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Post-surgical efficacy of early motion on intra-articular distal radius fracture and the effect of osteoporosis on outcomes

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Abstract

Aim: Post-surgical rehabilitation of intra-articular distal radius fractures in osteoporotic patients is still controversial. The aim of our study is to compare the effectiveness of early and late motion in intra-articular distal radius fractures in osteoporotic and non-osteoporotic patients.

Materials and Methods: Eighty patients were included in our study. The patients were divided into two groups according to osteoporosis (OP), (OP +, OP -). Each group was also divided into 2 groups according to initiation of motion ((Early motion subgroup (E-MOT), Late motion subgroup (L-MOT)). Quick Disabilities of the Arm, Shoulder and Hand (Q-DASH), Patient-Rated Wrist Evaluation (PRWE) scores, Range of Motion (ROM) and grip strength were evaluated at final follow-up.

Results: No significant difference was found among the groups in terms of age, gender ratio, right hand–left hand ratio, hand dominance, follow-up duration, or fracture classification. Contrary, the range of motion and functional results of OP+,E-MOT group were found to be more successful than the OP+,L-MOT group, there was no significant difference between the OP-,EMOT group and the OP-,L-MOT group.

Conclusion: Early motion has a positive effect on the results in osteoporotic patients compared to late motion, while it does not significantly affect outcomes in non-osteoporotic patients. Early motion after surgery for intra-articular distal radius fractures is crucial for osteoporotic patients, but less so for non-osteoporotic patients.

Introduction

Distal radius fractures are the most common the upper extremity fracture, with a higher incidence among osteoporotic patients [1]. It is still controversial whether surgical or non-surgical approaches are more successful in the treatment of intra-articular distal radius fractures in elderly osteoporotic patients.

Studies using locking plates have achieved successful outcomes, thus favoring surgical treatment over non-surgical alternatives [2, 3]. The primary aims of surgical treatment are achieving anatomical reconstruction, stable fixation, and initiating early postoperative motion [4]. Controversy continues regarding the timing of motion initiation in osteoporotic patients after surgery. Some studies recommend immobilization even if stable fixation is achieved through surgery [5, 6], while others suggest early post-operative motion [4, 7]. These studies demonstrate that initiating early motion without immobilization after surgical treatment positively affects outcomes, although they often include patients with both intra-articular and extra-articular distal radius fractures [2-4].

The most critical problem in osteoporotic intra-articular distal radius fracture is the limitation of joint motion, which negatively affects the outcomes. Initiating motion after surgery has a favorable effect on the results. Although a limited number of studies focus on early motion in osteoporotic distal radius fractures, there are no studies about isolated intra-articular fractures. Our hypothesis is that early post-operative motion in osteoporotic intra-articular distal radius fracture will increase Range of Motion (ROM), and thereby positively influencing functional outcomes. Additionally, we aim to compare the effect of early and late motion on results in non-osteoporotic intra-articular distal radius fractures.

Materials and Methods

Research design

This retrospective case-control study was performed in the rehabilitation department of Gaziosmanpaşa Research and Training Hospital. The data of the patients were obtained

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from the prospectively documented orthopedic clinical registry system.

Our study was approved by the Ethics Committee of Gaziosmanpaşa Training and Research Hospital (2021–297) and was performed in accordance with the tenets of the Declaration of Helsinki [8]. All methods were performed according to relevant guidelines and regulations. After informing the patients about the possible side effects of the treatments, written informed consent was obtained from each patient.

Sample size calculation

The primary outcome of our study was functional score at the last follow-up. We calculated the sample size based on the Patient-Rated Wrist Evaluation (PRWE) of a previous study [2].

Assuming a 3-point difference between the groups in PRWE rating scale with a α of 0.05, and a ß error of 0.8, the study required at least 16 patients in each group.

Participants

Two hundred and eighty eight patients fixed with volar locking plate between January 2015 and January 2020 for intra-articular distal radius fractures were retrospectively evaluated.

The following patient inclusion criteria:

- Patients over 40 years of age,
- Patients with type 23 C (complete articular) fracture in the distal radius according to the intra-articular AO classification,
- Patients with bone mineral density measurement and Dual Energy X-ray Absorptiometry (DEXA) value below -2.5,
- Patients actively participated in a rehabilitation program on a regular basis.

The following patient exclusion criteria:

- Patients with extra-articular distal radius fractures,
- Open fracture, accompanying tendon, nerve and vascular injury,
- Patients had previously surgical treatment with methods such as K wires, external fixators, dorsal plates, or treated with plaster casts,
- Additional fractures in the same extremity other than the distal radius fracture,
- Previously surgical history on the same upper extremity.

As a result of these inclusion and exclusion criterias, the study focused on the information of 152 patients who underwent volar plate fixation for intra-articular distal radius fractures. Fifty-two patients could not be contacted, 11 patients did not participate regularly in rehabilitation, and 9 patients had an additional fractures in the upper extremity either before surgery or during the follow-up period, which included open fractures, tendon, nerve, and vascular injuries. These patients were excluded from the study. Eighty patients were evaluated at the final follow-up.

The patients were divided into four groups based on osteoporosis (OP) and initiation of motion (MOT).

Group 1: OP+ (Osteoporosis present), E-MOT (Early initiation of motion).

Group 2: OP+ (Osteoporosis present), L-MOT (Late initiation of motion).

Group 3: OP- (No osteoporosis), E-MOT (Early initiation of motion).

Group 4: OP- (No osteoporosis), L-MOT (Late initiation of motion).

Rehabilitation programs

Rehabilitation was applied to all patients under the supervision of a physiotherapist.

(E-MOT) Early motion after surgery without immobilization (Group 1, Group 3)

For patients in Group 1 and Group 3, the rehabilitation process involved the following steps:

1. Reduction of bandaging and initiation of rehabilitation on the first day after surgery.
2. Daily massage of the incision area with lotion, three times a day, for 10 minutes each session, after the removal of stitches.
3. Implementation of elevation, cold application, and compression bandages to reduce edema formation.
4. Ensuring that the hand is positioned higher than the elbow, and the elbow is higher than the shoulder. Massage of the affected hand, starting from the fingertips and moving towards the axilla.
5. Gentle joint motion exercises using the Maitland technique, with grade 2 or 3 intensity, at a rate of one cycle per minute for the first three weeks.
6. Active hand and wrist exercises conducted in a whirlpool at 34°C for 15 minutes daily, lasting for three weeks after the removal of stitches in the second week.
7. Implementation of the grade I gliding Kaltenborn method in both anteroposterior and posteroanterior directions, with the distal radius stabilized in a neutral position after the second week.
8. Application of the grade I and II gliding Kaltenborn method between the third and sixth weeks.
9. Gradual incorporation of radiocarpal motion sustained at grade II at the end of the range by Kaltenborn.
10. Grip strength exercises performed three times a day between the first and sixth weeks, with each set involving 8-10 repetitions lasting for 5 minutes.
11. Additionally, scapular retraction exercises were applied from the first to the sixth week.

(L-MOT) Late motion starting after 4 weeks of immobilization (Group 2, Group 4)

For patients in Group 2 and Group 4, the rehabilitation process followed these steps:

1. Immobilization of the wrist with a short arm splint for a period of 4 weeks.
2. Elevation and cold application to reduce edema formation.
3. Ensuring that the hand is positioned higher than the elbow, and the elbow is higher than the shoulder.
4. Commencement of active exercises for all fingers on the first day after surgery.
5. Removal of the short arm splint at the end of the 4-week immobilization period.
6. Initiation of active hand and wrist exercises in a whirlpool at 34°C for 15 minutes daily, continuing for 4 weeks.
7. Implementation of joint motion exercises using the Maitland technique, with grade 2 or 3 intensity, at a rate of one cycle per minute.
8. Performance of the grade I and II gliding Kaltenborn method in both anteroposterior and posteroanterior directions, with the distal radius stabilized in a neutral position at the 6th week.
9. Conducting grip strength exercises three times a day between the 5th and 9th weeks, with each set involving 8-10 repetitions lasting for 5 minutes.
10. Additionally, scapular retraction exercises were applied from the 5th to the 9th week.

Measurement variables

ROM and grip strength were evaluated. Flexion, extension, supination, pronation, radial deviation, and ulnar deviation angles of the wrist joint were measured with a goniometer. Hand grip strength was measured with a Jamar dynamometer (Asimow Engineering, Los Angeles, USA) in shoulder 0° adduction, elbow 90° flexion and forearm neutral rotation. Each measurement was repeated three times and the average was recorded in kilograms (kg). Quick Disabilities of the Arm, Shoulder, and Hand (Q-DASH) and PRWE scoring were used for satisfaction assessment [9, 10]. A clinical examination was conducted by an independent examiner who was blinded to the treatment method.

Statistical analysis

The intention-to-treat principle was used in all analyses. The primary outcome (PRWE score) and secondary outcomes (Q-DASH, flexion, extension, pronation, supination, radial deviation, ulnar deviation, and grip strength) were described by means and SDs. The null hypothesis was that late motion in osteoporotic intra-articular distal radius fracture gives worse outcome than early motion. Statistical analysis was carried out using the Statistical Package for the Social Sciences for Windows version 15.0 (SPSS Inc., Chicago, IL, USA). Quantitative data were expressed as mean and standard deviation while analysed by descriptive statistical methods including the Pearson Chi square test and One-way Analysis of Variance (ANOVA). In order to compare multiple variables, post-hoc test was used. For the comparison of independent samples, analysis of variance (ANOVA) was used if the data were normally distributed, whereas the Kruskal-Wallis test was used if the data were not normally distributed. Differences with p-values < 0.05 were considered to be statistically significant.

Results

Age, gender distribution, right-left hand ratio, dominant hand status, mean follow-up period, and AO fracture classification did not show any significant differences among the groups ($p > 0.05$) (Table 1).

Flexion - Extension - Supination - Pronation: Patients in Group 2 (OP +, L-MOT) had significantly worse results in terms of flexion, extension, supination, and pronation compared to patients in the other groups ($p=0.0036$), (Table 2). It was observed that early motion without immobilization had a positive effect on wrist flexion, extension, supination, and pronation in osteoporotic patients but did not affect non-osteoporotic patients.

Radial – Ulnar Deviation: No statistically significant differences were observed between the groups in terms of radial and ulnar deviation ($p>0.05$). Early motion was found to have no effect on radial and ulnar deviations in both osteoporotic and non-osteoporotic patients.

Grip Strength: No statistically significant differences were determined between the groups in terms of grip strength ($p=0.4480$).

Q-DASH Score, PRWE Score: Patients in Group 2 (OP +, L-MOT) had significantly worse results in terms of Q-DASH and PRWE scores compared to patients in the other groups ($p<0.05$), (Table 2). It was found that early motion without immobilization had a positive effect on functional outcomes in osteoporotic patients, but did not affect non-osteoporotic patients.

Discussion

The restoration of ROM and functional outcomes after distal radius fractures are crucial. Prolonged wrist immobilization could lead to potential disability in distal radius fractures [11]. Early motion and axial load within first 3 weeks after surgery have been shown to have a significant positive effect on bone healing. Early motion enables the remodeling of multiple chondral fragments into the articular surface through active movement of the scaphoid and lunate [4]. Early postoperative motion allows patients to return to their daily life and work sooner, thereby improving their quality of life and physical comfort [12]. To achieve good ROM and functional results in distal radius fractures, it is recommended that immobilization should not be prolonged [13]. However, controversy remains regarding the optimal duration of immobilization, as overly short immobilization can result in a loss of fracture reduction in intra-articular fractures [13, 14]. Biomechanical studies have shown that fixation of distal radius fractures with locking plates provides five times more stability than what is required by active finger motion [15]. Consequently, early motion can be initiated after surgery, which has become a popular approach in recent years [16]. While the literature widely accepts early motion after locking

Table 1. Demographic data of the patients in the groups. Distribution of the patients in the groups according to rehabilitation protocol and osteoporosis.

		Group 1 (OP + IM -)	Group 2 (OP + IM +)	Group 3 (OP - IM -)	Group 4 (OP - IM +)	P
Age (year)		58.94 ± 12.92	57.52 ± 11.86	54.05 ± 10.24	53.16 ± 8.45	0.2828[a]
Male / Female		12 / 6	17 / 4	14 / 3	17 / 7	0.6202[b]
Right Hand / Left Hand		10 / 8	16 / 5	12 / 5	12 / 12	0.2135[b]
Dominant / Non-Dominant		12 / 6	15 / 6	14 / 3	15 / 9	0.5737[b]
Mean follow-up period (month)		29.44 ± 8.28	35.76 ± 14.24	30.82 ± 9.06	38.45 ± 18.72	0.1393[a]
AO Classification	C1	7	8	4	7	0.3045[b]
	C2	7	5	6	8	
	C3	4	8	7	9	

[a] Using ANOVA test. [b] Using a chi-square test. OP: Osteoporosis IM: 4 weeks of immobilization.

Table 2. Range of motion, grip strength and functional results at final follow-up.

	Group 1 (OP + IM -)	Group 2 (OP + IM +)	Group 3 (OP - IM -)	Group 4 (OP - IM +)	P
Flexion	77.50 ± 9.66	67.19 ± 14.30	79.35 ± 9.65	76.75 ± 9.44	**0.0036[a]**
Extension	69.38 ± 12.14	55.90 ± 14.00	69.76 ± 10.76	65.66 ± 8.65	**0.0007[a]**
Supination	78.66 ± 7.04	70.38 ± 9.16	80.17 ± 6.92	78.25 ± 8.43	**0.0010[a]**
Pronation	80.33 ± 8.26	71.04 ± 7.78	81.64 ± 8.70	77.66 ± 6.88	**0.0003[a]**
Radial Deviation	17.72 ± 2.56	16.23 ± 2.71	16.94 ± 3.40	17.62 ± 3.04	0.3401[a]
Ulnar Deviation	34.05 ± 7.88	35.14 ± 5.97	36.35 ± 8.85	37.66 ± 6.97	0.4317[a]
Grip Strength	29.11 ± 8.28	28.76 ± 7.45 1	32.47 ± 7.07	30.25± 7.23	0.4480[a]
Q-DASH Score	4.53 ± 3.89	9.48 ± 6.48	3.96 ± 4.58	4.30± 4.12	**0.0012[a]**
PRWE Score	3.44 ± 3.12	7.90 ± 6.0	3.11 ± 3.93	4.50± 4.51	**0.0058[a]**

[a] Using ANOVA test. OP: Osteoporosis IM: 4 weeks of immobilization.

plate fixation, consensus has yet still to be reached regarding osteoporotic patients.

There are various definitions of early motion in the literature. Indeed, there are studies that initiate motion after the 1st week using a removable thermoplastic splint, while others choose to immobilize patients with a short cast for 2 weeks before removing the cast and commencing motion [4, 17-9]. In our study, early motion commenced on the first postoperative day which was similar to only one other study. However, it's worth noting that the patients in this particular study used removable orthoses, unlike our approach [20]. Early motion was initiated on the first postoperative day, and joint mobilization was carried out using the Maitland technique with grade 2 or 3 intensity during the first three weeks in our study.

A meta-analysis that included four prospective randomized trials compared results at the six-month mark and concluded that early motion is more successful and safe in terms of outcomes when compared to late motion [21].

In a systematic review that included randomized controlled trials, the results of 293 early motion patients and 303 late motion patients were evaluated. The findings indicated that functional outcomes at 6 weeks were significantly better in the early motion group compared to the late motion group. Furthermore, results were significantly superior during the second and 6th weeks for early motion patients in terms of range of motion and grip strength. However, it was also noted that there might be a higher risk of implant loosening and/or fracture re-displacement associated with early motion [22].

In another study comparing early motion with late motion, it was observed that the early motion group had better results in the early period. However, there was no difference between the two groups in the later period. The disparities in the early period were attributed to the rigidity of the cast used. This study had a lack of homogeneity among the patients, with different fracture types and without any assessment for osteoporosis [23].

In a systematic review that incorporated five clinical studies, it was determined that early motion achieved superior results compared to late motion in various aspects, including 6th-week functional outcomes, visual analog scale (VAS) scores, grip strength, and range of motion. However, no differences were observed between the groups in terms of range of motion at 3 months, and there were no variations in any of the data throughout the first year [9].

In a prospective controlled randomized study, early and late motion were compared in distal radius fractures fixed with a volar plate. Early motion was initiated in 47 patients, while late motion was commenced in 48 patients. The results were evaluated at the 4th week, 3rd, 6th, and 12th months. During these evaluations, no significant differences were found in functional outcomes, range of motion (ROM), or grip strength. As a result, it was concluded that early motion did not have a positive effect on the results. In our study, the results for non-osteoporotic patients were consistent with this study. However, we discovered that early motion had a significant positive effect on the results in osteoporotic patients. The variation in patients included in the aforementioned study, such as different fracture types and the absence of osteoporosis assessment, likely influenced the results. Some patients had extra-articular fractures, while others had partial or complete intra-articular fractures, which raised questions about the homogeneity of the patient groups. In contrast, our study consisted of patients with the same type of intra-articular distal radius fracture, and their osteoporosis status was evaluated before categorizing them into groups based on the diagnosis of osteoporosis [20].

A randomized controlled study evaluated the results of early motion and late motion at the 2nd week, 6th week, 3rd month, and 12th month. The study found no significant difference in functional outcomes, range of motion (ROM), pain scores, and grip strength between the two motion protocols [24].

It has also been shown that the functional results of rehabilitation started early are more successful. Early motion showed better ROM and pain reduction [7]. Motion and exercise are important to prevent decreased bone density in elderly patients. The results of the studies in the elderly indicate that exercise may increase the thickness and resistance of cortical bone [25]. Early motion can prevent stiffness and positively affect bone formation.

Notably, there are no studies that directly compare early motion with late motion in osteoporotic patients. Our study addressed this gap by comparing early motion and late motion in both osteoporotic and non-osteoporotic patients. Our findings indicate that early motion has a positive impact on outcomes in osteoporotic patients compared to late motion, but it does not significantly affect outcomes in non-osteoporotic patients.

Limitations

Our study has several strengths, including long-term follow-up results, an uniform type of fracture (type 23 C according to AO classification), consistent surgical treatment, and the categorization of patients into different groups based on the diagnosis of osteoporosis and initiation of motion. The study also utilized specific inclusion and exclusion criteria. Although our study provides valuable information on rehabilitation of distal radius fracture, it also has certain limitations. Our study is a retrospective study in nature and conducted with a limited number of patients. Despite all surgical treatments being performed in the same hospital, different surgeons performed the operations. Therapeutic compliance is an ongoing challenge for the physical therapy field in general because it is difficult in retrospective studies to check that the proposed treatment plan has been implemented exactly as recommended.

Conclusion

In summary, our findings demonstrate that early initiation of motion has a positive impact on functional results and range of motion in osteoporotic patients. However, this approach did not significantly affect range of motion, grip strength, or functional outcomes in non-osteoporotic patients. Early initiation of motion without immobilization appears to be more crucial for osteoporotic patients compared to non-osteoporotic patients.

Ethical approval

This study was approved by the Ethics Committee of Gaziosmanpaşa Training and Research Hospital (2021–297) and was performed in accordance with the tenets of the Declaration of Helsinki.

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