of 14 points was considered on the Disabilities of the Arm, Shoulder, and Hand (DASH) functionality scale, with a standard deviation of 20, a significance level of 5%,

a statistical power of 80%, and an estimated loss of 20% for sample size calculation¹³. The formula used for sample size calculation was the difference of means for 2 independent groups:

$$n = \frac{2(Z_{\alpha} + Z_{\beta})^2 * S^2}{d^2}$$

Thus, the sample size was 44 subjects per group.

Procedures and equipment

Each patient was assigned a folio number, including their file with sociodemographic, clinical, and functional data obtained from the DASH scale. Quality of life was measured using the SF-36 survey. A commercial goniometer was used to measure the wrist range of motion, and the CAMRY electronic hand dynamometer, model EH101, was used to measure strength. For all, the arithmetic mean was calculated after 3 consecutive attempts, maintaining maximum grip strength for 4 seconds, with a 1-minute interval, as previously described^{14,15}. The visual analog scale was used for pain evaluation.

Outcome assessment

All participants were assessed for function, wrist range of motion, hand grip strength, quality of life, and pain at baseline and at 4, 12, and 24 weeks.

Regarding compliance, all patients from group #1 reported attending their therapies on time and filling their record card, completing the treatment cycles. In group #2, compliance was estimated between 81% and 90%. Patients had to repeat home exercises daily, which was monitored via phone calls, an exercise diary, and an checklist.

Statistical analysis

Qualitative variables were expressed as absolute and relative frequencies, and quantitative ones as measures of central tendency and dispersion. A univariate general linear model (ANCOVA) was used for comparing quantitative variables between treatment groups, considering the study variable (functionality, quality of life, pain, range of motion arcs, and hand grip strength) as the dependent variable and the study group as the independent variable. The model was adjusted for age, sex, and type of treatment.

The paired t-test was used to analyze intra-group dependent variables at the beginning and end of

Table 1. General characteristics of the study sample (n = 91)

Supervised (n = 46)	Telerehabilitation (n = 45)	Total (n = 91)	p
Age (years)*	47.17 ± 13.1	43.69 ± 13.8	45.4 ± 13.5
Female sex†	27 (58.7)	25 (55.6)	52 (57.1)
Right side affected†	45 (97.8)	43 (95.6)	88 (96.7)
Low-energy injuries†	30 (65.2)	29 (64.4)	59 (64.8)
Extension injury†	23 (50.0)	23 (51.1)	46 (50.5)
Flexion injury†	10 (21.7)	4 (8.9)	14 (15.4)
Surgical treatment†	21 (45.7)	22 (48.9)	43 (47.3)
Disability days*	90.23 ± 28.2	84.33 ± 26.4	87.3 ± 27.3

*Data are expressed as mean ± standard deviation.

†Data are expressed as n (%).

follow-up. Statistical significance was established as $p < 0.05$. IBM-SPSS Software® v21 was used for statistical analysis.

Results

A total of 110 patients with distal radius fractures were identified, 10 of whom were excluded from the study for presenting radius and ulna fractures, thus assigning 50 patients to each group. Subsequently, 7 patients were eliminated for not following treatment, and 2 for abandoning it (4 in the control group and 5 in the rehabilitation group) (Fig. 1).

The final sample consisted of 91 patients (46 in the control group and 45 in the experimental one), of whom more than 50% were women, with a mean age of 45 years. Almost 100% of the injuries were on the right side, while 65% were low-energy injuries, being forced extension the most frequent mechanism of injury. Less than 50% of fractures were treated surgically, with a mean of 87 days of disability. No statistically significant differences were found between the 2 groups (Table 1).

Type AO23 A fracture occurred in 55.5% of the supervised group vs 62.2% of the telerehabilitation group; type OA23B occurred in 43.5% of the supervised group vs 37.8% of the telerehabilitation group. No statistically significant differences were found either.

At 24 weeks, both treatment groups showed statistically significant differences in functionality, wrist range of motion, quality of life, and reduction of pain, with no inter-group differences except for hand grip strength (Tables 2 and 3).

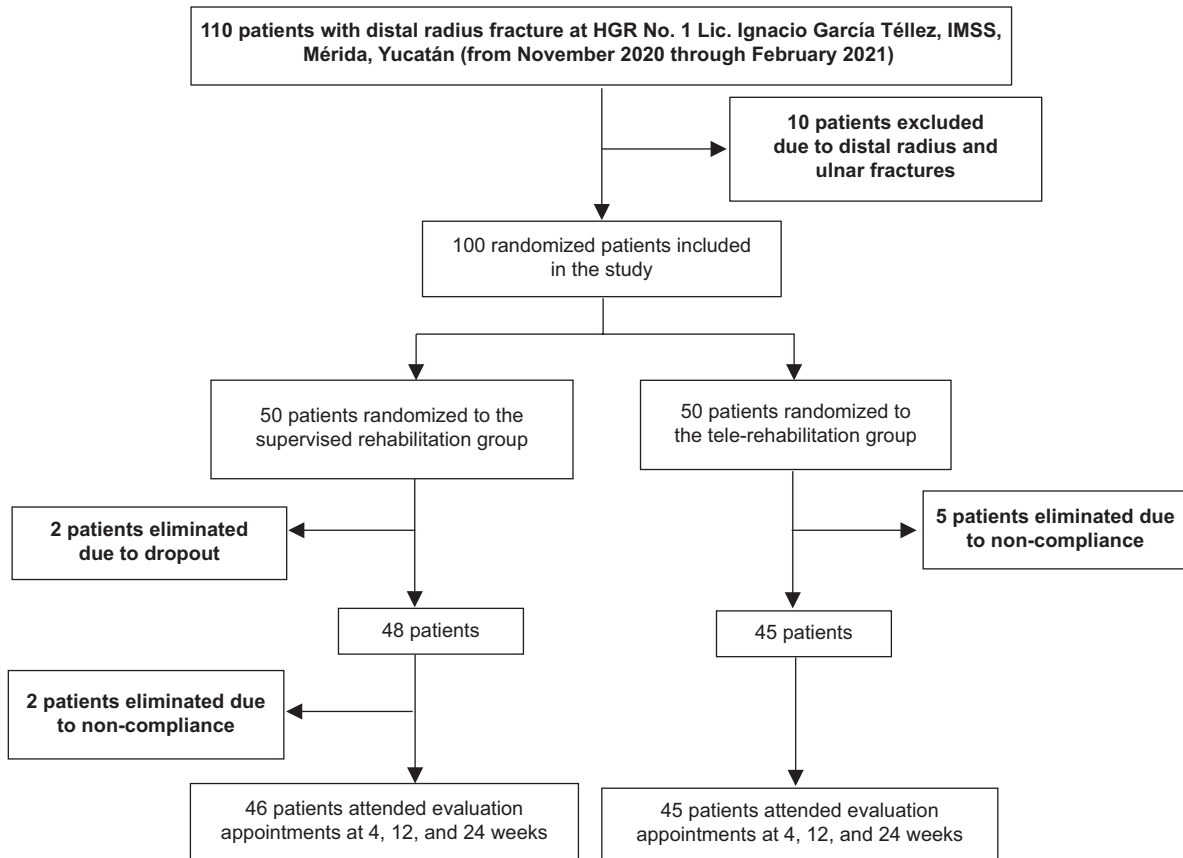


Figure 1. Flowchart of patient selection with distal radius fracture.

At the end of the study, 8 patients experienced residual pain (5 from the supervised therapy group and 3 from the telerehabilitation group), and 6 patients had difficulty fully closing their hand (three in the supervised therapy group and three in the telerehabilitation group).

One patient from the supervised therapy group experienced dislocation of the ulna bone after a fall from his support surface, requiring conservative treatment. On the other hand, a patient from the telerehabilitation group developed hypoesthesia in the area of the radial nerve of the affected hand, confirmed by electroneuromyography, revealing axonal sensory neuropathy of the radial nerve. There were no cases of malunion, nonunion, tendon rupture, or soft tissue infection.

Discussion

In this study, at 24 weeks, both treatment groups showed statistically significant differences in functionality, wrist range of motion, quality of life, and pain reduction, with no inter-group differences being reported; only an inter-group difference was found in hand grip strength,

with better results in the telerehabilitation group from 12 weeks onwards.

The mean age the study participants was 45 years, which is similar to the mean age reported by Egund et al.¹⁶ in the Swedish population and Handoll and Elliott¹⁰ in the United Kingdom. A total of 57% of the patients were women, which is similar to the findings made by Handoll and Elliott¹⁰ in the United Kingdom and Azad et al.¹⁷ in Southern California, although lower than that described by Rundgren et al.¹⁸ in Sweden. The most frequent injury mechanism was low energy (65%), with the hand in extension, which is consistent with the findings made by MacIntyre and Sander et al.¹⁹ (73.1%), who demonstrated that the most common injury in adults results from low-energy trauma after sustaining a fall from their height.

The most common fracture type was AO23A, which is similar to the fracture type reported by the study conducted by Sander et al.¹⁹, who reported a prevalence of 43.3%, being subtype A2 present in 39.6% of the patients younger than 65 years.

A total of 52% of the patients in this study received conservative treatment, which is a similar rate to that

Table 2. Active range of motion and grip strength of the hand by treatment group

Variable	Group	Evaluation time									
		Baseline		4 weeks		12 weeks		24 weeks		Baseline - 24 weeks	
		Mean ± SD	p	Mean ± SD	p	Mean ± SD	p	Mean ± SD	p	Intra-group p	
Flexion of the wrist of the affected side (degrees)	Supervised	38.61 ± 16	0.87	50.65 ± 16	0.11	57.48 ± 13	0.57	60.48 ± 11	0.30	< 0.05*	
	Telerehabilitation	38.71 ± 11.37		53.02 ± 11		56.93 ± 9		59.91 ± 8		< 0.05*	
Extension of the wrist of the affected side (degrees)	Supervised	18.63 ± 22	0.74	42.26 ± 22	0.27	49.48 ± 18	0.22	53.57 ± 17	0.43	< 0.05*	
	Telerehabilitation	21.69 ± 19		43.96 ± 17		49.02 ± 16		51.49 ± 15		< 0.05*	
Radial deviation of the affected wrist (degrees)	Supervised	9.57 ± 10	0.58	17.13 ± 11	0.90	20.43 ± 10	0.99	21.65 ± 10	0.95	< 0.05*	
	Telerehabilitation	10.36 ± 9		18.80 ± 10		20.84 ± 8		22.19 ± 8		< 0.05*	
Ulnar deviation of the wrist of the affected side (degrees)	Supervised	19.13 ± 11	0.70	25.70 ± 10	0.35	29.52 ± 8	0.68	31 ± 7	0.70	< 0.05*	
	Telerehabilitation	20.62 ± 9		28 ± 9		29.96 ± 7		30.88 ± 7		< 0.05*	
Grip strength of the side of the affected side (kg)	Supervised	5.22 ± 4	0.0†	9.98 ± 7	0.07*	12.09 ± 7	0.00†	14.33 ± 7	0.00†	< 0.05*	
	Telerehabilitation	7.08 ± 5		12.46 ± 6		15.33 ± 7		18.19 ± 8		< 0.05*	

*Statistically significant differences within the group ($p < 0.05$).†Statistically significant differences between groups ($p < 0.05$).**Table 3. Comparison of functionality, quality of life, and pain by treatment group**

Variable	Supervised (Mean ± SD)	Telerehabilitation (Mean ± SD)	Inter-group p-value
DASH			
Baseline	66.40 ± 19.29	58.06 ± 21.41	0.23
4 weeks	38.48 ± 25.03	28.70 ± 19.33	0.12
12 weeks	20.57 ± 18.46	13.66 ± 11.68	0.18
24 weeks	9.93 ± 11.34	5.95 ± 6.21	0.32
Intra-group p	0.003*	< 0.001	
SF-36			
Baseline	68.3 (19.0)	69 (14.8)	0.20
4 weeks	75.5 (15.4)	74.8 (13.6)	0.37
12 weeks	77.9 (14.5)	79.8 (11.5)	0.60
24 weeks	81.5 (17.1)	82.7 (10.9)	0.20
Intra-group p	0.001*	< 0.001*	
EVA			
Baseline	4.7 ± 2.7	4.8 ± 2.8	0.43
4 weeks	2.6 ± 2.9	2.8 ± 2.7	0.97
12 weeks	1.9 ± 2.6	1.3 ± 1.9	0.13
24 weeks	0.9 ± 1.7	0.7 ± 1.1	0.75
Intra-group p	0.001*	< 0.001*	

*Statistically significant intra-group difference ($p < 0.05$).

DASH, Disabilities of the Arm, Shoulder and Hand; EVA, Visual Analog Scale; SF-36, Short Form Health Survey.

was reported by Azad et al.¹⁷ in their study. Intra- and inter-group analyses were performed for range of motion arcs, comparing functionality at the beginning and at the end, finding statistically significant differences for all variables in the intra-group comparison, while no differences were found in the inter-group

comparison except for hand grip strength. These results are similar to those reported by Wakefield and McQueen²⁰, who found significant improvement in joint mobility range for flexion and extension at the 6-month follow-up. There was also a statistically significant increase in hand grip strength in both groups at 12 and 24 weeks, with an absolute gain of 9 kg in the supervised therapy group and 11 kg in the telerehabilitation group, which was statistically significant; however, this difference is not valid since these variables were not homogeneous from the beginning of the study. The difference in strength reported between the beginning and the end in both groups is similar to that reported by Challis et al.²¹, who described a 9.3 kg increase in a group of patients who received a statistically significant 10-week course of face-to-face physical therapy.

Different former studies suggest that home programs are more effective than supervised programs for increasing functional recovery^{6,7,20,22-24}. However, other authors have not found any differences between patients who did home exercises and those who received professional follow-up care from therapists^{8,9}. In our study, the supervised physical therapy group received a mean 10 sessions, which was not a factor that affected the results, as in several studies comparing the effectiveness of supervised physical therapy vs home exercises, the difference in the number of sessions between the 2 varied from 3 to 12 sessions, showing similar effectiveness^{7,9,20,25,26}.

The improvement in functionality was slightly higher in the home program group, although a statistically nonsignificant difference was reported. According to a study, the most critical factor in hand functionality recovery is treatment compliance²⁷. Based on this, we believe patients with distal radius fractures should be encouraged to take responsibility for treatment compliance to promote functional recovery. In studies where higher functionality has been reported in home programs, researchers believe that in supervised programs, therapists may be too cautious in treating these patients, which may limit patients from doing exercises beyond the point where they become painful, resulting in slower recovery²⁸.

Supervised therapy should be spared for patients with poor or suboptimal fixation, and with complications after fixation with a volar locking plate, including complex regional pain syndrome and carpal tunnel syndrome²⁴.

Regarding quality of life, as expected, both groups had higher function and quality of life, with no inter-group differences being reported as in former studies^{20,23}.

Subacute complications were mainly mechanical symptoms, which is consistent with the description given by Azad et al.¹⁷, who reported a prevalence of 2.06% of this type of complication in their population, among which residual pain and incomplete hand closure attributed to finger stiffness were stressed out, in a rate < 16% reported by Moore and Leonardi-Bee²⁹. The most frequent causes of these complications are inadequate immobilization with plaster, edema, unmanageable pain, lack of patient cooperation, lack of understanding when doing the exercises, or no motivation³⁰; this may persist up to 1 year after distal radius fracture³¹. However, long-term follow-up for late complications was not part of the objectives of this study.

We estimate that patients with distal radius fractures often achieve optimal strength, range of motion, and functionality within 3-6 months after sustaining the injury, regardless of whether treatment is conservative or surgical²⁹. A 7-year follow-up prospective study of women older than 50 years with distal radius fractures revealed that 15% of them were more likely to have significant functional decline attributed to the musculoskeletal system's status (including bone loss), body mass index, general health status, and associated comorbidity³².

The management of musculoskeletal conditions through real-time telerehabilitation effectively achieves a significant improvement in physical function and pain³³, which makes it a feasible option thanks to its low cost and the patient's adequate commitment to perform and complete their routine.

Most patients reported feeling comfortable with the platform. In their own words, it is easy to access, find, and understand rehabilitation therapy instructions, with clear guidance and simple visualization of videos. This study did not analyze this aspect, but it would be interesting to do so in future studies.

Study limitations

The main issues reported by our patients were technical aspects, such as accessing an internet connection, and an unstable signal in remote or hard-to-reach communities, as well as individuals with limited financial resources who could not afford internet access for long periods of time. Older adults who were afraid due to their poor technological skills overcame this barrier by having caregivers or close family members use a cellphone with internet access. Another limitation was the difference in functionality at the beginning of the study between both groups, which limited the comparison of effectiveness at the end of follow-up.

Strengths found

We consider the main strengths of the study to be its methodological design, complete patient follow-up, and sample size.

Implications for the routine clinical practice

Based on these results, we consider remote rehabilitation through digital platforms to be an effective option for improving short- and long-term functionality in patients with uncomplicated distal radius fractures. We also believe that emphasis should be placed on patient education to make sure they take responsibility and improve treatment compliance, thereby enhancing their functionality.

Conclusions

The telerehabilitation program in patients with uncomplicated distal radius fractures increased functionality, quality of life, pain, and range of motion in a similar way compared to supervised rehabilitation. Therefore, telerehabilitation in these patients is considered a feasible option to improve functionality and quality of life, with the advantages of avoiding patient travel to the rehabilitation unit, reducing costs, and preventing rehabilitation service overload.

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Conflicts of interest

None declared.

Ethical disclosures

Protection of human and animal subjects. The authors declare that no experiments were performed on humans or animals for this study.

Confidentiality of data. The authors declare that they have followed the protocols of their work center on the publication of patient data.

Right to privacy and informed consent. The authors have obtained the written informed consent of the patients or subjects mentioned in the article. The corresponding author is in possession of this document.

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