

A Comparison of Elbow Flexion and Elbow Extension on Hand Swelling after Surgery in Closed Fracture of Distal End Radius: Pilot Randomized Control Trial

Chidchanok Sakdapanichkul¹, Nattakorn Mahasupachai¹, Parunyu Vilai¹,
Cholawish Chanlalit^{1*}

¹ Department of Orthopaedics, Faculty of Medicine, Srinakharinwirot University, Rangsit-Nakhon Nayok Rd, Ongkarak Ongkarak, Nakhon Nayok, Thailand 26120

Abstract

Elbow posture in reducing hand edema was rarely reported in literature. Elbow extension may promote lymphatic and venous drainage better than elbow flexion, which might lead to a better edema reduction after a surgery in an upper extremity. Twenty-four patients who required a surgery for distal end radius fracture were recruited for a pilot study and randomized into elbow flexion and extension groups. Elbow posture was set after the surgery until 48 hours postoperatively. Hand volume was measured at 24 and 48 hours postoperatively. Range of motion, quick Disabilities of Arm, Shoulder, and Hand score, and handgrip strength were recorded at 2, 6, and 12 weeks follow-up. In results, the mean edema reduction was 3.30% (SD=15.36) and 14.14% (SD=8.55) in the elbow flexion and extension groups, respectively. Elbow extension posture significantly reduces the size of the edema by 4.28 times as much as over the 24 hours period as what could be achieved by the elbow flexion posture ($p=0.044$). In conclusion, this randomized pilot study is feasible for a full-scale project for studying the elbow posture in edema reduction. Elbow posture might play an important role for reducing hand edema in postoperative protocol after a surgery in upper extremity.

Keywords: Distal radius surgery, Elbow flexion and extension; Elbow posture, Reduce hand edema

* Correspondence to:

Cholawish Chanlalit

Department of Orthopaedics, Faculty of Medicine,
Srinakharinwirot University, Rangsit-Nakhon Nayok
Rd, Ongkarak Ongkarak, Nakhon Nayok, Thailand
26120 Phone: 037-3950856 dial to 60610

Email: chanlalit@hotmail.com

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INTRODUCTION

Distal end radius fracture is one of the common fractures seen in the emergency room, accounting for approximately 3 percent of all upper extremity injuries [1]. The main goal of the treatment is to restore the function of the wrist as much as possible [2]. After a surgery, joint stiffness can develop through four stages of bleeding, edema, granulation tissue and finally fibrosis [3]. Stiffness proceeding edema is one of the problems affecting daily activities.

The first and second stages play important roles as they can be minimized. In the first stage, occurring in minutes to hours after the surgery or trauma, bleeding will cause distension of joint capsule and swelling of periarticular tissues. This stage can be minimized by different surgical techniques to reduce bleeding. Later, occurring hours to days in stage 2, platelets and dead cells, including injured cells, will release inflammatory mediators. These mediators will cause the nearby blood vessels to dilate and the plasma to leak, resulting in the

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swelling of periarticular tissue. Similarly, like in the stage one, the compliance of joint movement will be decreased as the joint will be difficult and painful to move. This stage can be minimized by different protocols to reduce edema [4, 5], which will be discussed in this study.

From the principle of elevating an upper limb above heart level in promoting a reduction of edema, venous return will be enhanced by gravity; however, postoperatively in distal end radial fracture with immobilization, upper limb posture will usually be in an elbow flexion. This can lead to compromised circulation around the elbow. Moreover, a study of supracondylar fracture by Mapes RC et al. [6] found that vascular safety can be enhanced by elbow extension and forearm supination. Therefore, elbow extension might have a better venous and lymphatic drainage consequently reducing finger and hand edema better than with the elbow flexion after the surgery of an upper limb.

To our knowledge, there has been no study comparing whether elbow flexion or extension has better efficiency in reducing postoperative edema in the fingers and hand.

Objectives

The primary objective of this study is to compare the efficiency between elbow flexion and extension on reducing fingers and hand edema postoperatively at 48 hours compared with 24 hours. The secondary objective is to compare functional outcomes which are wrist range of motion, handgrip strength, and quick Disabilities of Arm, Shoulder, and Hand (DASH) score [7] between elbow flexion and extension at 2 weeks, 6 weeks, and 12 weeks follow-ups.

MATERIALS AND METHODS

This study was registered in the Thai Clinical Trials Registry (TCTR20210429005). Strategic Wisdom and

Research Institute, ethic committees of Srinakharinwirot University, gave approval for ethics review (SWUEC/F-341/2562). A prospective randomized pilot study was conducted at H.R.H. Maha Chakri Sirindhorn Medical Center (MSMC), Srinakharinwirot University, during May 2020 to April 2021. Patients with closed distal end radius fracture who needed a surgery and were older than 18 years old were recruited. Patients who were subject to the satisfaction of the inclusion criteria and exclusion criteria gave written informed consent before starting the experiment. Exclusion criteria were patients who refused operative treatment, did not give consent, underwent revision surgery, had bilateral fractures on upper extremities, pathological fracture, distal end radius fracture for more than 2 weeks, associated ulnar fracture except ulnar styloid, history of major surgery of the contralateral hand, history of breast surgery, concurrent disease of hand (e.g. Dupuytren's or rheumatoid arthritis), contraindication in elevating the hand or flexing or extending elbow, and wound on their hands that prevents them from exposing to water.

Demographic data were obtained for all participants, which were age, gender, duration from accident to surgery, dominant hand, fracture side of hand, AO classification, surgical technique, surgeon, operation time, associated injury, volume of fingers and hand of normal side and surgical side at 24-hour postoperatively.

Before the surgery, the patients were randomized with minimization method into two groups, elbow flexion and elbow extension. The surgeons and patients would not know the group allocation until after the surgery. The factors that were used in minimization are American Orthopedic/Orthopedic Trauma Association (AO/OTA) classification and different surgeons. There were 3 types from AO/OTA classification: extra-articular (A), partial articular (B), and complete articular (C). The surgeons were orthopedic surgeons from Upper Extremity Reconstruction and Sports Orthopedics

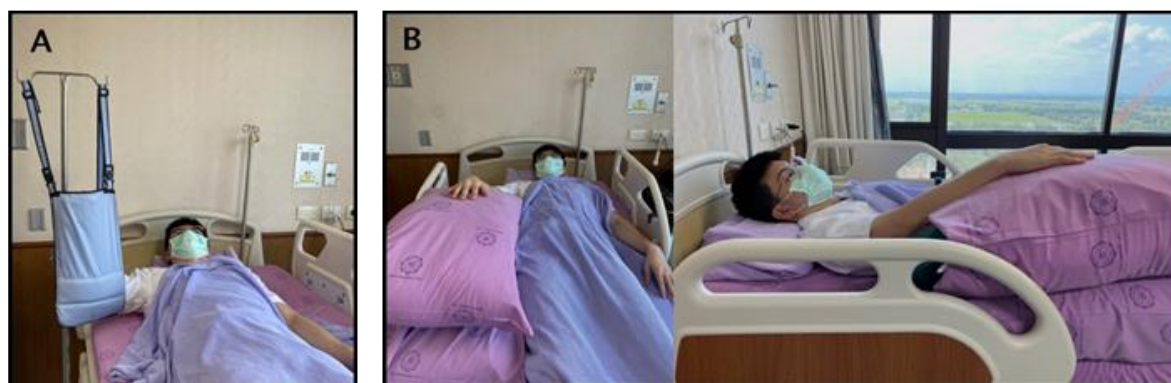


Figure 1. (A) Elbow flexion (B) Elbow extension



Figure 2. Volumetry of hand

Medicine Excellent Center and well-trained traumatic orthopedic interns at MSMC.

After the surgery, a pillowcase or pillows were used immediately after the patients arrived back at the in-patient ward. At 24-hour postoperatively, the volume of the fingers and hand of both the surgical and normal sides were measured. At 48-hour postoperatively, the volume of the fingers and hand of surgical side was measured.

The volume of fingers and hand was measured by using the water displacement method according to the Archimedes principle. A container will be filled up with room-temperature sterile water to the point of overflowing. Fingers and hand were lowered into the container until the distal volar crease of wrist touches the water. The fingers and hand then displaced the water, which then flowed into a smaller container. The volume of the displaced water equaled the volume of the fingers and hand. The displaced water was measured using a 100-ml graduated cylinder with a 1-ml scale. This method of volumetry had intraclass correlation coefficients (ICCs) for inter- and intra-rate reliability with 0.999 (0.998-1.000) and 0.837 (0.682-0.924), respectively (Figure 2).

To minimize the contamination, the container was sterilized and sterile water was used. The surgical hand was painted with povidone iodine solution and then alcohol before the measurement. The surgical wound was covered with sterile waterproof patch (Tegaderm®) before putting the hand into the water. After the hand was taken off the water, the sterile waterproof patch was opened and the wound was examined immediately. The wound was closed with a new sterile waterproof patch (Tegaderm®) after a wound dressing (Figure 2).

In postoperative medication, a 2-gm bolus dose and then 1 gm of cefazolin intravenously every 6 hours was used as a prophylactic antibiotic. If a patient was allergic to cefazolin, the alternative was 600 mg of clindamycin intravenously every 8 hours. Pain control was 3 to 4 mg

of morphine intravenously every 4 hours during the first 24 hours and then every 6 hours during the next 24 hours.

In the first secondary objective, wrist range of motion, grip strength, and quick DASH score were examined after the surgery at 2 weeks, 6 weeks, and 12 weeks. Ranges of motion, including wrist flexion, extension, pronation, and supination, were measured in degrees. The handgrip strength was measured using an electronic hand grip dynamometer and the outcome were shown as kilogram (kg). The quick DASH score was used to evaluate the ability in performing daily activities. In the second of the secondary objectives, each coming adverse event or complication were recorded and managed with standard treatment.

The person who measured the volume was a well-trained nurse from another department who did not look after the patients. The same person measured the volume of each patient. The wrist range of motion, grip strength, and quick DASH score were measured by one well-trained nurse from the outpatient department. The two people who assessed the outcome did not know the group allocation.

Sample Size and Statistical Method

The sample size was calculated by a formula for comparing a proportion between two population groups (Cohen, 1988) [8]. There was no study that had the same intervention with this study and so the calculation was based on a comparable study of Baker et al (2010). They measured the volume of the hand twice, once preoperatively and again 24-hours postoperatively. The percentage of edema of fingers and hand at 24-hour postoperatively compared to preoperatively in hand elevation group and non-elevation group are 2.3% and 4.2%, respectively.

After the sample calculation according to the formula, a sample size of 1362 participants in each group is required to show a clinical significance with the power

of 80% at a confidence interval of 95%. With the expectation of drop out or discontinuation of 10%, a sample size of 1514 participants is required in each group and resulted in 3028 participants in total for this study. However, the duration of this study is limited and rarely possible to collect 3028 participants, prospectively. Moreover, there has been no study comparing whether elbow extension can reduce hand edema better than elbow flexion. This study was conducted as a pilot randomized study with a sample size of 12 participants in each group and so a total of 24 participants in this study.

Demographic data of the sampling population will be analyzed as percentage and count for categorical data while as mean, median, minimum, and maximum for continuous data. The primary objective will be shown as percentage edema reduction mean and analyzed as mean percent difference between the two groups with 95% confidential interval by using independent t-test. The first secondary objective, evaluating on the wrist range of motion, grip strength, and quick DASH score, will be reported as mean differences with 95% CI. T-test and multiple linear regression will be used for the mean difference at 2 weeks, 6 weeks, and 12 weeks. The overall mean difference will be reported by using generalized estimating equation (GEE) with 95% CI. The second secondary objective, which is each coming up adverse event or complication, will be shown as count. A p-value of less than 0.05 was statistically significant. All statistical analysis was performed using STATA version 14.0.

RESULTS

There were 28 patients who met all the inclusion criteria. Four of them were excluded due to refusing to give consent, having wound on hand that could not expose to water, ulnar shaft fracture, and bilateral fracture of upper extremities. Therefore, the remaining 24 patients were allocated into two groups with 12 patients in each group. The data for primary objectives could be obtained from all 24 patients. However, one patient from elbow flexion group and one patient from elbow extension group lost follow up at postoperative 6 weeks and 12 weeks. Two patients from elbow flexion group lost follow up at postoperative 12 weeks.

Demographic data of all patients in both groups were similar (Table 1). The surgical hands after surgeries were significantly swelling compared with normal hand in elbow flexion group (p-value = 0.0004) and elbow extension group (p-value < 0.0001) (Table 2).

Table 1. Demographic data of sampling population.

Characteristics	Elbow Flexion	Elbow Extension	p-value
Age (years old)			
Mean ± SD	48.5±16.6	45.2±18.1	0.643
Median (Min, Max)	50 (22,73)	51.5 (22,71)	
Gender			
Male	4	7	0.219
Female	8	5	
Duration from accident to surgery (hours)			
Mean ± SD	10.08±4.73	7.67±4.62	0.170
Median (Min, Max)	12 (0,14)	7.5 (0,14)	
Dominant hand			
Right	12	12	NA
Left	0	0	
Fracture			
Right	4	5	0.673
Left	8	7	
Type: AO Classification			
A	4	2	0.637
B	3	4	
C	5	6	
Surgical technique			
ORIF with PAS (volar approach)	11	11	1.00
Corrective			
Osteotomy (volar approach)	1	1	
Surgeons			
A	6	6	1.00
B	1	2	
C	2	1	
D	2	1	
E	1	1	
F	0	1	
Operation time (hours)			
Mean ± SD	79.83±15.51	84.92±33.36	0.637
Median (Min, Max)	78.0(60,110)	72.5(47,137)	
Associated injury			
Yes	4	6	0.680
No	8	6	

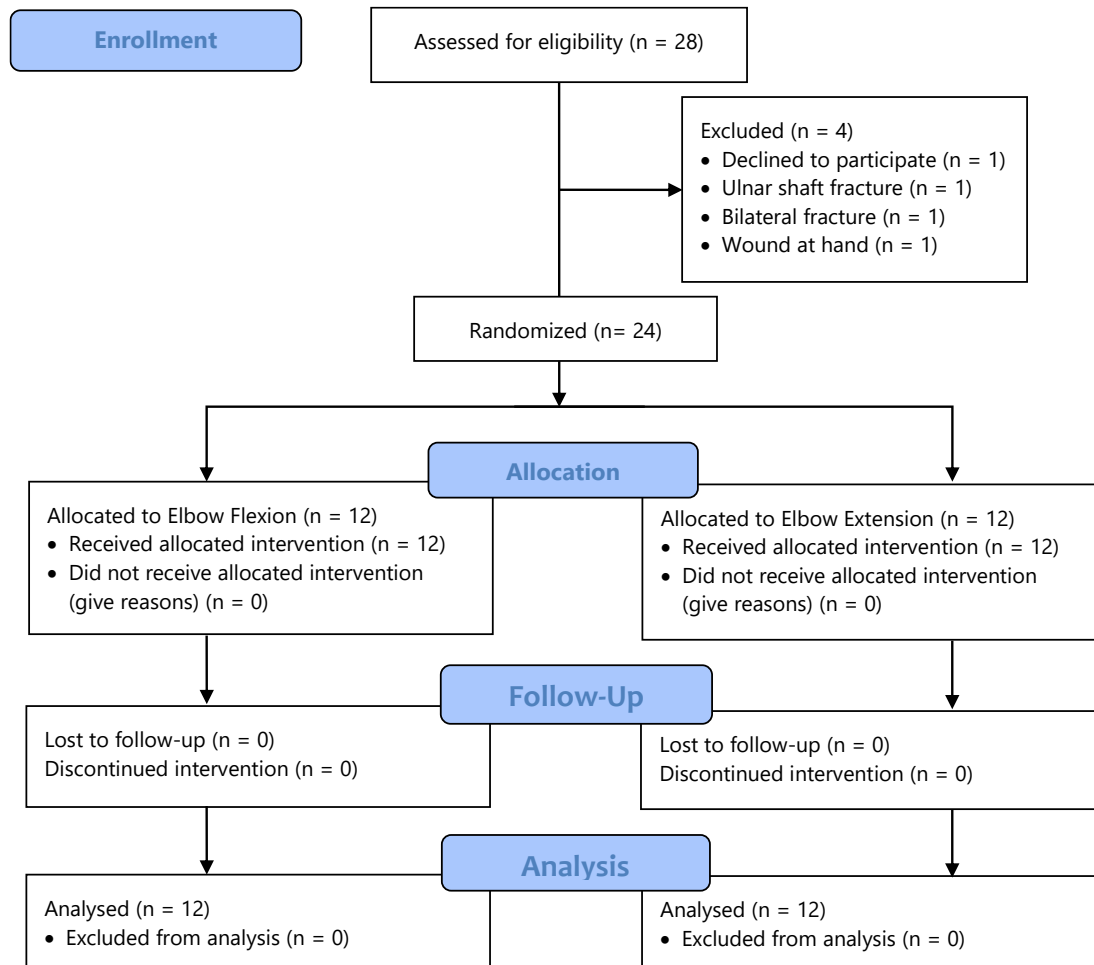


Figure 3. CONSORT Diagram

Table 2. Comparison of mean volume of fingers and hand between normal and surgical hand at 24 hours, postoperatively.

Groups	Volume of fingers and hand (ml)		p-value
	Normal Hand (24 hours postoperatively)	Surgical Hand (24 hours postoperatively)	
Elbow Flexion			
Mean±SD	241.25±49.35	301.92±80.84	0.0004
Median	238.50	306.50	
(Min, Max)	(147, 338)	(151, 486)	
Elbow Extension			
Mean±SD	281.58±44.32	374.42±77.54	<0.0001
Median	272.50	351	
(Min, Max)	(229, 402)	(292, 557)	

The mean edema reduction, measured postoperatively at 24 and again at 48 hours, was 3.30% (SD=15.36) in the elbow flexion group, and 14.14% (SD=8.55) in the elbow extension group. The results show that using the elbow extension posture

significantly reduces the size of the edema by 4.28 times as much as over the 24 hours period as what could be achieved by the elbow flexion posture ($p = 0.044$) (Table 3).

Table 3. Comparison of mean (SD) values for percentage edema reduction between elbow flexion and extension of surgical side at 24- and 48-hour, postoperatively.

Surgical Side	Percentage Edema Reduction Mean (SD)	Mean Percent Difference (95% CI)	p-value
Elbow Flexion	3.3 (15.36)	10.83 (0.31-21.36)	0.0442

Of all the follow-ups, most clinical outcomes were not significant between the two groups (Table 4). Only wrist flexion and extension were better in elbow extension group at 2 weeks follow-up with the mean difference of 16.71° (4.17°–29.25°) (p -value=0.012) and 17.42° (4.50°–30.34°) (p -value=0.011), respectively.

No complication from the protocol occurred.

Table 4. Comparison of wrist range of motion, grip strength, and quick DASH score at 2, 6, and 12 weeks, postoperatively

Outcomes	Elbow Flexion		Elbow Extension		Mean Difference*	95% CI	P-value
	Mean	SD	Mean	SD			
Wrist range of motion (degree): flexion							
2 weeks	16.82	14.01	34.54	11.93	16.71	(4.17-29.25)	0.012
6 weeks	30.45	16.04	40.00	16.43	2.05	(-17.84-13.74)	0.787
12 weeks	46.67	9.68	53.18	18.20	0.90	(-18.02-16.22)	0.912
Overall	N/A	N/A	N/A	N/A	0.34	(-10.25-9.58)	0.947
Wrist range of motion (degree): Extension							
2 weeks	10.91	12.41	23.64	18.32	17.42	(4.50-30.34)	0.011
6 weeks	30.91	15.62	32.72	19.28	10.63	(-24.32-3.06)	0.120
12 weeks	45.00	4.33	49.73	17.25	1.11	(-15.62-13.40)	0.872
Overall	N/A	N/A	N/A	N/A	5.31	(-13.29-2.67)	0.193
Wrist range of motion (degree): Pronation							
2 weeks	56.36	25.11	47.27	23.49	-11.71	(-35.20-11.78)	0.309
6 weeks	61.82	20.65	61.36	18.85	7.78	(-6.76-22.32)	0.275
12 weeks	71.11	22.61	79.09	13.00	11.28	(-2.44-25.02)	0.100
Overall	N/A	N/A	N/A	N/A	10.30	(-0.12-20.74)	0.053
Wrist range of motion (degree): Supination							
2 weeks	48.18	34.22	50.00	26.08	1.59	(-28.36-31.54)	0.912
6 weeks	60.61	31.04	64.09	24.78	5.78	(-13.06-24.63)	0.526
12 weeks	84.44	10.14	82.73	7.86	-1.73	(-10.21-6.74)	0.669
Overall	N/A	N/A	N/A	N/A	3.52	(-7.55-14.59)	0.533
Grip strength (kg)							
2 weeks	1.72	2.99	4.79	5.05	2.98	(-1.11-7.07)	0.143
6 weeks	6.73	5.51	12.23	4.77	1.82	(-1.64-5.28)	0.283
12 weeks	12.44	5.86	19.30	4.83	4.00	(-0.66-8.66)	0.087
Overall	N/A	N/A	N/A	N/A	3.16	(0.10-6.22)	0.043
Quick DASH score (points)							
2 weeks	50.88	20.16	45.74	19.38	-2.10	(-19.97-15.78)	0.808
6 weeks	37.61	15.27	29.72	20.21	-4.01	(-14.98-6.95)	0.451
12 weeks	17.47	14.70	10.66	9.64	-7.01	(-18.98-4.96)	0.231
Overall	N/A	N/A	N/A	N/A	-6.59	(-15.54-2.36)	0.149

* Mean difference adjusted for baseline measurements, age, and sex for each visit using analysis of multiple linear regressions. Overall mean difference was analyzed using generalized estimating equations implemented under generalized linear model.

DISCUSSION

After recruitments of sample population, many of the exclusion criteria were used to eliminate possible confounders that might affect the outcome. They were history of mastectomy, associated injury on ipsilateral upper extremity, pathological fracture, concurrent hand disease such as Dupuytren's and rheumatoid arthritis,

and a fracture that occurred for more than 14 days. Furthermore, the demographic data of the sample population showed no difference in age, AO classification, surgical techniques, surgeons, operative time, associated injuries, gender, dominant hands, and the side of fracture. Additionally, there was significant

hand edema of the hand on the surgical side compared to the hand on the normal side.

For the primary outcomes, the result showed that the elbow extension group had a significant higher percentage reduction mean than the elbow flexion group. For secondary outcomes, mostly, there was no difference in clinical outcomes between the two groups.

There are two comparable studies studying about reducing hand edema postoperatively. Baker RP et al⁹. conducted a randomized study of comparing hand swelling in patients with hand elevation and non-elevation after a surgery of fasciectomy or trapeziectomy for patients with Dupuytren's disease. The volume measurement of hand was performed twice, at 30 minutes before the surgery and at 24-hour postoperatively. The result showed that the swelling was less in the limb elevation group but the result was not statistically significant. Fagan DJ et al¹⁰. performed a controlled clinical trial comparing hand swelling in patients with the use of a Bradford sling (elbow flexed 90 degrees) and simple arm sling (elbow flexed 45 degrees) after a surgery of carpal tunnel decompression. In both groups, the hand was placed above heart level. The volume measurement of the hand was performed twice; preoperatively, and at 5 days postoperatively. The result showed that the mean increase in volume of operated hand was less in the Bradford sling than in the simple arm sling, but there was no statistically significant difference in their results. These studies worked on minor surgeries that might not even give a significant hand edema. Secondly, the later study compared different angle of elbow flexion, but not between flexion and extension. Only 45 degrees might not make a big difference in lymphatic and venous drainage.

In this randomized pilot study, however, it was performed on a major surgery, which was on the distal end radius fracture. The angle of elbow compared was 90 degrees, which was larger than the previous study. Both groups had the surgical hand elevated. This was the first pilot randomized controlled trial study of hand edema reduction that focus seriously on the posture of elbow after a major surgery.

Even though the result came out with statistically significant difference, but it was a pilot study. This cannot yet conclude that the elbow extension group can reduce hand edema better than the elbow flexion group until a full-scale project with a higher sample size was proved.

With this feasible result, in the future, elbow posture might play an important role in postoperative protocol for reducing edema after a surgery in upper extremities.

CONCLUSION

This randomized pilot study is feasible for a full-scale project for comparing the efficiency of edema reduction between elbow flexion and extension methods. Elbow posture might play an important role for reducing hand edema in postoperative protocol after a surgery in upper extremity.

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