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ORIGINAL ARTICLE

THE EFFECT OF MYOFASCIAL CHAIN EXERCISE TRAINING ON GRIP STRENGTH, PAIN AND FUNCTIONALITY IN THE EARLY PERIOD AFTER SURGICAL FIXATION OF DISTAL RADIUS FRACTURES

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ABSTRACT

Background: The deep fascia of the forearm connects anatomical structures from the thorax, extending through the upper back and axillary regions to the forearm. When past studies on distal radius fracture and fascia were evaluated, no study was found that investigated the effects of myofascial chain exercise training in the upper extremity, aimed at eliminating postoperative fascia weaknesses and strengthening myofascial chains. To compare the effectiveness of early structured myofascial chain exercise training via telerehabilitation with conventional wrist exercises in terms of grip strength, pain, functionality, and proprioception in patients who underwent volar plate surgery following an isolated distal radius fracture.

Materials and methods: Between the 4 and 6 weeks-post-op, 20 cases were included in the group 1 (n = 10) wrist exercises training, and the group 2 (n = 10) structured myofascial chain exercises training. In pre- and post-study evaluations, Quick DASH Score, Visual Analog Scale, Hand Functional Index, Michigan Hand Outcome Questionnaire, Joint Range of Motion Measurement Test, Hand Grip Strength Measurement Test, Pinch Grip Strength Measurement Test and Purdue Pegboard Test were used. Exercise groups completed 16 sessions, 4 days a week and 1 session per day, 8 sessions of synchronous telerehabilitation with physiotherapist supervision, and 8 sessions of home program.

Results: There was a statistically significant in active (p = 0.008) and passive (p = 0.005) extension, Purdue Pegboard Test (right hand: p = 0.027, left hand: p = 0.040, both hands: p = 0.048, right and left and both hands: p=0,011), and Hand Function Index (p = 0.012) in G2.

Conclusion: In our study, myofascial chain exercises via telerehabilitation were found to be more effective on functional outcomes than wrist-oriented exercises after distal radius fracture.

KEYWORDS

Distal radius fracture, physiotherapy and rehabilitation, myofascial chain exercises, fascial rehabilitation, telerehabilitation

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INTRODUCTION

The focus on telerehabilitation has significantly increased during the pandemic, fueled by technological advancements and the growing need for distance-based rehabilitation services[1]. The pre-pandemic interest in integrating telerehabilitation into the management of orthopedic patients as an alternative to traditional face-to-face visits has extended into the post-pandemic era, particularly in the field of physiotherapy for treating musculoskeletal conditions and post-operative rehabilitation[2]. This approach has gained popularity due to its potential to enhance accessibility, convenience, and cost-effectiveness[3]. Specifically, in the treatment of distal radius fractures, telerehabilitation has shown promising results. Studies have demonstrated its effectiveness in improving joint range of motion and reducing edema, though it may be less effective than in-person therapy for muscle strength and overall functionality[4].

Clinical studies show that physiotherapy is useful in improving movement limitation in distal radius fracture and increases the level of active movement by reducing the level of pain[5]. It is known that providing functional restoration with physiotherapy not only increases the quality of life[6], but also reduces the number of days that patients cannot go to work[7]. Post-surgical rehabilitation proceeds similarly to conservative treatment[8]. When exercise approaches in the literature have been examined, it has been that wrist and forearm specific exercises are recommended for treatment, but there are not enough studies to constitute evidence value[9,10].

Due to prolonged immobilization after surgery and more disrupted tissue integrity compared to closed reduction, problems such as disuse atrophy, proprioception and loss of range of motion are associated with all upper extremity disorders including elbow and shoulder joints[11], which are positioned together with the wrist after surgery and whose use is restricted[12].

Fascial adhesions caused by excessive thickening and loss of elasticity of the fascia restrict movement and can lead to chronic pain and dysfunction[13]. Fascia integrity is one of the factors affecting fracture healing[14]. The antebrachial fascia, which inserts internally into many muscle fibers of the pronator teres and flexor carpi radialis muscles, is one of the structures affected in distal radius fracture[15].

There is no study investigating the effects of myofascial chain exercise training in published studies on the evaluation of distal radius fracture and fascia. In addition, there are no studies investigating the elimination of postoperative fascia weaknesses and strengthening of myofascial chains. The aim of this study was to investigate the effectiveness of structured whole body myofascial chain exercise training on muscle strength, range of motion, proprioception, skill, and self-assessment questionnaires in early rehabilitation after distal radius fracture.

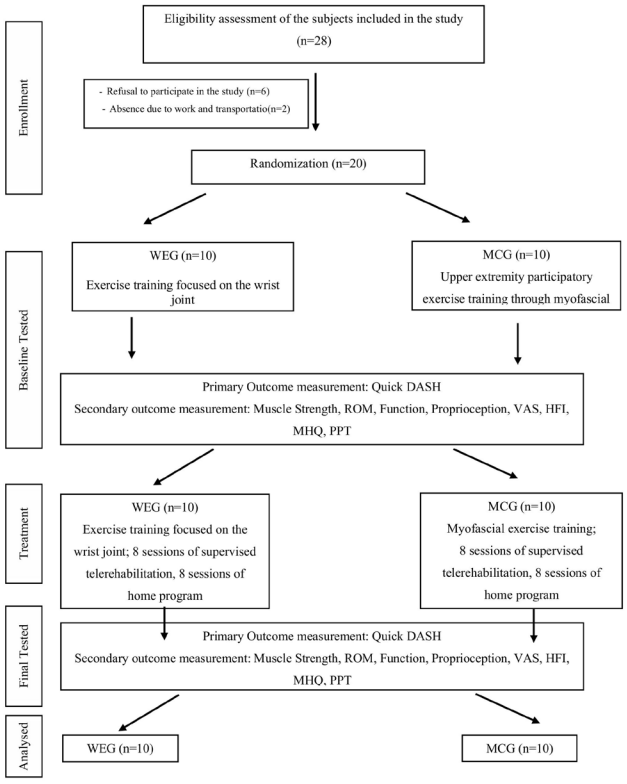


Figure 1. *Flow chart of the patients.*

METHODS

Trial design

This study adopted a block randomized controlled trial design with balanced randomization (1:1) and blinded cases. The ethics committee, which consolidated from Ministry of Health, approved the study (File Code: 2021-10/04). This study was a priori registered (Trial Code: NCT06215872) and reported according to the Consolidated Standards of Reporting Trials (CONSORT) guidelines[16].

Participants

Participants with distal radius fracture operated by volar plating and nailing method were recruited from the Department of Orthopedics and Traumatology, Health Sciences University Hospital. Initially, the study starting date was planned between post-operation 4-6 weeks, with ith the post-operation meeting the day after the cast came off. In this meeting, patients were informed about the early- and mid-stages of physical therapy and our late-term program; the meeting also gave information on groups and exercise descriptions. We enrolled only surgically treated cases and did not include conservatively managed fractures. Fixation hardware may restrict wrist motion and create a recovery pattern that differs from conservative care, sometimes with persistent limitation. To keep the study population comparable and to apply the planned exercise pathway consistently, only patients treated with surgical fixation were included. The study inclusion criteria were as follows:

1) Aged 25-60 years;

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2) Ability to communicate written and verbally in Turkish;
3) Being diagnosed with distal radius fracture;
4) At the earliest post-operative week 4, at the latest post-operative week 6;
5) Fixation was done using volar plating and nailing method;
6) Post-op, if instruments were left temporarily, these instruments should be removed before the study;
7) Adequate bone union must be completed to start the exercise program;
8) Having a minimum of 6 m^2 area that will allow exercises to be done and fit a table;
9) Having a device and internet infrastructure with the necessary equipment for telerehabilitation;
10) Any another medical history.

Participants who were excluded from the study for the following:

1) Having a previous forearm fracture on the affected side;
2) Concomitant fracture in the contralateral upper extremity;
3) Presence of other accompanying bone and soft tissue injuries other than radius fracture;
4) Having inflammatory joint diseases, metabolic diseases, and neurological diseases;
5) Presence of mental and cognitive disorders that prevent cooperation;
6) Having studied or graduated from the Physiotherapy and Rehabilitation department.

The criteria for study discontinuation were as follows:

1) Missing two exercise sessions in a row;
2) Pain complaints (minimum 5 points according to VAS);
3) Failure to ensure co-operation in tele-rehabilitation or assessment or training sessions;
4) Occurrence of one of the complex regional pain syndrome subtypes after fracture;
5) Inability to maintain continuity in exercises. Informed patient consent was collected prior to enrollment and baseline testing was carried out at the Physiotherapy and Rehabilitation Laboratory in Faculty of Health Sciences, University-between October 2022 and January 2024.

Sample size

Previously published data on minimal clinical significance level of the DASH (Disabilities of the Arm, Shoulder and Hand) Subjective Knee Score (d = 1.16) guided our sample size estimates. To ensure statistical power of 95% (β = 0.95) and an α-level of 0.05 (2-tailed testing), a sample size of n = 10 was calculated for each group. We aimed to recruit twenty-eight participants (in total) to allow for possible dropouts. Sample size and power calculated with "G*Power v3.1.9" software[17].

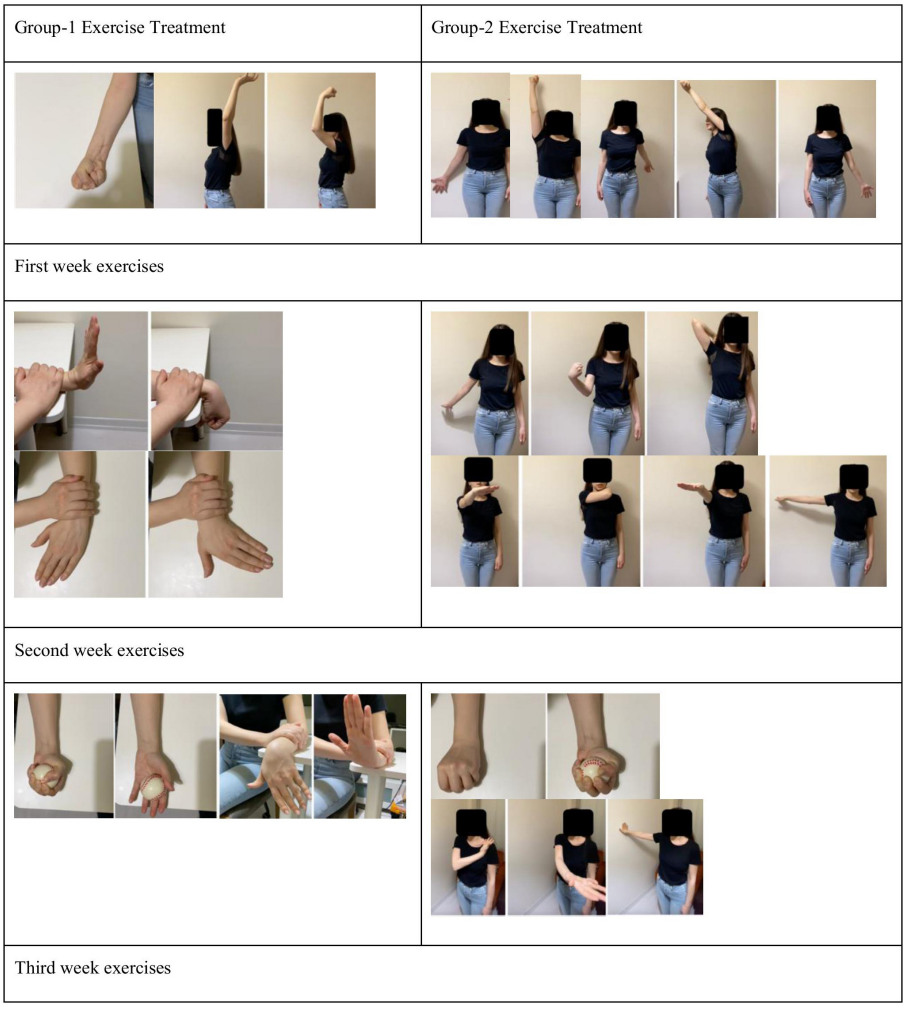


Figure 2. *Exercise illustrations.*

Randomization

Block randomization method was used according to age and gender. Subjects who accepted the invitation to participate in study were divided into two groups with computerized randomization system as "Research Randomizer" website with sealed envelope method. Patients were included two groups as follows:

1) Group 1 (G1) wrist exercises training group (n = 14) treated with upper extremity exercises;
2) Group 2 (G2) myofascial chain exercises training group (n = 14) treated with myofascial chain exercises.

A statistician assessed patient eligibility criteria for block randomization, and the operating surgeon performed the allocation using sealed envelopes.

Outcome measures

Tests were performed face-to-face before and after treatment, with 4 weeks between assessments for both groups. Pre-treatment and post-treatment improvement of G2 and G1 were compared within and between groups.

All patients were assessed with same tests as follows:

1) *Wrist strength assessment with "Takei Handheld Dynamometer"*[18]: During the test, the patient in the sitting position was instructed not to support the body with the elbow and the force value was recorded by squeezing the device in the palm of the hand.
2) *Thumb strength assessment with "Saehan SH5005 Pinch Gauge"*[19]: The device was held by the researcher by the indicator part and the force value was recorded by asking the volunteer in the sitting position to squeeze between the thumb and forefinger.
3) *Joint range of motion assessment in extension, flexion, radial deviation and ulnar deviation directions with goniometer*[20]: Wrist maximum flexion, extension, radial deviation and ulnar deviation were evaluated in range of motion measurement. Active and passive range of motion in all directions was measured by using a goniometer.
4) *Proprioception assessment:* After teaching the patient 30 and 60 degrees of wrist flexion and 30 and 60 degrees of wrist extension by giving verbal feedback, the patient could perform the exercises with his or her eyes open and closed, respectively.
5) *Skill assessment:* Perform tasks against time using the Purdue Pegboard device in the order and shapes specified in the manual[21].

All tests were repeated 3 times and the best result was recorded.

Activity and participation were assessed by using Hand Functional Index (HFI)[22], Visual Analogue Scale (VAS)[23], Quick DASH Score[24-26], Michigan Hand Outcomes Questionnaire (MHQ)[27]; also all questionnaires were performed with printed papers and face-to-face.

Primary Outcome Measures was the DASH with G2 in-group change from baseline to the end of sessions..

Intervention

Both G1 and G2 performed 16 sessions of progressive structured exercise training with the same programs, as follows:

Demographic and clinical characteristics		Median (minimum-maximum)/n(%)		Comparison between groups - p
		G2	G1	G2-G1
Gender (F/M)	Female	6 (60)	4 (40)	
	Male	4 (40)	6 (60)	
Age (year)		53.5 (20-68)	48.0 (19-67)	0.325**
Height (cm)		165 (155-183)	171.5 (155-179)	
Weight (kg)		63.5 (55-106)	80 (60-90)	
BMI (kg/m²)		24.20 (19.37-38.93)	28.57 (22.47-35.38)	0.151**
Surgical features	Right	6 (60)	8 (80)	
	Left	4 (40)	2 (20)	
	Dominant	5 (50)	6 (60)	
	Non-dominant	5 (50)	4 (40)	
Dominant hand	Right	9 (90)	10 (100)	
		1 (10)	0 (0)	

Table 1. *Demographic data form.*

*Abbreviations: BMI, body mass index; G2, myofascial chain group; G1, wrist exercise group; **Mann Whitney-U test.*

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	Median (minimum-maximum)				Change within group – p		Comparison between groups - p	
	G2		G1		G2*	G1*	G2-G1**	
	BT	AT	BT	AT			AT	BT
VAS	5 (4-7)	1 (0-3)	3 (0-10)	1 (0-7)	**0.005**	**0.010**	0.191	0.875
Hand grip	1 (5-50)	17.5 (7-75)	5 (1-50)	16 (5-56)	**0.005**	**0.008**	0.309	0.270
Pinch grip	5 (1-12)	9 (5-17)	6.5 (1-17)	9 (2-17)	**0.012**	**0.007**	0.382	0.733

Table 2. *Comparison of VAS and grip strength test results within and between groups.*
Abbreviations: VAS, Visual Analog Scale; G2, myofascial chain group; G1, wrist exercise group; BT, before treatment; AT, after treatment.
**Wilcoxon test; **Mann Whitney-U test.*

1) 30 minutes in the first sessions to 60 minutes in last sessions, with 2 to 4 exercises every session;
2) Four sessions in total, two sessions per week with supervision by a physiotherapist and two sessions of home exercise;
3) Five sets in a session;
4) Ten times repeat and 10 second resting times for each exercise every session;
5) Telerehabilitation supervision given by physiotherapist.

Telerehabilitation application was planned by following the existing literature[28]. Illustrations are given in *Figure 2*.

Statistical analysis

Distribution of all data were evaluated using Kolmogorov-Smirnov Test and Shapiro Wilk Test with 95% confidence interval. Chi-Square test was used for categoric data such as demographics. Differences between groups were determined with Kruskal Wallis Test and Mann-Whitney-U Test for ordinal data. All analyses were performed with using SPSS (Statistical Package for Social Sciences) v25.0 software.

RESULTS

Twenty-eight patients who accepted the invitation to participate in the study were followed up weekly by phone during the post-surgical period until the cast and splint were removed. After the cast and splint were removed, 28 operated patients were evaluated. Eight operated patients were excluded from the study because they did not participate after the evaluation tests. The study was completed with a total of 20 cases. A diagram is given in *Figure 1*.

No significant differences were found for gender, height, weight, dominant extremity, and surgical characteristics between G2 and G1. The demographic characteristics of the participants are summarized in *Table 1*.

Pain and Grip Strength: VAS score, hand grip strength and pinch grip strength were significantly increased in both G2 and G1. The results of pain and grip strength assessments are summarized in *Table 2*.

Range of Motion: In the analysis of intra-group changes before and after treatment; active and passive; flexion, extension, radial and ulnar deviation ranges of motion all increased significantly in G2. In G1, active and passive flexion, extension, ulnar deviation and passive radial deviation ranges of motion increased significantly, while no significant change was found in active radial deviation. Active and passive extension were significantly higher in G2 than in G1 after treatment. *Table 3* summarizes the pre- and post-treatment changes in wrist range of motion parameters, including flexion, extension, radial and ulnar deviation, for both G1 and G2 groups.

Performance (Purdue Peg Board) test: In the analysis of intra-group changes before and after treatment, a significant increase was found in G2 and G1 in right hand, left hand, right hand and left hand and both hands scores. There was a significant increase only in G2 in both hand scores, while no significant change was found in G1. *Table 4* presents the Purdue Pegboard test results, showing intra-group changes in manual dexterity for both G1 and G2 groups.

Self-Assessment Questionnaires: In the analysis of intra-group changes before and after treatment, it was found that the DASH results, which were accepted as the primary outcome measure, showed a significant increase in both G2 and G1. In the hand function index (HFI) questionnaire, G2 showed significant improvement after treatment compared to pretreatment ($p < 0.05$), whereas G1 did not show significant improvement ($p > 0.05$). Statistical analysis was performed for the primary outcome measure: the DASH questionnaire score. The mean change in DASH score was calculated as "-32.49 ± 23.90" points in G2 and "-25.00 ± 16.66" points in G1.

DISCUSSION

In our study, myofascial chain exercises were found to be more effective on functional outcomes, especially wrist active and passive extension range of motion, than wrist-focused exercises after distal radius fracture.

Since our study was the first study in the literature investigating the efficacy of fascia improvement in both upper extremity and distal end fractures of the radius fixed

	Median (minimum-maximum)				Change within group – p		Comparison between groups - p	
	G2		G1		G2*	G1*	G2-G1**	
	BT	AT	BT	AT			BT	AT
Active flexion	32.5 (10-50)	60 (45-70)	20 (10-30)	40 (30-60)	**0.005**	**0.005**	**0.042**	**0.001**
Pasive flexion	38.5 (12-60)	65 (55-85)	25 (12-35)	50 (35-65)	**0.005**	**0.005**	**0.042**	**0.001**
Active extension	27.5 (5-40)	57.5 (40-60)	20 (5-35)	35 (10-60)	**0.008**	**0.007**	0.126	**0.008**
Pasive extension	35 (7-50)	65 (55-70)	23.5 (7-40)	40 (20-75)	**0,005**	**0.012**	0.119	**0.015**
Active RD	10 (5-25)	17.5 (10-30)	12.5 (7-15)	12.5 (7-20)	**0.027**	0.317	0.573	0.062
Pasive RD	14 (10-30)	22.5 (15-35)	16 (9-20)	20 (10-30)	**0.022**	**0.049**	0.879	0.143
Active UD	15 (5-30)	20 (15-35)	15 (10-25)	20 (15-30)	**0.016**	**0.012**	0.845	0.875
Pasive UD	20 (10-35)	27.5 (17-40)	18.5 (12-27)	25 (20-35)	**0.027**	**0.011**	0.593	0.848

Table 3. *Intragroup and intergroup comparison of wrist range of motion test results.*
Abbreviations: G2, myofascial chain group; G1, wrist exercise group; UD, ulnar deviation; RD, radial deviation; BT, before treatment; AT, after treatment.
**Wilcoxon test; **Mann Whitney-U test.*

with open reduction internal fixation volar plate, there are no published studies in which the results can be compared one-to-one.

Soares et al. (2023) evaluated the improvement of pain relief, range of motion, function and grip strength in both the short- and medium-term in patients with distal radius fractures and reported that a physiotherapist supervised exercise program was not more effective than an unsupervised program[29]. Another study explained that home programs are a safe method that can be used in uncomplicated open reduction internal fixation distal radius fractures fixed with a volar plate. In the present study, a home exercise program was applied until the use of plaster splint was discontinued, followed by a home program combined with supervised telerehabilitation sessions[30]. The results of this study have similar aspects in terms of both method and population with our study. This hybrid approach aligns with the broader trend highlighted in orthopedic practice, where telemedicine is increasingly leveraged for postoperative follow-up and rehabilitation support[35].

Gamo et al. (2022) reported that the groups showed similar levels of improvement and the results of VAS, range of motion, grip strength and self-assessment questionnaires

	Median (minimum-maximum)				Change within group – p		Comparison between groups - p	
	G2		G1		G2*	G1*	G2-G1**	
	BT	AT	BT	AT			BT	AT
Right	12.5 (8-14)	13 (12-17,)	10 (6-13)	13 (9-15)	**0.027**	**0.035**	0.117	0.240
Left	11 (3-15)	13 (11-17)	11.5 (9-16)	13 (10-15)	**0.040**	**0.046**	0.909	0.563
Both hands	9 (6-12)	11 (8-13)	9 (4-10)	10 (4-12)	**0.048**	0.105	0.283	0.278
Right + left + both	31.5 (23-39)	36 (32-45)	28 (23-36)	36,00 (28-40)	**0.011**	**0.007**	0.128	0.269
Assembly	18 (12-24)	22 (16-40)	16 (12-24)	20 (20-24)	0.071	**0.009**	0.386	0.840

Table 4. *Intragroup and intergroup comparison of Purdue Pegboard Test results.*
Abbreviations: G2, myofascial chain group; G1, wrist exercise group; BT, before treatment; AT, after treatment;
**Wilcoxon test; **Mann Whitney-U test.*

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were similar when compared to the exercises performed during the clinic visit and home exercises for the same periods of time. In our study, the participants exercised 4 days a week for 1 hour, participated in 2 sessions of tele-rehabilitation and 2 sessions of the home program. Each session lasted between 40 and 60 minutes. In this respect, it was seen that shorter exercise sessions in our study yielded the results that overlapped with the literature[31]. Although detailed anthropometric variables such as hand span were not directly measured, the comparable age, sex, BMI and hand dominance distribution between groups suggests that grip-strength differences are unlikely to be attributed to anthropometric imbalance; nevertheless, the influence of anthropometric features on hand strength has been highlighted in the literature[36].

In a study comparing an 8-week standard rehabilitation program including similar exercises with a 6-week accelerated rehabilitation program, it was reported that mobility, strength, and the DASH results that were obtained because of the accelerated program were significantly better. The exercises used in the study performed on a similar population to our study and the exercise program planned for G1 and forming the basis for G2 have the same characteristics. The results of the program applied for 4 weeks in our study overlap with the results of the study in the literature[32]. In our study, the result is similar to the study of Brehmer et al., the latter of which showed that the improvement in DASH score in G2 was 29.96% higher than in G1.

In the Quadlbauer et al. study, the authors applied an exercise program covering the entire upper extremity, including the shoulder joint, to the group wearing a removable splint from the 1st post-operation day and to the group wearing a plaster splint from the 5th week. They reported that exercises applied from the early period gave significantly better results in range of motion and grip strength at the end of year one[33]. In addition to the similar aspects of the exercise programs used in our study and the programs applied on the population with similar characteristics to our study, another similar feature is that free programs were applied in our study from post-operation day 1 until the study participation date.

In a meta-analysis study investigating the benefits of early mobilization in distal radius fracture[34], the outcomes of patients who started ROM exercises two weeks after surgery were compared at 6 weeks, 3 months and 6 months. They reported that early ROM exercises resulted in better functional scores and grip strength up to 6 months post-operatively and that early exercise was safe and did not increase complication rates. For these reasons, we included only surgically fixed fractures. Fixation hardware may restrict wrist motion and create a recovery course that differs from conservative care; this also allowed an early and consistent mobilization pathway for the myofascial chain program.

In the literature, early mobilization has come to the forefront because of developing technology and surgical examinations in recent years, but no studies on innovative exercise approaches have been found. It is very important that our study completely overlaps with the existing literature and offers a different perspective to the literature. When analyzing the results of our study, we found that our study had similar results with the published literature.

There are some limitations in our study. One is related to the start of the study during the partial lockdown period of the Covid-19 pandemic. On the other hand, this is an advantage of the study for inclusion to all subjects without except for exclusion criteria including the supervision sessions were implemented with the telerehabilitation method. At the end of the study, it was seen that telerehabilitation was very useful as per the feedback received from patients. Second, the number of patients was low during the study period. Third, the duration of the study was long because of the pandemic.

In this study, the 4-week exercise program might be adequate for myofascial chain exercises, while the wrist exercises program should be continued for over 4 weeks post-operation.

CONCLUSION

In our study, myofascial chain exercises were more effective in flexion and extension range of motion than he wrist exercise protocol, while improvements in active and passive ulnar deviation, active and passive radial deviation range of motion, pinch grip strength, Purdue pegboard test, hand function index were similar in both groups.

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