EDITOR'S CHOICE

Efficacy of Hand Therapy After Volar Locking Plate Fixation of Distal Radius Fracture in Middle-Aged to Elderly Women: A Randomized Controlled Trial

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Purpose This study aimed to evaluate the efficacy of hand therapy after volar locking plate fixation of distal radius fractures in middle-aged to elderly women.

Methods Fifty-seven patients diagnosed with distal radius fractures who had undergone volar plate fixation were enrolled in a prospective, randomized controlled trial. Patients were randomized into the hand therapy and independent exercise (IE) groups, in which they exercised independently under the surgeon's direction with and without hand therapy, respectively. The primary outcome was the functional outcome measured using the Disability of Arm, Shoulder, and Hand questionnaire after 6 weeks. The secondary outcomes were functional outcomes measured using the Patient-Rated Wrist Evaluation questionnaire, active and passive ranges of motion (ROMs), grip strength, key pinch strength, and pain measured on a visual analog scale. Patients were followed up in the outpatient department at 2, 4, 6, and 8 weeks and at 3 and 6 months.

Results The Disability of Arm, Shoulder, and Hand scores were significantly lower in the hand therapy group at 6 weeks after surgery (12.5 vs 19.4 in the IE group). The postoperative visual analog scale pain scores were significantly lower in the hand therapy group at 2, 4, and 6 weeks (10.2 vs 17.6 in the IE group). The active ROM of the wrist flexion-extension arc at 2, 4, 6, and 8 weeks; active ROM of the pronation-supination arc at 6 and 8 weeks; and passive ROM of the wrist flexion-extension arc at 2, 4, and 8 weeks were significantly greater in the hand therapy group.

Conclusions Hand therapy improved the outcomes after volar locking plate fixation for distal radius fracture in middle-aged to elderly women at 8 weeks after surgery. No significant between-group differences were observed in any functional outcome measure at 6 months after surgery, as previously reported. *(J Hand Surg Am. 2022;47(1):62–68.*

Type of study/level of evidence Therapeutic II.

Key words Distal radius fracture, hand therapy, middle-aged to elderly women, volar locking plate fixation.

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DISTAL RADIUS FRACTURES are among the most common fractures of the upper extremity and tend to occur with a bimodal age distribution (ie, in young patients with high-energy trauma and in elderly patients with low- to moderate-energy trauma due to osteoporosis).[1] Elderly women have a 5-fold higher risk of distal radius fracture compared to elderly men.[2] An increasingly active and growing elderly population is responsible for the increased incidence of distal radius fractures over the past 40 years.[3]

Several randomized trials have compared hand therapy with home exercise programs after the treatment of distal radius fractures.[4–12] It has been reported that there is a tendency for slightly better functional and patient-reported results with the use of hand therapy than without it at 6 weeks and 3 months after surgery, although these differences disappeared at 6 months after surgery.[11–13] These randomized trials assessed adults regardless of age and sex. We focused on the early postoperative clinical outcomes of middle-aged to elderly women, who have a high risk of distal radius fracture. This study aimed to evaluate the efficacy of hand therapy after volar locking plate fixation of distal radius fracture in middle-aged to elderly women.

MATERIALS AND METHODS

Study design

Female patients older than 40 years with distal radius fracture and who underwent volar plate fixation at Bellland General Hospital between September 2014 and May 2018 were included in this prospective, 2-arm, parallel-group, randomized controlled trial. Patients with polytrauma, open fracture, ulnar head fracture (excluding ulnar styloid fracture), ipsilateral extremity fracture, present or previous fracture to the contralateral side, history of complex regional pain syndrome, collagen vascular disease, or limited cognitive capacity were excluded. We obtained informed consent from the patients, as well as institutional review board approval from the local ethics committee for this clinical research. The trial was registered at the University Hospital Medical Information Network Clinical Trials Registry in Japan.

Patients were randomized into the hand therapy and independent exercise (IE) groups, in which they exercised independently under a surgeon's (K.G.) direction with and without hand therapy, respectively. A block randomization sequence was generated using random number generator software with a permutated block of 4. The randomization was performed by an investigator (S.K.) who had no contact with the patients. Allocations were kept in sequentially numbered, sealed envelopes, which were opened after the patient gave informed consent at the preoperative visit in the outpatient department.

The patients were hospitalized on the day of surgery and discharged the next day. The operations were performed under ultrasound-guided supraclavicular brachial plexus block.[14] All fractures, whether dorsally or volarly displaced, were managed through a volar flexor carpi radialis approach.[15] We used Acu-Loc2 VDR Plates (Acumed) and Acu-Loc2 VDR Proximal Plates (Acumed) without postsurgical orthosis placement. Analgesics were not prescribed for the patients after discharge. On the day after surgery, a hand therapist (N.B.) instructed the patients in both groups on how to perform a standard home exercise program (Appendix E1, available online on the *Journal's* website at www.jhandsurg.org) and the required duration (30 minutes, at least 3 times daily). Patients in both groups began with active ranges of motion (ROM) of the upper limb, including the shoulder and elbow, on the affected side. The patients were also instructed to perform maximum passive ROM training using the contralateral hand as much as possible from the second week. The patients in both groups were scheduled to visit the surgeon at 2, 4, 6, and 8 weeks and at 3 and 6 months after surgery. At the outpatient visits, the attending physician asked the patients whether they could perform the home exercise program. If the patients reported that they could not understand the exercise, they received an explanation at each outpatient visit.

The hand therapy group underwent 40 minutes of hand therapy twice a week for 12 weeks. During the first 2 weeks, although priority was given to finger motion using the "6-pack" digital motion exercise (Appendix E1), active wrist exercises, including a dart-throwing motion, were also started.[16] After wound healing was confirmed, hand therapy was started with active exercise of the fingers, wrist joint, and forearm for 10 minutes in a whirlpool bath at 36 to 38 °C. From the second week, wrist and forearm passive ROM and light strengthening with wrist isometrics and gripping with hand therapy putty were performed. After the fourth week, proprioceptive neuromuscular facilitation exercises, which are methods of flexibility training that can reduce hypertonus, allowing muscles to relax and lengthen, were introduced. After the fifth week, progressive strengthening exercises for the forearm and hand muscles were initiated. Starting at 5 weeks after surgery, the frequency of hand therapy was at the

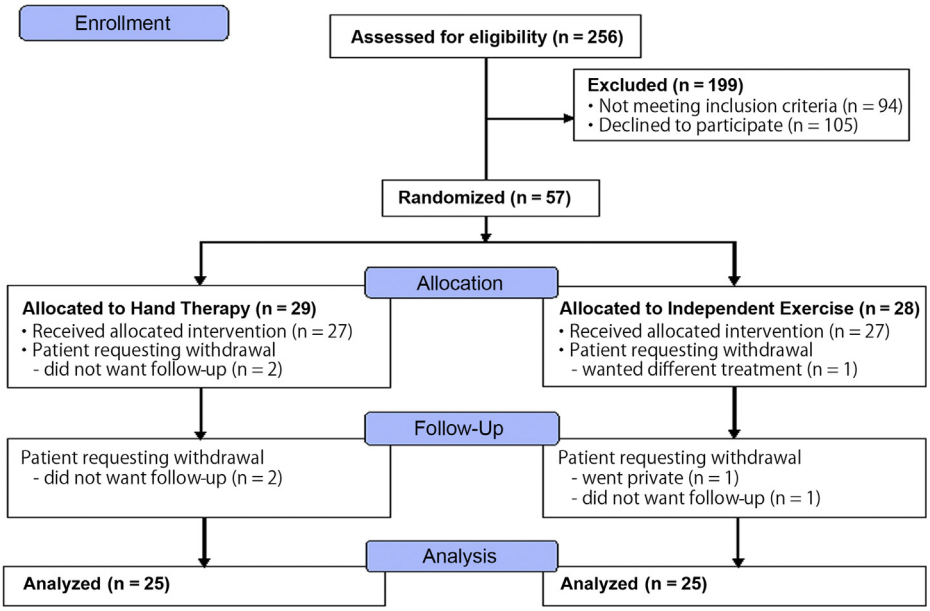

FIGURE 1: Consolidated Standards of Reporting Trials flow diagram.

discretion of the hand therapists, depending on the patient's recovery.

The main outcome measure was the functional outcome measured using the Disability of Arm, Shoulder, and Hand (*Quick*DASH) questionnaire after 6 weeks.[17,18] The secondary outcomes were functional outcomes measured using the Patient-Rated Wrist Evaluation (PRWE) questionnaire, active and passive ROMs, grip strength, key pinch strength, and pain measured on a visual analog scale (VAS).[19–21]

Assessments of all outcomes were performed at every visit for both groups. The outcome assessor (T.K.) was blinded to group allocation. The participants were instructed to not reveal the treatment group to which they belonged.

Statistical analysis

We performed an *a priori* sample size estimate prior to the study, and determined that 22 patients per group would provide 90% power to detect a 10-point difference in *Quick*DASH scores between cohorts to reach statistical significance with the alpha set at 0.05 and assuming *Quick*DASH SD of 10. The target enrollment was 50 patients, with an expected rate of patient loss of 10%.

We compared outcome variables using the 2-tailed independent Student's *t* test for continuous variables. Significance was set at $P < .05$.

RESULTS

Of the 256 patients eligible for this study, 57 consented to participate and were randomized into the hand therapy (n = 29) and IE groups (n = 28; Fig. 1). The distributions of demographic variables, including age, body mass index, injury in the dominant hand, associated ulnar styloid fracture, fracture type, time from injury to surgery, preoperative *Quick*DASH, and preoperative PRWE, were similar between groups (Table 1). Patients in the hand therapy and IE groups had mean ages (±SDs) of 68.9 ± 8.5 and 66.8 ± 10.7 years, respectively. Complete follow-up was obtained for all patients. The average number of visits in the hand therapy group was 16.3.

The *Quick*DASH scores were significantly lower in the hand therapy group at 6 weeks after surgery (12.5 vs 19.4 in the IE group; Fig. 2). The VAS pain scores were significantly lower in the hand therapy group at 2 (18.8 vs 28.8 in the IE group), 4 (12.5 vs 21.1 in the IE group), and 6 weeks (10.2 vs 17.6 in the IE group; Fig. 3). The active ROM of the wrist flexion-extension arc at 2, 4, 6, and 8 weeks and that of the pronation-supination arc at 6 and 8 weeks were significantly greater in the hand therapy group. Moreover, the passive ROM of the wrist flexion-extension arc at 2, 4, and 8 weeks was significantly greater in the hand therapy group (Fig. 4). There were no differences in PRWE, grip strength, and key pinch strength at any time point. The results of the 6-week and 6-month evaluation items are shown in Tables 2 and 3, respectively.

TABLE 1. Baseline Demographic and Clinical Information

Characteristic	Hand Therapy Group, n = 29	IE Group, n = 28
Age at injury,* y	68.9 (8.5)	66.8 (10.7)
BMI*	23.1 (3.7)	24.4 (4.6)
Injury in the dominant hand, n (%)	17 (59)	17 (61)
Associated ulnar styloid fracture, n (%)	12 (44)	11 (36)
Arbeitsgemeinschaft für Osteosynthesefragen/ Orthopedic Trauma Association fracture type, no. of patients		
A	9 (A2 = 3, A3 = 6)	10 (A2 = 5, A3 = 5)
B	1 (B3 = 1)	0
C	19 (C1 = 8, C2 = 3, C3 = 8)	18 (C1 = 9, C2 = 2, C3 = 7)
Time from injury to surgery,* d	7.3 (4.7)	6.0 (3.2)
Preoperative *Quick*DASH*	70.4 (13.2)	68.7 (16.7)
Preoperative PRWE*	76.0 (12.3)	82.4 (13.1)

BMI, body mass index.
*Data are presented as means (SDs).

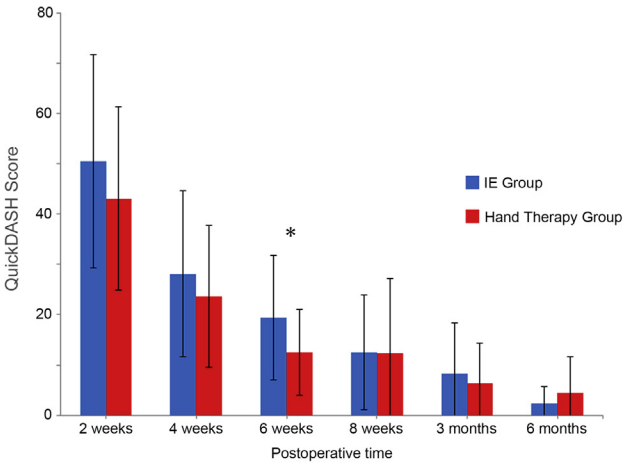

FIGURE 2: The *Quick*DASH scores at 2, 4, 6, and 8 weeks and at 3 and 6 months after the surgical intervention, expressed as means ± SDs. *$P < .05$.

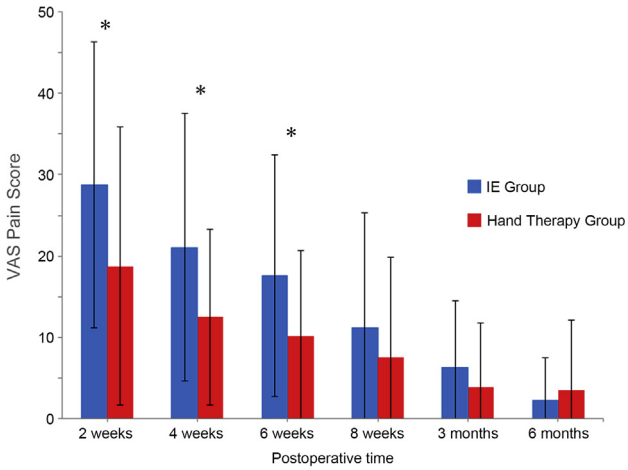

FIGURE 3: The VAS pain scores at 2, 4, 6, and 8 weeks and at 3 and 6 months after the surgical intervention, expressed as means ± SDs. *$P < .05$.

In both groups, there were no patients with complex regional pain syndrome, tendon injury, nerve injury, infection, or implant failure, and none underwent additional surgery.

DISCUSSION

In the last 2 decades, several studies have compared home exercise instruction with a formal hand therapy program for patients after distal radius fracture. Several of these reports compared the interventions after volar locking plate fixation of distal radius fracture. Krischak et al[5] found that greater ROM, grip strength, and PRWE scores were achieved by the home program group than by the supervised therapy group at 6 weeks after surgery. They stated that a possibly important factor for the better outcome of patients in the home program group could be the longer exercise time. Souer et al[12] reported that prescription of formal hand therapy did not improve the average motion, disability score, and VAS pain score at 6 months after volar locking plate fixation of a fracture of the distal part of the radius. Valdes et al,[13] in a systematic review, found no statistically significant differences in the PRWE score, wrist or forearm motion, pain, or grip strength between clinic- and home-based therapy exercise programs at 6 months

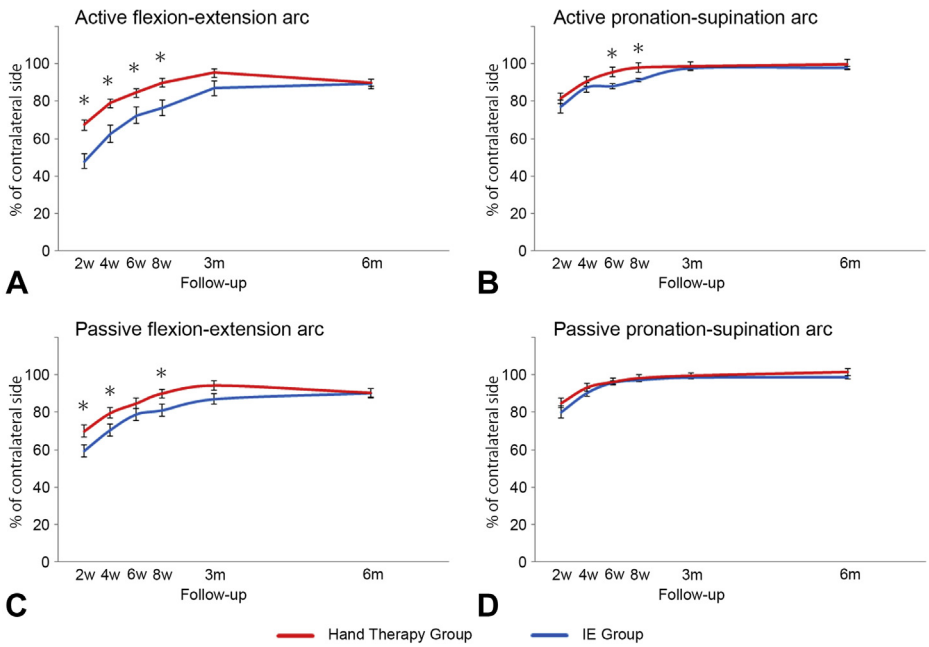

FIGURE 4: Ranges of motion of the **A**, **C** wrist flexion-extension arcs and **B**, **D** forearm pronation-supination arcs as percentages of the contralateral side, expressed as means ± standard errors. *$P < .05$.

TABLE 2. Comparison of Cohorts at 6 Weeks After Surgery*

Outcome	Hand Therapy Group		IE Group		*P* Value
	Mean	SD	Mean	SD	
*Quick*DASH	12.5	8.6	19.4	12.4	.027†
PRWE	18.0	11.5	22.9	18.4	.257
Active flexion-extension arc, % of contralateral side	84.8	13.7	72.4	21.8	.020†
Active pronation-supination arc, % of contralateral side	95.7	12.5	88.2	7.1	.012†
Passive flexion-extension arc, % of contralateral side	84.7	13.2	78.9	15.9	.166
Passive pronation-supination arc, % of contralateral side	96.2	9.1	95.9	4.2	.878
Grip strength, % of contralateral side	66.4	20.0	65.8	18.2	.914
Key pinch strength, % of contralateral side	78.2	14.2	77.9	13.0	.937
Pain, VAS score	10.2	10.5	17.6	14.8	.046†

*Data are provided as means with SDs.
†Statistically significant difference.

after the operation. They also concluded that patients without complications benefited equally from a home program and instructed or supervised therapy.[10] Clementsen et al[11] found that early mobilization and multiple physiotherapy visits did not improve wrist function compared with standard treatment with a dorsal plaster orthosis for 2 weeks, a single physiotherapy visit, and home exercises.

In our study, we focused on middle-aged and elderly women because we believe that there are differences in the postoperative courses of young patients with high-energy trauma and of older patients with low-energy trauma associated with osteopenia and osteoporosis, in that high-energy trauma may be accompanied by more severe soft tissue injuries that affect the postoperative recovery. In most studies, patients in the supervised hand therapy and home exercise groups did not receive comparable home exercise program instruction; however, in this study, all patients in both groups received instructions about the home exercise program from the hand therapist. These 2 groups only differed in whether supervised hand therapy was prescribed. Our supervised hand therapy protocol was similar to that of Brehmer and Husband,[22] who reported that starting ROM exercises immediately (3–5

TABLE 3. Comparison of Cohorts at 6 Months After Surgery*

Outcome	Hand Therapy Group		IE Group		*P* Value
	Mean	SD	Mean	SD	
*Quick*DASH	4.4	7.2	2.4	3.3	.212
PRWE	3.8	7.3	1.1	1.7	.080
Active flexion-extension arc, % of contralateral side	89.9	10.1	89.3	12.8	.852
Active pronation-supination arc, % of contralateral side	99.8	12.3	98.0	4.4	.473
Passive flexion-extension arc, % of contralateral side	90.4	10.7	90.3	13.3	.960
Passive pronation-supination arc, % of contralateral side	101.6	9.7	98.8	3.8	.172
Grip strength, % of contralateral side	88.5	18.3	86.9	13.8	.724
Key pinch strength, % of contralateral side	96.8	15.3	94.5	24.0	.691
Pain, VAS score	3.4	8.7	2.2	5.3	.558

*Data are provided as means with SDs.

days) after volar open reduction and internal fixation of distal radial fractures and starting strengthening exercises 2 weeks after surgery will facilitate an earlier return to clinically relevant function and potentially allow for an earlier return to daily activities, work, and sports.

Considering that a distal radius fracture affects the whole upper limb function, the *Quick*DASH score was selected as the primary outcome rather than the PRWE score, which only evaluates the affected wrist joint. Kleinlugtenbelt et al[23] found that the PRWE and *Quick*DASH are valid and reliable patient-reported outcome measures in assessing function and disability in patients with displaced distal radius fractures.[24,25] Jayakumar et al[26] reported that based on ceiling effects, it appears preferable to use the *Quick*DASH over the PRWE in the later stages of recovery after upper limb fractures. The minimal clinically important difference of *Quick*DASH has been previously reported.[27–30] Kazmers et al[31] established the minimal clinically important difference of *Quick*DASH as 6.8 using an anchor-based method for a hand surgery population. In our study, the difference in *Quick*DASH between the 2 groups at 6 weeks exceeded this value. However, this clinical importance was minimal because the difference was less than most estimates of the minimal clinically important difference for *Quick*DASH.

This study had several limitations. It was not double blinded because the patients knew whether they were undergoing hand therapy. The follow-up period was short (up to 6 months). We did not assess the quality-adjusted life years or other utility measures alongside costs.[32] Although it would not be desirable to prescribe hand therapy indiscriminately because it places a financial burden on both patients and health-care systems, appropriate hand therapy could be cost effective by facilitating an early return to previous activity levels.

In our study, hand therapy improved the functional and pain outcomes after volar locking plate fixation for distal radius fracture in middle-aged to elderly women at 6 weeks after surgery. Pain may be an important factor for functional recovery, as Souer et al[12] concluded that pain was the most important independent predictor of *Quick*DASH scores. There were no differences in grip strength and pinch strength at any time point. Patients in both groups were compliant with the protocols and may have been properly performing the strengthening exercises at home. There are several possible reasons for this result. First, with the high follow-up frequency, the patients may have understood the exercises better. However, for some of the patients who did not immediately understand the exercises, we were able to immediately clarify and correct any misunderstanding. Second, the exercise duration may be important. Even though the patients were instructed to perform the home exercise program, the amount of exercise actually performed at home remained unknown. At 6 months after surgery, there were no significant differences in any of the functional and pain outcome measures between the hand therapy and IE groups. This was consistent with previous studies despite the different study setting, rehabilitation protocol, and study population. On the basis of these results, hand therapy for up to 6 or 8 weeks may accelerate the early functional recovery and pain reduction after volar locking plate fixation for distal radius fracture in middle-aged to elderly women.

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