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Manual passive rehabilitation program for geriatric distal radius fractures

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Abstract

Limitation of wrist range of motion (ROM) is a common complication of distal radius fractures (DRFs) in geriatric patients. The present study aimed to evaluate the effectiveness of rehabilitation in the restoration of wrist ROM after geriatric DRF. Eighty-eight geriatric patients with DRF, 59 women and 29 men aged 71.69 ± 6.232 years participated in the study. The time from wrist immobilization to rehabilitation was 12.89 ± 5.318 weeks. Daily rehabilitation was performed 30 minutes a day for 8 weeks. Active wrist ROM was measured before and at 2, 4, and 8 weeks after rehabilitation. Data were analyzed by the repeated measures multivariate analysis of variance (MANOVA), one-way MANOVA, and analysis of variance (ANOVA). Repeated measures MANOVA suggested a significant time effect for ROM (Wilks Lambda = 0.002, F = 7500.795, P < .001). Compared with before rehabilitation, each wrist ROM was significantly improved at 2, 4, and 8 weeks after rehabilitation. The one-way MANOVA demonstrated that changes in ROM were significantly different between groups (Wilks Lambda = 0.007, F = 559.525, partial eta square = 0.993, P < .001), indicating that patients in the short-term stiffness group (≤3 months) had a significantly greater increase in ROM than patients in the long-term stiffness group (>3 months). The results of this study suggest an 8-week daily rehabilitation program for geriatric patients with limited ROM <3 months after DRF.

Abbreviations: AO = Arbeitsgemeinschaft fur Osteosynthesefragen, ANOVA = analysis of variance, DRF = distal radius fracture, MANOVA = multivariate analysis of variance, ROM = range of motion, SPSS = Statistical Product and Service Solutions, STROBE = strengthening the reporting of observational studies in epidemiology.

Keywords: distal radius fracture, range of motion, rehabilitation, wrist stiffness

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The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

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1. Introduction

Since the human species as a whole is growing older, medical services should be prepared to meet the needs of an older population.[1] In the elderly population, distal radius fracture (DRF) is common, with an incidence between 200 and 1200 per 100,000 person-years.[2,3] In the geriatric population over 65 years, DRFs are the second most common fractures after hip fractures, and they account for almost one-fifth of all fractures in this age group.[4,5] In the majority of patients, DRF does not cause any limitations to daily activities; however, residual disability is not uncommon, especially in elderly patients.[6,7]

Many factors, including patients' general health, the mechanism of injury, articular involvement, associated injuries, medical comorbidities, and drug therapies, may affect the healing of DRF, rehabilitation, and functional recovery of the upper extremity.[7,8] Nonoperative treatment with a cast has been suggested as the primary treatment modality in patients aged over 65 years.[9] Prolonged immobilization of the wrist joint in casts usually makes early rehabilitation impossible in geriatric DRF. If controlled mobilization is not initiated as early as fracture healing permits, permanent stiffness, and residual disability may result, especially in geriatric patients.[10,11]

There is a plethora of literature regarding how to prevent wrist complications in the management of DRFs.[12] No study has detailed the management of wrist stiffness in geriatric patients with DRFs in the late rehabilitation process. Therefore, this study aimed to investigate the immediate short-term effects of the passive rehabilitation method for improving wrist range of motion (ROM) during a therapy session for geriatric patients with wrist stiffness after DRF. A secondary purpose of this study was to determine if there were any differences in ROM change between the short and long stiffness groups. A third purpose of this study was to determine the optimum duration of rehabilitation for patients with short- and long-stiffness.

2. Methods

The study was reported in accordance with the strengthening the reporting of observational studies in epidemiology (STROBE) guidelines. It was designed as a retrospective single-center study and approved by the Institutional Review Board of the Third Hospital of Hebei Medical University (#W2020-060-1). Due to the retrospective nature of our study, the requirement for informed consent was waived.

2.1. Inclusion and exclusion criteria

Between April 2017 and October 2019, patients who underwent surgical or conservative treatment for acute DRFs and received rehabilitation carried out by the physical therapist, WZ, in our hospital were included. Demographic characteristics and clinical and follow-up information were obtained from the patients' medical records. Inclusion criteria were patients aged 60 years or older, definite diagnosis of DRF, wrist stiffness, receiving daily rehabilitation for 8 weeks after DRF, and complete data available in medical records. Exclusion criteria were pathological (metastatic) or old fracture (>2 weeks since occurrence), open fracture of the distal radius, concurrent fractures or disease in the contralateral forearm and wrist, serious medical comorbidities, and incomplete medical records.

Eighty-eight patients were included in the final analysis in this study. Relevant demographics, including time of immobilization before active rehabilitation, age, sex, Arbeitsgemeinschaft fur Osteosynthesefragen (AO) fracture classification, and surgical or conservative intervention, are shown in Table 1.

Table 1

Demographic characteristics.

Characteristics	Values
Gender (n, %)	
Female	59 (67.05)
Male	29 (32.95)
Age (mean, SD), yr	71.69 (6.232)
Weeks immobilized (from fracture to rehabilitation), wks	12.89 (5.318)
Injury mechanism (n, %)	
Slip fall	49 (55.68)
Fall >2 ft.	13 (14.77)
Hit injury	6 (6.82)
Unspecified	20 (22.73)
AO fracture type (n, %)	
A	17 (19.32)
B	11 (12.50)
C	58 (65.91)
Dominance (n, %)	
Right	76 (86.36)
Left	12 (13.64)
Fracture side (n, %)	
Right	69 (78.41)
Left	19 (21.59)
Intervention (n, %)	
Surgery	73 (82.95)
Conservation	15 (17.05)

2.2. Rehabilitation process

All patients received pre-rehabilitation education. Patients were informed that the rehabilitation program consisted of 4 parts: superficial heat modalities, manual passive stretching training, forearm massage, and self-rehabilitation. During manual passive stretching training, there were 15 to 20 seconds of pain that needed to be tolerated as much as possible. The whole rehabilitation program took 30 minutes, once a day, for 8 weeks in the clinic and self-rehabilitation twice a day at home.

3. Superficial heat modalities

Superficial heat modalities are commonly used for preconditioning joints to increase joint ROM during the mobilization stage after wrist fracture.[13] All patients had their arms placed in a hot water pot at 40°C (104°F) for 15 minutes before active rehabilitation. The entire forearm and hand were submersed to the level of the mid-upper arm, with the elbow flexed. This pretreatment can accelerate blood circulation, soften tendons and ligaments around the wrist joint, and reduce pain during active rehabilitation.

4. Manual passive stretch training

Manual passive stretch training included wrist extension, flexion, radial deviation, pronation, and supination training. During the

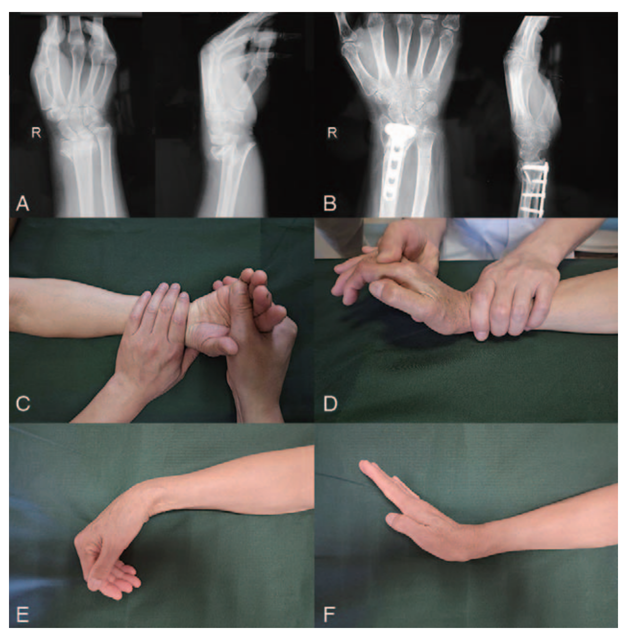

Figure 1. A 71-year-old female patient diagnosed with right distal radius-type C fracture after a slip fall. She underwent open reduction and internal fixation and cast fixation for 2 weeks. The rehabilitation program started after 8 weeks and the maximal active wrist flexion and extension were 12° and 20°, respectively. (A) and (B) showing that preoperative and postoperative anteroposterior and lateral radiographs, respectively. (C) and (D) showing method of manual passive wrist flexion and extension stretch training, respectively. (E) and (F) showing that maximal active wrist flexion and extension are 55° and 49°, respectively.

training, the patients were asked to lie in a supine position on the examination bed. Figure 1 shows wrist extension training of a 65-year-old patient with wrist stiffness after DRF.

4.1. Wrist extension training

The affected upper limb was placed on the side of the body naturally with the palm facing down. The palmer side of the distal forearm was pressed and fixed on the bed as close as possible. The affected hand was held by the palm, and the palmar muscle tendons were slowly stretched and pulled until the pain was almost intolerable. The wrist joint was fixed in the maximum extension position for 15 to 20 seconds, and a quick massage of the forearm was performed subsequently. After repeating this extension training 3 to 5 times, the palmar tendons were stretched and the pain was relieved. The wrist extension angle would gradually increase, but no more than the maximum passive extension angle of the contralateral health wrist, which is usually between 90° and 100°.

4.2. Wrist flexion training

The affected upper limb was placed on the side of the body naturally with the palm facing up. The dorsum of the distal forearm was pressed and fixed on the bed as close as possible. The affected hand was held by the dorsum, and the dorsal muscle tendons were slowly stretched and pulled until the pain was almost intolerable. The wrist joint was fixed in the maximum flexion position for 15 to 20 seconds, and a quick massage of the forearm was performed subsequently. After repeating this 3 to 5 times, the wrist flexion angle would gradually increase, but the final expected training result had to be no more than the maximum passive extension angle of the contralateral health wrist, which is usually approximately 90°.

4.3. Wrist radial deviation training

Since the wrist was required to be fixed in the ulnar deviation position by a brace or cast after DRF, patients always suffered from wrist stiffness at the ulnar deviation position. Therefore, rehabilitation training aims to correct ulnar deviation to a neutral position first, and then restore the range of radial deviation. The affected upper limb was fixed on the bed, and the hand was held and pulled to the radial side until the pain was almost unbearable. The wrist joint was fixed in this position for 15 to 20 seconds, and a quick massage of the forearm was performed subsequently. Training was repeated 3 to 5 times. However, the final expected training result of the radial deviation angle refers to the contralateral health wrist, which is usually around 25°.

4.4. Wrist rotation training

The affected upper limb was placed on the side of the body naturally with elbow flexion to 90°. The upper arm was pressed and fixed on the bed as close as possible to ensure that the elbow was neither lifted nor moved during training. The affected hand was held by the therapist with 2 hands, and forearm was pronated and supinated, respectively, until the pain was almost unbearable. Patients experienced more intense pain during rotation training than the other trainings; therefore, the patients' painful faces should be carefully observed, and further rotation should be stopped immediately. To prevent ligament injury of the distal radioulnar joint and to avoid joint exudation and swelling, the range of rotation training should be improved slowly. Based on our experience, the recommended daily improvement of rotation is between 5° and 10°. The final expected passive pronation and supination were 110° and the active pronation and supination would be 90°.

4.5. Outcome measurements

All patients had active ROM of their wrist measured before and at 3 consecutive follow-up visits, including 2, 4, and 8 weeks after rehabilitation program was initiated. ROM was measured by the same hand therapist with >10 years of experience. Active wrist ROM, consisting of wrist extension, flexion, radial deviation, ulnar deviation, pronation, and supination, were measured. These measurements were taken before and at 2, 4, and 8 weeks of rehabilitation, respectively. Measurement techniques for wrist flexion/extension and radial/ulnar deviation were completed as recommended by the American Society of Hand Therapists using a standard goniometer.[14] For measurement of active forearm rotation, the modified finger goniometer technique was used.[15]

4.6. Statistical analysis

Statistical analysis was performed using IBM Statistical Product and Service Solutions (SPSS version 23.0; Armonk, New York, NY). Repeated measures multivariate analysis of variance (MANOVA)/Bonferroni test was conducted on the dependent variables over time. If a significant time effect was found, a post-hoc Bonferroni test was conducted to evaluate whether the ROM at each follow-up significantly differed from that before rehabilitation. Improvement ROM was calculated by subtracting the ROM before rehabilitation from that at each follow-up. The average change for each measurement was then calculated and used as the dependent variable in the MANOVA. Once the MANOVA was complete, several one-way analysis of variance (ANOVA) were conducted to determine if there was a group difference in ROM changes for each wrist measurement based on stiffness time (Group A ≤3 months and Group B >3 months). The estimated marginal means for the change degree of each of the measurements were also calculated along with 95% confidence intervals. Statistical significance was set at $P<.05$.

5. Results

Table 2 shows the wrist ROM before and at 2, 4, and 8 weeks immediately after rehabilitation. Although the assumption of no univariate or multivariate outliers and multivariate normality was not fully satisfied, the original data were preserved for subsequent analysis. Since Mauchly test of sphericity was not met, Greenhous–Geisser correction was applied. Repeated measures MANOVA suggested a significant time effect for ROM (Wilks Lambda = 0.002, $F=7500.795$, $P<.001$). Compared with before rehabilitation, each wrist ROM was significantly improved at 2, 4, and 8 weeks after rehabilitation.

Table 3 shows the changes in ROM in patients with short- and long-term stiffness at 2, 4, and 8 weeks after rehabilitation. The one-way MANOVA demonstrated that changes in ROM were significantly different between groups (Wilks Lambda = 0.007, $F=559.525$, partial eta square = 0.993, $P<.001$), indicating that patients in the short-term stiffness group had a significantly larger increase in ROM than patients in the long-term stiffness group.

Table 2

Wrist ROM before and after rehabilitation (standard deviation in bracket).

		Wrist ROM, °			
Wrist motion	**N**	**Before**	**2 weeks**	**4 weeks**	**8 weeks**
Extension	88	13.9 (3.948)	20.15 (6.158)	36.4 (7.844)	43.91 (6.219)
Flexion	88	21.74 (6.066)	28.65 (8.358)	39.44 (7.342)	44.95 (6.87)
Radial deviation	88	–9.61 (2.838)	–5.73 (3.548)	5.75 (5.34)	9.76 (4.144)
Ulnar deviation	88	18.42 (1.952)	20.56 (1.523)	22.16 (0.883)	24.32 (1.18)
Pronation	88	17.31 (4.637)	24.97 (7.656)	36.19 (8.501)	44.77 (9.456)
Supination	88	21.88 (3.575)	30.68 (5.686)	38.74 (6.926)	43.43 (7.474)

N = number of case; ROM = range of motion.

The partial eta-squared for the analysis was 0.993, indicating that 99.3% of the variance in ROM was explained by the term stiffness. When assessing individual motions, except ulnar deviation, patients with short-term stiffness showed a greater improvement in wrist extension, flexion, radial deviation, pronation, and supination than those in the long-term stiffness group, at 2, 4, and 8 weeks after rehabilitation.

ANOVA was conducted to determine if there were differences in ROM change among the 3 follow-up periods in the short- and long-term stiffness groups, respectively. In each ROM, there were significantly different changes at 2, 4, and 8 weeks after rehabilitation in short- and long-term stiffness.

6. Discussion

The fracture of the distal radius, the most common fracture of the arm in geriatric patients, would heal; however, incomplete functional recovery can lead to significant functional consequences.[10,11,16] Patients with DRF are often referred for hand therapy to achieve rapid recovery, strength, ROM improvement, and long-term disability reduction.[17] Although there are many magnitudes of wrist rehabilitation, the changes in ROM are quite different. A moderate-quality randomized control trial found that core-strengthening activities did not benefit hand-related outcomes in wrist rehabilitation.[18] Superficial heat modalities, such as therapeutic whirlpool and hot packs, can achieve a small gain in ROM; therefore, they are often used to precondition the joint for therapeutic stretching,[19] which was adopted in this study. The results of the current study suggest that passive rehabilitation can effectively improve wrist ROM in geriatric patients with DRF.

Our rehabilitation program is based on a biopsychosocial model. The present study confirmed the effectiveness of manual passive stretching in the recovery of wrist ROM. However, the almost unbearable pain involved limits its application. A study found greater functional improvement in the treatment of anxiety and depression.[20] In the process of our rehabilitation process, patients are given psychological treatment to relieve anxiety and depression. Patient education is also given to increase patients' awareness of the rehabilitation process and their confidence in the outcome. In addition, after passive stretch training, forearm massage was administered to relieve pain and provide psychological comfort.

The present study found that wrist ROM improved continuously during the 8-week rehabilitation process, and the changes in ROM were greater in patients with short-term stiffness than in those with long-term stiffness. Our results suggest that rehabilitation should be started as early as possible, which is consistent with previous studies. Various studies on early active motion have shown beneficial results, but no one protocol is clearly superior to another.[21,22] There is no consensus on the duration of rehabilitation. Based on our data, the rehabilitation effect at 8 weeks was better than that at 4 weeks in both groups. Therefore, it recommends a full 8-week rehabilitation course.

Table 3

Changes of ROM after rehabilitation (standard deviation in bracket).

		Change of wrist ROM, °		
Group	**Direction**	**2 weeks**	**4 weeks**	**8 weeks**
A	Wrist extension	8.29 (4.229)	27.68 (5.868)^{a}	33.42 (6.488)^{a,b}
	Wrist flexion	9.32 (4.777)	21.84 (5.065)^{a}	26.61 (4.175)^{a,b}
	Radial deviation	4.45 (2.009)	17.5 (4.065)^{a}	20.58 (3.422)^{a,b}
	Ulnar deviation	2.21 (0.875)	3.63 (1.422)^{a}	5.87 (2.28)^{a,b}
	Pronation	10.74 (6.181)	24.13 (6.347)^{a}	32.5 (5.646)^{a,b}
	Supination	11.34 (6.274)	21.05 (5.317)^{a}	26.47 (5.931)^{a,b}
B	Wrist extension	4.05 (1.541)*	15.32 (5.822)^{a,*}	24.95 (4.81)^{a,b,*}
	Wrist flexion	4.08 (1.923)*	12.37 (4.327)^{a,*}	19.26 (5.51)^{a,b,*}
	Radial deviation	3 (1.065)*	11.55 (2.501)^{a,*}	16.95 (2.731)^{a,b,*}
	Ulnar deviation	2.13 (1.018)	3.74 (1.571)^{a}	6.08 (1.992)^{a,b}
	Pronation	4.61 (2.626)*	13.11 (3.667)^{a,*}	20.21 (4.557)^{a,b,*}
	Supination	8.45 (6.310)*	17.74 (8.120)^{a,*}	26.71 (8.084)^{a,b,*}

Group A: stiffness time ≤3 months; Group B stiffness >3 months. ROM = range of motion.
[a] Symbol indicates a statistically significant difference from change of wrist ROM at 2 weeks.
[b] Symbol indicates a statistically significant difference from change of wrist ROM at 4 weeks.
[*] Symbol indicates a statistically significant difference from change of wrist ROM in Group A.

Because this is a retrospective single center study which was held at the Third Hospital of Hebei Medical University, we consider the possibility of selection bias in the charts. Another limitation is that only active ROM was measured rather than passive ROM. Although not providing information about maximal wrist motion, this measurement provides a picture of the functional use and mobility of the wrist. A prospective data collection is important for any outcome study, such as this article, to avoid issues relating to missing data and potential recall bias that can occur in retrospective studies.[23]

7. Conclusion

In this study, continuous improvement of wrist ROM was observed in an 8-week long daily rehabilitation program. Although both patients with short-term and long-term stiffness benefited from rehabilitation, the change in ROM was greater in the former group than in the latter group. Therefore, the current study recommends an 8-week daily rehabilitation program for geriatric patients with limited ROM <3 months after DRF.

Author contributions

Wei Zhang, Lei Wang, Xiong Zhang, Qing Zhang, Baoli Liang, and Bing Zhang participated in the design, collection and reviewing the data, the statistical analysis, interpretation the data, and drafting the manuscript. All authors read and approved the final manuscript.

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