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Original Article

# Effect of Activation of Shoulder Girdle Muscles Exercises versus Hand on Wrist Joint Mechanics of Patients Post Intraarticular Distal Radius Fracture Surgeries

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## Abstract

**Background**: therapeutic exercises post DRFs surgeries are shown to be very important in preventing complications and deformities. The orthopedic nurses' role post DRFs surgeries includes physical assessment, pain management, and patients' education on the safe compensatory strategies for enhancing hand functional abilities. **Aim:** Compare the effect of activation of shoulder girdle muscles exercises versus hand on wrist joint mechanics of patients post intraarticular distal radius fracture surgeries. **Design:** A comparative quasi experimental research design. **Setting:** This study was carried out at the Hadara Orthopedic and Traumatology University Hospital, Alexandria. **Subjects:** A convenience sample of 50 adult patients with intraarticular DRF, who were scheduled for surgeries. **Tools**: Three tools were used for data collection; Tool I: Wrist Functional Abilities Index; Interview Schedule. Tool II: Mobility Index of the Wrist joint. Tool III: Complications of Intraarticular Distal Radius Fracture Checklist. **Results:** The results showed that there was a highly significantly more improvement in the total patient rated wrist evaluation and range of motion mean score at 6$^{th}$ and 8$^{th}$ week post exercises performance in the study group (I) than the study group (II) (P=0.001*). Moreover, there was a statistically significant difference between patients of both studied groups' hand grip strength in the 6$^{th}$ and 8$^{th}$ week post exercises (P=0.043, P=0.013; respectively). With regard to total complications and wrist joint plain x ray results scores in the 6$^{th}$ week and 3 months' post exercises a statistically significant difference between group I and II were noted (P=0.047, P=0.043; and P=0.034, P=0.049 respectively). **Conclusion:** Therapeutic shoulder girdle muscles, elbow and hand exercises practices following intraarticular DRFs surgeries have been shown to improve wrist joint functional abilities, range of motion and muscle strength more than hand exercises only. **Recommendation**: It is recommended that health team members namely, surgeons, nurses, and physical therapists consider incorporating active shoulder girdle exercises into DRFs' the treatment program.

**Keywords:** Shoulder girdle muscles and hand exercises, Wrist Joint Mechanics, Functional abilities, Range of motion, and DRFs surgery.

## Introduction

Distal radius fractures (DRFs) are one of the most common admitted orthopedic upper extremity fractures. Moreover, DRFs continue to possess a major significant impact on the health and well-being of young adults of both genders; resulting

in a considerable functional impairment, that necessitates immediate medical attention and proper nursing management (**Crowe et al., 2020; Hong et al., 2020)**. The DRFs account for 17% of all orthopedic fractures in the western world; as well as accounting around 75% of forearm fractures in the United States. Moreover; DRFs represent one third of upper extremity fractures with an incidence of greater than 20% of all orthopedic fractures in Hadara Orthopedic and Traumatology University Hospital, Alexandria, Egypt (2020) **(Ziebart, Nazari, & MacDermid, 2019; Pavone et al., 2020; Statistical record of Hadara Orthopedic and Traumatology University Hospital, 2020)**.

Nevertheless; DRFs are mainly caused by forearm motor vehicle accidents or high energy trauma; which is commonly induced by fall from height on an outstretched hand with the wrist in dorsiflexion **(Sultan, Abdul Aziz, & Alsaleem, 2017)**. Furthermore, patients with DRFs frequently complain from post-traumatic distal upper extremity pain, crepitus and tenderness overlying the fracture site, swelling with ecchymosis, in addition to the limited forearm and wrist motion **(Mauck & Swigler, 2018; Rachuene et al., 2021)**.

As regards to the diagnosis of examination of DRFs: three wrist radiography views are performed: postero-anterior (PA), lateral, and oblique views of the forearm to confirm the presence of fracture **(Oulianski, Avraham, & Lubovsky, 2022)**. However, DRFs treatment are tailored based on numerous factors such as: age, lifestyle, associated medical conditions, associated injuries, compliance, functional requirements, the fracture type and severity, condition of the soft tissue, fracture comminution, fracture displacement, and concomitant fractures. Though, it can be treated either conservatively with closed reduction and immobilization, or surgically using a variety of fixing techniques **(Rachuene et al., 2021)**.

Distal radius fractures have been linked to poor functional outcomes ranging from 6% to 80%and are associated with a series of postoperative complications. Accordingly, performing ROM exercises act as the most prevalent physiotherapy strategy designed to reduce such complications, reduce pain, maintain joint and soft tissue mobility, minimize disability, and promote activity **(Abu El Kasem, Aly, Kamel, & Hussein, 2020)**.

Nevertheless, orthopedic nurses play a fundamental role in the maintain the ongoing improvement of intraarticular DRFs surgeries care standards and outcomes. However, reducing the likelihood of developing complications, lowering the risk of the morbidity and mortality, improving recovery, restoring functional ability and improving patients' outcomes are the primary goals of orthopedic nurses' management. Moreover, performing accurate assessment of the patient's health status and comprehensive physical examinations are the first step in managing DRFs patients and controlling existing or potential health hazards; these acts as a base line data for developing patient care goals. Furthermore, pain management, nutrition, hydration, skin care, remobilization, rehabilitation, maintaining musculoskeletal strength and flexibility in addition to motivation; are all nursing care priorities (**You & Zheng, 2018; Saad et al., 2020)**. Moreover, one of the main responsibilities of orthopedic nurse is educating intraarticular DRF patients about exercises; where therapeutic exercises training namely shoulder girdle muscles, elbow and hand exercises has to be scheduled prior to surgery and maintained throughout the early and late postoperative periods until the patient's physical function and societal engagement are fully recovered (**Chen et al., 2020).** Likewise, the nurse should be aware about the specified intraarticular DRFs patient's mobility restrictions besides to assessing and encouraging these patients' gradual regain of physical activities, while remaining within weight bearing, tight grasping, and lifting restrictions. Additionally, the nurse has to give strict instructions regarding: carrying, pushing, and pulling; also to avoid sharp increase in pain during exercises **(Hinkle & Cheever, 2018)**.

## Significance of the study:

Hence, there are lacking of comprehensive data regarding effect of activation of unaffected joints by active exercises namely: shoulder, elbow, and fingers following DRFs surgeries on wrist joint ROM, and muscle strength, during wrist joint immobilization period. Furthermore, there is no recent related evidence suggesting that mobilization of such joints could compromise their repair integrity. Thus, this study anticipated to contribute in the nursing profession; being a remarkable recent innovative nursing research; intended to add a building block in nursing science being the foundation of clinical practice, and to reinforce collaborative orthopedic care by comparing the effect of two muscles exercises on wrist joint mechanics among intraarticular DRFs surgeries patients.

## Aim of the Study:

The present study aimed to compare the effect of activation of shoulder girdle muscles exercises versus hand on wrist joint mechanics of patients post intraarticular distal radius fracture surgeries.

## Hypotheses of study:

1- Patients post intraarticular DRFs who received shoulder girdle muscles and hand exercises exhibited improved mean scores of functional abilities, ROM and muscle strength of the affected wrist; than those patients who received hand exercises only.

2- Patients post intraarticular DRFs surgeries who received shoulder girdle muscles and hand exercises exhibited less pain level in the affected wrist; than those patients who received hand exercises only.

3- Patients post intraarticular DRFs surgeries who receive shoulder girdle muscles and hand exercises exhibited improved bone healing without complications of the affected wrist; than those patients who received hand exercises only.

## Materials and Method:

**Research design:**

A comparative quasi experimental research design was utilized.

**Setting:**

This study was carried out at inpatient units and hand surgery outpatient clinics of "Hadara Orthopedic and Traumatology University Hospital".

**Subjects:**

A convenience sample of 50 adult patients with intraarticular DRF who were scheduled for surgeries, were included and assigned randomly and alternatively into two equal groups: 25 patients each. The study group (I) received shoulder girdle, elbow, and hand exercises, while the study group (II) received only hand exercises, which were performed by the researchers and approved by the treating surgeon.

Epi info 7 program was used to estimate the sample size using a population size of 30/3 months, a Confidence coefficient of 95%, and an acceptable error of 5%. Thus, the minimum sample size required was 50 patients.

**Inclusion criteria:**

- Adult patients (18-60 years); who were planned for immediate intraarticular unilateral DRF surgeries.
- Free from other multiple joint involvements such as: rheumatoid arthritis, other body trauma.
- Free from or have controlled associated disorders as cardiac or endocrine disorders.

## Tools for data collection:

Three tools were used for data collection:

**Tool I: Wrist Functional Abilities Index; Interview Schedule:**

This tool was measured through the Patient-Rated Wrist Evaluation (PRWE) which was adopted from **MacDermid, Turgeon, Richards, Beadle, and Roth (1998)** by the researchers. However, it is a fifteen-item questionnaire designed to measure wrist functional abilities. It was divided into two subscales:

- **Pain subscale:** It comprised five items, including pain at rest, pain that occurs during activities like wrist movements and lifting objects, also rating when pain was at its worst, in addition to rating how frequently patients experience pain.
- **Functional ability subscale:** It comprised ten items, which was further sub divided into two sections:

A. **Specific functional activities:** It encompassed six items regarding activities involving wrist motion and strength as: turn a doorknob, cut meat using a knife, fasten buttons on the shirt, using the affected hand to push up from a chair, carry a 10lb (4.5 Kg) object and use bathroom tissue.

B. **Usual functional activities:** This section involved four items covering four domains namely: household work as cleaning, maintenance, personal care activities like dressing, washing, job or usual everyday work as well as recreational activities.

In addition, the **"Patient's Sociodemographic and Clinical Data Sheet"** was attached to tool I; where it included items related to:

1. **Sociodemographic data** as: age, gender, marital status, level of education, occupation and place of residence.

2. **Clinical data** such as: admission date, diagnosis, associated medical diseases, mechanism of injury, operative date, type of fracture, type of operation, operative side, operative date, discharge date and length of stay in hospital.

**Scoring system of the studied patient's PRWE subscales:**

- **Pain score** = Sum of the 5 pain items (out of 50). Where, best score = "0", and the worst score = "50".
- **Functional ability score** = Sum of the 10 functional ability subscale items (out of 100); in which the best score = "0", and the worst score = "100"

**Computing the total PRWE score was performed through the following formula:**

**Total score of the PRWE** = Sum of pain subscale scores + sum of functional ability subscale scores.

Thus, the total PRWE score ranged from "0"= "A perfectly well functioning wrist free of pain", to a total of "150" = "A completely disabled and painful wrist".

**Tool II: Mobility Index of the Wrist joint:**

It was divided into two parts as follows:

**Part I: Range of Motion of the Wrist:**

This part was adapted by the researchers from **Washington State Department of Social and Health Service [DSHS] (2014); Reese and Bandy (2016); Donaldson (2019).** Where, the researchers utilized the goniometer to evaluate ROM of the affected wrist joint through measuring its joint angle. Collected data were compared against normal values for each range, to be scored and classified into "Normal", "Limited" and "No motion". Where, "Normal motion"= "2", "Limited motion" = "1" and "No motion" = "0".

**Part II: Grip Strength of the Affected Hand:**

This part was adapted by the researchers from **National Health and Nutrition Examination Survey [NHANES] (2011) & Roberts et al. (2011).** The grip strength was measured by the researchers using a handheld dynamometer to evaluate the affected hand muscles strength. Collected data were compared against normal values to be scored and categorized according to "Female and Male ages" into "Excellent", "Very good", "Good", "Fair" and "Poor"

**Tool III: Complications of Intraarticular Distal Radius Fracture Checklist:**

This tool was developed by the researchers based on review of relevant literature **Chung, Malay, Shauver & Kim (2019); Seigerman et al. (2019); Hinkle, Cheever & Overbaugh (2021)**.

This tool was divided into two parts as follows:

**Part I: Intraarticular Distal Radius Fracture Postoperative Complications:**

The researchers obtained data related to intraarticular DRF postoperative complications from the patients' medical records. It consisted of two sub parts:

- **Early complications:** It comprised 2 items including: compressive neuropathy and compartment syndrome complications.
- **Late complications:** It consisted of 9 items namely: wrist joint stiffness, complex regional pain syndrome, arthritis, delayed union, nonunion, malunion, infection, tendon complications and others as: pin migration, digit stiffness, shoulder pain or stiffness, ulnar sided wrist pain, and prolonged or unusual swelling.

**Total DRFs postoperative complications score:**

Each patient's total complications score was calculated through assigning for each complication sub-parts' item a score ranging from "0" to "1"; where "0"= "Not present" while "1"= "Present".

**Part II: Distal Radius Plain X- Ray:**

This subpart was used to assess the fracture healing process, which was evaluated by the assistance of orthopedic surgeon through plain radiography (X-rays) of the affected distal radius. Findings were compared against normal x- ray finding. This part was categorized into 4 classifications namely: "Non-union", "Delayed union", "Mal-union" and "Union".

**Total intraarticular distal radius plain x ray results score:**

Each patient's total score was calculated by assigning to each category a score ranging from "0" to "3"; where "0"= "Nonunion", "1"= "Delayed union", "2"= "Malunion" and "3"= "Union".

**Method:**

- Approval from the Research Ethics Committee, Faculty of Nursing, Alexandria University was obtained.
- An official permission was obtained from the Faculty of Nursing, Alexandria University to the study setting; to obtain their permission for collecting necessary data.
- An official permission was attained from the hospital director and head of the departments of the selected hospital setting, after explanation of the study aim.
- Tool I was adopted by the researchers and then translated into Arabic language. While Tool II part I &II was adapted by the researchers. In addition, Tool III was developed by the researchers after reviewing the relevant recent literature.

- Reliability of all tools was tested by means of Cronbach's alpha. Reliability coefficient for tool I English and Arabic versions, II and III were 0.871, 0.821, 0.842 and 0.881; respectively.
- All tools as well as the developed educational booklets utilized during data collection were tested for content validity by 3 experts in the Medical-Surgical Nursing, and two experts in the orthopedic field. However, necessary modifications were carried out accordingly.
- A pilot study was carried out on 10% from the study sample (5 patients); to assess the feasibility and applicability of the tools. Nevertheless, the necessary modifications were carried out accordingly. Those patients were excluded from the current study sample.
- Data collection was started and continued for a period of 12 months from May 2020 to May 2021. Data were collected from the study group (I), followed by the study group (II).

**The study was carried out through four phases:**

**1. Assessment phase:**

Initial assessment was carried out by the researchers after explaining the study aim; in the selected orthopedic units for both study groups' patients immediately on admission utilizing the three study tools to collect: baseline data about: sociodemographic and clinical data, pain level, functional ability, wrist ROM, hand grip strength and initial x- ray results.

**2. Planning phase :**

In this phase the study goals, priorities, contents, and expected outcomes were designed by the researchers. Where, the researchers also created individualized exercises sessions' plans for each patient in each group based on the data collected from the initial assessment and review of the related literature.

However, two illustrated coloured booklets were developed by the researchers in simple Arabic language; where booklet (I) was provided to group (I), while booklet (II) was distributed to group (II) patients; during the implementation phase. However, booklet (I) covered both active shoulder girdle and hand exercises, while booklet (II) enclosed hand exercises only.

**Goals and patient's outcomes expected at the end of the study included:**

- Displayed lower pain levels while engaging in various wrist activities.
- Exhibited better mean functional abilities scores.
- Exhibited range of motion and muscle strength within normal values.
- Demonstrated absence of complications.
- Develop bone healing as exhibited in x- ray.

**3. Implementation phase :**

The researchers' instructions were implemented individually for each patient in the both study groups in two sessions; moreover, simple Arabic videos were employed on the researchers' laptop. Additionally, the developed coloured booklets were distributed on each patient in both study group from the beginning of the first session.

**The first session** was carried out individually preoperatively (day before surgery) for each patient in both study groups, in the inpatient units; using face to face discussion. This session was continued for a period of 60-90 minutes; it covered the following contents: anatomy of the shoulder girdle and upper limb, definition of distal radius fracture, line of treatment and it purposes, complications of fracture, required types of exercises and their benefits.

**The second session** was also conducted individually in the 1st day postoperatively for each patient in both study groups, in the inpatient units; using demonstration and re-demonstration, where continued for a period of 60-90 minutes. This session included teaching about: exercises that were carried out by the researchers after explaining the purpose of the study; where, each patient was asked to repeat the specifically taught exercises, until the researchers was assured that the patient had gained the required skill. Moreover, patients were informed to carry out exercises as follows: -

**As for Group (I):**

Patients in this group were instructed to perform the two types of exercises namely: active shoulder girdle exercises and active hand exercises.

**A. Active shoulder girdle exercises:**

Exercises were performed three to four times daily (10 repetition) to the unaffected joints (shoulder, elbow & fingers) of the affected upper limb; immediately postoperative for six consecutive weeks **Cambridge University Hospitals. [CUH] (2017); PDH Academy Course (2018).**

**Active shoulder girdle exercises included the following three types:**

- **Active range of motion (AROM) of shoulder joint, that incorporated:** shoulder flexion, extension, abduction, adduction, circumduction, internal, and external rotation.
- **Active range of motion of elbow joint, which included:** elbow flexion, and extension.
- **Active range of motion of fingers namely:** finger flexion, extension, abduction, and adduction. In addition to thumb extension, flexion, abduction, adduction, and thumb opposition.

**B. The active hand exercises:**

Each patient was received hand exercises training by the researchers, after which they were instructed to practice these exercises through four phases on the wrist and fingers joints of the affected upper limb **David Gesensway (2016a, 2016b, 2016c, 2016d)** as follows:

- **Phase I:**

It started “immediately” postoperatively up to the “4th” postoperative day. Exercises was performed 3 times / day (repetition: 15-20 times each).

**Where, Phase I included the following exercises:**

- Exercise 1: "Finger glides"
- Exercise 2: "Single finger bends"
- Exercise 3: "Tabletop"
- Exercise 4: "Finger spread"

- **Phase II:**

It incorporated exercises that were conducted post-surgery from “5th” day to “4th” week. Exercises were performed 3times/day (repetition: 10 times each).

**However, Phase II included the following exercises:**

- Exercise 1: "Thumb circles"
- Exercise 2: "Thumb to fingertips"

- Exercise 3: "Single finger bends"
- Exercise 4: "Finger glides"

- **Phase III:**

This phase started approximately "4" to "6" weeks post-surgery; once the doctor had examined patients' x- ray and permits for strengthening and passive stretching exercises. Exercises were performed 3 times/day (repetition: 5 each time).

**Phase III included the following exercises:**

- Exercise 1: "Wrist extension / flexion"
- Exercise 2: "Wrist side to side motion "
- Exercise 3: "Forearm rotation"
- Exercise 4: "Passive wrist extension"
- Exercise 5: "Passive wrist flexion"
- Exercise 6: "Passive forearm supination and pronation"
- Exercise 7: "Putty grip"
- Exercise 8: "Putty fingertip pinch"

- **Phase IV:**

It started approximately "6" to"8" weeks after surgery. The exercises were done only every other day (repetition: 20-50 each time), Patients were instructed to resume all day activities as tolerated.

**Where, Phase IV comprised the following exercises:**

- Exercise 1: "Wrist curls – extension"
- Exercise 2: "Wrist curls – flexion"
- Exercise 3: "Radial deviation"

**As regards to Group (II):**

Patients were exposed to one type of exercises only namely: active hand exercises.

**A. Active hand exercises:**

The researchers trained each patient in group II, instructing them to perform these exercises on the affected upper limb's wrist and fingers joints throughout four phases; likewise, as described previously.

## 4. Evaluation phase:

The researchers evaluated all patients in both study groups **three** times utilizing the three study tools either in the Inpatient Units or the Outpatient Clinics; in order to assess their pain level, functional ability, joint ROM, in addition to hand grip strength. Where the researchers' assessments were performed before surgery**, prior to exercises** implementation, and additionally post exercises implementation namely: **immediately** following surgery, at the **sixth** and the **eighth** week postoperatively; using the study tools I and II.

Further evaluations were carried out to assess the development of postoperative complications **immediately** following surgery, at the **sixth** and **three months** thereafter, utilizing the study tool III-part I.

On the other hand, evaluations of the affected hand's bone healing were performed **four** times using study tool III part II immediately following surgery, as follows: **Pre**-operatively, **immediate** post implementing exercises, then at the **sixth** week and **three months** thereafter. However, comparisons were done between both groups to compare the effect of activation of shoulder girdle muscles exercises versus hand on wrist joint mechanics of patients post intraarticular distal radius fracture surgeries.

**Ethical considerations:**

Written informed consent was obtained from all patients after explaining the study aim. These patients were informed that their participation in the study was voluntary, and they could withdraw at any time without affecting their hospital care. Study participants' privacy and anonymity were respected. Data confidentiality was assured.

**Statistical analysis of the data:**

Data were fed to the computer and analyzed using IBM SPSS software package version 20.0. (Armonk, NY: IBM Corp). Qualitative data were described using number and percent. The Shapiro-Wilk test was used to verify the normality of distribution. Quantitative data were described using range (minimum and maximum), mean, standard deviation and median. Significance of the obtained results was judged at the 0.5% level.

## Results:

**Table (1):** shows the comparison between the two studied groups according to their socio demographic data. It was noticed that, more than one third (36.0%) of both groups were less than 30 years. On the other hand, less than 32.0% of both groups age ranged from 50 to less than 60 years. Concerning gender, 60.0 % of group I compared to 44.0% of group II were males. Regarding the marital status, more than half (52.0%) of group I, compared to more than one third (36.0%) of group II were married. Moreover, minorities (4.0% and 8.0%) of group I and II; respectively were illiterate. While more than one quarter (28.0%) of group I and less than one third (32.0%) of group II had university education. The same table reveals that; the largest percentage (52.0%) within group I were employee, while (40.0%) in group II were manual workers. Additionally, more than three quarters (76.0%) and more than two thirds (68.0%) of group I and II; respectively were from urban areas.

**Table (2):** represents the comparison between the two studied groups according to their clinical data. In relation to associated medical diseases, more than two thirds (68.0%) of those in group I and the vast majority (92.0%) of group II didn't have any associated diseases. A statistically significant difference was observed between both groups in relation to presence of associated diseases (P=0.034*). Concerning the mechanism of injury, the most common form in group I and group II was simple fall as reported by 28.0% and 44.0% of them; respectively. It was found that the majority (84.0% and 68.0%; respectively) of both studied groups I and II had type C fracture. Regarding the type of operation, the highest percentage of both groups had volar ORIF as mentioned by 64.0% and 84.0% of them; respectively. These operations were done mainly on the right side as stated by 64.0% and 68.0% of the patients in group I and group II; respectively. With respect to the length of hospital stay it was found that, less than half (40.0%) in group I stayed 5 days postoperatively. While less than half (48.0%) in group II had stayed 4 days.

**Table (3):** reveals the comparison between the two studied groups patients' regarding their total rated wrist evaluation (PRWE) mean score at the three assessment intervals; pre, six- and eight-weeks post exercises. With respect to the total PRWE mean score in group I, it was (142.8±12.22) pre-exercises, and dropped to (43.68±12.45 and 12.20±16.44) in the 6th and 8th week post exercises; respectively, with a statistically significant difference between the three assessment intervals (p=0.001). On the other side, the mean group II score pre exercises was (142.56±9.91), and reduced to (60.80±19.91) in the 6th week post exercises, and to (30.96±23.02) in the 8th week post exercises, with a statistically significant difference between the three assessment intervals (p=0.001). In addition, the differences between group I and II were significant either at the pre exercises interval (p=0.014), or post exercises in the 6th week and the 8th weeks (p=0.001); respectively.

**Table (4):** illustrates the comparison between the two studied groups according to their total range of motion (ROM) mean score of the affected wrist at the three assessment intervals; pre, six and eight weeks post exercises. With respect to group I, the total ROM mean score was (0.0±0.0) pre exercises, and elevated to (10.28±2.56) in the 6th week post exercises, then reached (11.56±1.29) in the 8th week post exercises, with a statistically significant difference between the three assessment intervals (p=0.001). While, group II ROM total mean score started with (0.0±0.0), and increased to (7.68±2.53), and (10.04±2.44) in the 6th and 8th week post exercises; respectively, with a statistically significant difference between the three assessment intervals (p=0.001). Moreover, statistically significant differences were noted between group I and group II in the 6th week (p=0.001), and the 8th week (p=0.001).

**Table (5):** shows the comparison between the two studied groups according to their grip strength of the affected hand at three assessment intervals; pre, six and eight weeks post exercises. In relation to group I total hand grip strength mean score was (0.80 ± 4.0) pre exercises, and raised to (178.8 ± 44.84, and 188.4 ± 58.34) in the 6th and 8th week post exercises; respectively. A statistically significant differences between the three assessment intervals were declared (p=0.001). Regarding group II total hand grip strength mean score was elevated from (9.60± 10.20) pre exercises to (138.4 ± 54.29, and 151.0 ± 58.59) in the 6th and the 8th week post exercises; respectively, with statistically significant difference between the three assessment intervals (p=0.001). The same table reveals statistically significant difference between the two studied groups' hand grip strength in the 6th and 8th week post exercises (p=0.043, $\chi 2$=p=0.013; respectively).

**Table (6)**: illustrates comparison between the two studied groups according to their total intraarticular distal radius fractures postoperative complications score at the three assessment intervals; immediate postoperative, six weeks and three months post exercises. It was noticed that, more than one quarter of group I (28.0%) experienced immediate postoperative complications, while only 12.0% and 8.0% of them experienced such complications in the 6$^{th}$ week and at three months post exercises; respectively. On the other hand, less than one third of group II patients (32.0%) experienced immediate postoperative complications, which increased to 36.0% in the 6th week postoperative, then lessened to 32.0% after 3 months post exercises. Finally, the same table demonstrates that, there is a statistically significant difference between group I and II with regard to total complications score in the 6$^{th}$ week and 3 months post exercises (P=0.047, p=0.043; respectively).

**Table (7):** shows the comparison between the two studied groups in relation to the wrist joint plain x ray results at the four assessment intervals; pre, immediate postoperative, six weeks and three months post exercises. It was noticed that, the vast majority of group I patients had wrist joint union at the 6$^{th}$ week and 3 months post exercises (92.0% and 96.0%; respectively). On the other hand, regarding group II during the 6$^{th}$ week assessment interval; 68.0% of them had wrist joint union, which was raised to 72.0% after 3 months. A statistically significant differences were noticed between group I and II post 6th week (P=0.034) and post 3 months interval (P=0.049). Moreover, statistically significant differences between preoperative, immediate postoperative, 6$^{th}$ week, and 3 months' intervals were noted, where (P=0.001).

**Table (1): Comparison between the two studied groups according to their socio demographic data:**

| Socio demographic data | Group I (n = 25) | | Group II (n = 25) | | $\chi^2$ | P |
|---|---|---|---|---|---|---|
| | No. | % | No. | % | | |
| **Age (years):** | | | | | | |
| 18 –less than 30 | 9 | 36.0 | 9 | 36.0 | 0.174 | $^{MC}p=$ 1000 |
| 30 – less than 40 | 4 | 16.0 | 4 | 16.0 | | |
| 40 – less than 50 | 4 | 16.0 | 4 | 16.0 | | |
| 50 – 60 | 8 | 32.0 | 8 | 32.0 | | |
| **Gender** | | | | | | |
| Male | 15 | 60.0 | 11 | 44.0 | 1.282 | 0.258 |
| Female | 10 | 40.0 | 14 | 56.0 | | |
| **Marital status** | | | | | | |
| Single | 7 | 28.0 | 9 | 36.0 | 1.439 | $^{MC}p=$ 0.774 |
| Married | 13 | 52.0 | 9 | 36.0 | | |
| Divorced | 3 | 12.0 | 4 | 16.0 | | |
| Widow | 2 | 8.0 | 3 | 12.0 | | |
| **Level of education** | | | | | | |
| Illiterate | 1 | 4.0 | 2 | 8.0 | 2.025 | $^{MC}p=$ 0.971 |
| Read and write | 3 | 12.0 | 3 | 12.0 | | |
| Primary education | 0 | 0.0 | 1 | 4.0 | | |
| Preparatory education | 0 | 0.0 | 0 | 0.0 | | |
| Secondary education | 8 | 32.0 | 7 | 28.0 | | |
| University | 7 | 28.0 | 8 | 32.0 | | |
| Others(postgraduate studies) | 6 | 24.0 | 4 | 16.0 | | |
| **Occupation:** | | | | | | |
| Manual | 5 | 20.0 | 10 | 40.0 | 3.308 | $^{MC}p=$ 0.308 |
| Employee | 13 | 52.0 | 9 | 36.0 | | |
| Housewife | 6 | 24.0 | 6 | 24.0 | | |
| Retired | 1 | 4.0 | 0 | 0.0 | | |
| **Place of residence:** | | | | | | |
| Rural | 6 | 24.0 | 8 | 32.0 | 0.397 | 0.529 |
| Urban | 19 | 76.0 | 17 | 68.0 | | |

**Table (2): Comparison between the two studied groups according to their clinical data: (n = 25 each)**

| Clinical data | Group I (n = 25) | | Group II (n = 25) | | $\chi^2$ | P |
|---|---|---|---|---|---|---|
| | No. | % | No. | % | | |
| **Associated medical diseases:** | | | | | | |
| Yes | 8 | 32.0 | 2 | 8.0 | 4.500* | 0.034* |
| No | 17 | 68.0 | 23 | 92.0 | | |
| **If Yes (n=8)** | | | | | | |
| Renal Failure | 1 | 12.5 | 0 | 0.0 | 2.299 | $^{MC}$p= 1.000 |
| Hypertension | 3 | 37.5 | 2 | 100.0 | | |
| Hepatitis | 2 | 25.0 | 0 | 0.0 | | |
| Lumber disc prolapse | 2 | 25.0 | 0 | 0.0 | | |
| **Mechanism of injury** | | | | | | |
| Simple fall | 7 | 28.0 | 11 | 44.0 | 2.979 | $^{MC}$p= 0.592 |
| Fall from height | 6 | 24.0 | 6 | 24.0 | | |
| Motor vehicle accident | 5 | 20.0 | 2 | 8.0 | | |
| Athletic | 3 | 12.0 | 4 | 16.0 | | |
| Assault | 4 | 16.0 | 2 | 8.0 | | |
| **Type of fracture** | | | | | | |
| Type C | 21 | 84.0 | 17 | 68.0 | 1.754 | 0.185 |
| Type B | 4 | 16.0 | 8 | 32.0 | | |
| **Type of operation** | | | | | | |
| Volar ORIF | 16 | 64.0 | 21 | 84.0 | 4.570 | $^{MC}$p= 0.092 |
| Percutaneous pinning | 8 | 32.0 | 2 | 8.0 | | |
| Specific fragment fixation | 1 | 4.0 | 2 | 8.0 | | |
| **Operative side** | | | | | | |
| Left | 9 | 36.0 | 8 | 32.0 | 0.089 | 0.765 |
| Right | 16 | 64.0 | 17 | 68.0 | | |
| **Length of hospital stay (days):** | | | | | | |
| 3 | 0 | 0.0 | 2 | 8.0 | 8.606* | $^{MC}$p= 0.042* |
| 4 | 9 | 36.0 | 12 | 48.0 | | |
| 5 | 10 | 40.0 | 7 | 28.0 | | |
| 6 | 0 | 0.0 | 3 | 12.0 | | |
| 7 | 6 | 24.0 | 1 | 4.0 | | |

$\chi^2$: **Chi square test** MC: **Monte Carlo**

p: p value for comparing between the studied groups *: Statistically significant at $p \leq 0.05$

**Table (3): Comparison between the two studied groups regarding their total patients' rated wrist evaluation (PRWE) mean score at the three assessment intervals; pre, six and eight weeks post exercises**

| Total patients' rated wrist evaluation | Group (I) (n =25) | | | Group (II) (n =25) | | | U ($p_1$) | U ($p_2$) | U ($p_3$) |
|---|---|---|---|---|---|---|---|---|---|
| | Pre exercises | Post six weeks | Post eight weeks | Pre exercises | Post six weeks | Post eight weeks | | | |
| **Pain assessment** | **(0–50)** | | | | | | | | |
| Min. – Max. | 40.0 – 50.0 | 6.0 – 27.0 | 0.0 – 17.0 | 40.0 – 50.0 | 10.0 – 39.0 | 0.0 – 30.0 | 224.50 (0.066) | 163.00* (0.003*) | 188.50* (0.014*) |
| Mean ± SD. | 47.56 ± 4.14 | 13.92 ± 5.30 | 4.80 ± 6.49 | 47.48 ± 3.03 | 20.04 ± 8.32 | 9.76 ± 8.32 | | | |
| Median | 50.0 | 12.0 | 0.0 | 48.0 | 19.0 | 9.0 | | | |
| **Fr.($p_0$)** | **49.515*(<0.001*)** | | | **50.0*(<0.001*)** | | | | | |
| **Functional ability assessment** | **(0–100)** | | | | | | | | |
| Min. – Max. | 80.0 – 100.0 | 14.0 – 44.0 | 0.0 – 27.0 | 79.0 – 100.0 | 24.0 – 74.0 | 0.0 – 52.0 | 221.0 (0.054) | 144.0* (0.001*) | 119.00* (<0.001*) |
| Mean ± SD. | 95.28 ± 8.08 | 29.76 ± 7.89 | 7.40 ± 10.12 | 95.08 ± 7.43 | 40.76±12.15 | 21.20±15.22 | | | |
| Median | 100.0 | 30.0 | 0.0 | 98.0 | 40.0 | 19.0 | | | |
| **Fr.($p_0$)** | **50.00*(<0.001*)** | | | **50.0*(<0.001*)** | | | | | |
| **Total PRWE score** | **(0–150)** | | | | | | | | |
| Min. – Max. | 120.0–150.0 | 24.0–67.0 | 0.0–44.0 | 119.0–150.0 | 36.0–113.0 | 0.0–81.0 | 191.50* (0.014*) | 146.50* (0.001*) | 144.500* (0.001*) |
| Mean ± SD. | 142.8±12.22 | 43.68±12.45 | 12.20±16.44 | 142.56±9.91 | 60.80±19.91 | 30.96±23.02 | | | |
| Median | 150.0 | 40.0 | 0.0 | 146.0 | 61.0 | 28.0 | | | |
| **Fr.($p_0$)** | **50.00*(<0.001*)** | | | **50.0*(<0.001*)** | | | | | |

**Table (4): Comparison between the two studied groups according to their total range of motion (ROM) mean score of the affected wrist at the three assessment intervals; pre, six and eight weeks post exercises**

| Total range of motion of the affected wrist | Group (I) (n =25) | | | Group (II) (n =25) | | | U ($p_1$) | U ($p_2$) | U ($p_3$) |
|---|---|---|---|---|---|---|---|---|---|
| | Pre exercises | Post six weeks | Post eight weeks | Pre exercises | Post six weeks | Post eight weeks | | | |
| Min. – Max. | 0.0 – 0.0 | 6.0 – 12.0 | 7.0 – 12.0 | 0.0 – 0.0 | 6.0 – 12.0 | 6.0 – 12.0 | 312.50 (1.000) | 155.500* (0.001*) | 165.00* (0.001*) |
| Mean ± SD. | 0.0 ± 0.0 | 10.28 ±2.56 | 11.56 ±1.29 | 0.0 ± 0.0 | 7.68 ± 2.53 | 10.04 ±2.44 | | | |
| **Fr.($p_0$)** | **46.723*(<0.001*)** | | | **44.356*(<0.001*)** | | | | | |

**Table (5): Comparison between the two studied groups according to their grip strength of the affected hand at the three assessment intervals; pre, six and eight weeks post exercises**

| Grip strength of the affected hand | Group (I) (n =25) | | | | | | Group (II) (n =25) | | | | | | Test of sig ($p_1$) | Test of sig ($p_2$) | Test of sig ($p_3$) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Pre exercises | | Post six weeks | | Post eight weeks | | Pre exercises | | Post six weeks | | Post eight weeks | | | | |
| | No. | % | No. | % | No. | % | No. | % | No. | % | No. | % | | | |
| Poor | 25 | 100 | 1 | 4.0 | 0 | 0.0 | 25 | 100 | 5 | 20.0 | 4 | 16.0 | – | $\chi^2$= 8.264* $^{MC}p$= 0.043* | $\chi^2$= 11.769* $^{MC}p$= 0.013* |
| Fair | 0 | 0.0 | 4 | 16.0 | 5 | 20.0 | 0 | 0.0 | 10 | 40.0 | 8 | 32.0 | | | |
| Good | 0 | 0.0 | 16 | 64.0 | 6 | 24.0 | 0 | 0.0 | 8 | 32.0 | 5 | 20.0 | | | |
| Very Good | 0 | 0.0 | 4 | 16.0 | 3 | 12.0 | 0 | 0.0 | 2 | 8.0 | 6 | 24.0 | | | |
| Excellent | 0 | 0.0 | 0 | 0.0 | 11 | 44.0 | 0 | 0.0 | 0 | 0.0 | 2 | 8.0 | | | |
| **$p_0$** | | | **<0.001*** | | **<0.001*** | | | | **<0.001*** | | **<0.001*** | | | | |
| Mean ± SD. | 0.80 ± 4.0 | | 178.8±44.84 | | 188.4±58.34 | | 9.60±10.20 | | 138.4±54.29 | | 151.0±58.59 | | t=4.017 (<0.001*) | t=2.869* (0.006*) | t= 2.262* (0.028*) |
| **$p_4$** | | | **<0.001*** | | **<0.001*** | | | | **<0.001*** | | **<0.001*** | | | | |

**Table (6): Comparison between the two studied groups according to their total intraarticular distal radius fractures postoperative complications score at the three assessment intervals; immediate postoperative, six weeks and three months post exercises**

| Total intraarticular DRFs postoperative complications | Group (I) (n =25) | | | | | | Group (II) (n =25) | | | | | | Test of sig ($p_1$) | Test of sig ($p_2$) | Test of sig ($p_3$) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | immediate Post operative | | Post six weeks | | Post three months | | immediate Post operative | | Post six weeks | | Post three months | | | | |
| | No. | % | No. | % | No. | % | No. | % | No. | % | No. | % | | | |
| **Total complications score** | | | | | | | | | | | | | | | |
| Not present | 18 | 72.0 | 22 | 88.0 | 23 | 92.0 | 17 | 68.0 | 16 | 64.0 | 17 | 68.0 | $\chi^2$=0.095 | $\chi^2$=3.947* | $\chi^2$=4.500* |
| Present | 7 | 28.0 | 3 | 12.0 | 2 | 8.0 | 8 | 32.0 | 9 | 36.0 | 8 | 32.0 | (0.758) | (0.047*) | (0.034*) |

**Table (7): Comparison between the two studied groups according to the wrist joint plain x ray results at the four assessment intervals; pre, immediate postoperative, six weeks and three months post exercises.**

| Distal radius plain x ray results | Group (I) (n =25) | | | | | | | | Group (II) (n =25) | | | | | | | | Test of sig ($p_1$) | Test of sig ($p_2$) | Test of sig ($p_3$) | Test of sig ($p_4$) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Pre operative | | immediate | | six weeks | | three months | | Pre operative | | immediate | | six weeks | | three months | | | | | |
| | No. | % | No. | % | No. | % | No. | % | No. | % | No. | % | No. | % | No. | % | | | | |
| Nonunion | 25 | 100 | 25 | 100 | 0 | 0.0 | 0 | 0.0 | 25 | 100 | 25 | 100 | 0 | 0.0 | 0 | 0.0 | – | – | $\chi^2$=4.500* 0.034* | $\chi^2$=5.357* $^{FE}p$= 0.049* |
| Delayed union | 0 | 0.0 | 0 | 0.0 | 2 | 8.0 | 1 | 4.0 | 0 | 0.0 | 0 | 0.0 | 8 | 32.0 | 7 | 28.0 | | | | |
| Mal union | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | | | | |
| Union | 0 | 0.0 | 0 | 0.0 | 23 | 92.0 | 24 | 96.0 | 0 | 0.0 | 0 | 0.0 | 17 | 68.0 | 18 | 72.0 | | | | |
| $p_0$ | | | | | <0.001* | | <0.001* | | | | | | <0.001* | | <0.001* | | | | | |

$\chi^2$: **Chi square test** MC: **Monte Carlo** FE**: Fisher Exact**

$p_0$: p value for **Post Hoc Test (Dunn's)** for **Friedman test** for comparing between **Pre-operative** and each other periods in **each other group**

$p_1$: p value for comparing between the studied groups in **Pre-operative** period

$p_2$: p value for comparing between the studied groups in **Post-operative** period

$p_3$: p value for comparing between the studied groups in **Post six weeks** period

$p_4$: p value for comparing between the studied groups in **Post three months** period

*: Statistically significant at $p \leq 0.05$

## Discussion:

Post DRFs surgeries most patients are presented with symptoms such as: limited ROM in numerous planes of movement, joint stiffness, severe pain and moderate to severe disability. However, these symptoms impede specific hand functions and pose a challenge to the DRF recovery process **(Thackeray & Miller, 2019; Ranota, 2020).** Therefore, postoperative physical exercises therapy are extremely beneficial and should be initiated immediately as soon as possible post DRFs surgeries, and continued during the early and late postoperative period to achieve best functional wrist joint recovery in addition to prevention of complications. Thus, exercise therapy following DRFs surgery is generally used to minimize unsatisfactory surgical outcomes in an attempt to accelerate the regaining of functional ability **(Ikpeze et al., 2016; Randall, 2017).**

**As regards socio demographic &clinical characteristics of the studied groups**

**Regarding age,** the result of the present study showed that; most studied DRFs affected age in both groups were ranging from young adults and middle-aged adults; however, it might seem logical to occur in the young adult age groups due to their increased physical activity or participation in sports related activities. While middle aged adults DRFs may be ought to the fact that, ageing predisposes to bone loosening which is considered normal, as the bone becomes more fragile and may break more easily. Age related study result are in line with **Jerrhag et al. (2017)** who found that; young and middle-aged adults contributed 48% of distal forearm fractures. However, this finding contradicts with **Bakouri, El-Soufy, El-Hewala, and Fahmy (2021)** who stated that; DRFs are the most common fractures in old age patients over 65 years, as they accounted for almost one-fifth of all fractures in this age group.

**Concerning patients' gender,** it was observed that, a remarkable predominance of male was present in study group (I), as compared to female patients who were predominant in study group (II). From the researcher point of view, increased incidence of DRFs in males is probably due to their intense involvement in outdoor activities namely: riding vehicles and heavy manual labor, which make them more vulnerable to trauma and injury. While in women; loss of bone density usually speeds up after menopause due to less in estrogen production, which has been proven to prevent excessive bone breakdown during the body's normal process of forming, breaking down, and re-forming bone. This result come in line with **Court-Brown, Clement, Duckworth, Biant, and McQueen (2017) & Luokkala et al. (2020)** who mentioned that; women have a greater risk of sustaining a DRFs than men. In addition, this goes in the same line with **Refai, Basiony, and Ahmed (2019)** who found that the majority (70%) of their DRFs participants were women. in contrast, **Khan et al. (2016)** revealed that, male patients predominated female ones (36 males to 24 females). Moreover, **Ibrahim, Soudy, Nafea, Farhan, and Fouda (2021)** found that; the majorities (90%) of DRFs in their study were male.

**In relation to level of education,** the present study revealed that secondary and university education participants formed the greatest proportion among the two studied groups' patients; which could be a predictor of better outcomes following DRFs. This result was supported by **Paksima, Pahk, Romo, and Egol (2014)** who found that; almost one third of their studied DRFs' patients who had a high school degree and one fifth had a college degree presented better DRFs outcomes. **Regarding occupation,** employee& manual work represents the highest percentage among the two studied groups; which might be a factor of sustained DRFs occurrence. In the same line with this finding; **Philip, Macdermid, Nair, Walton, and Grewal (2019)** found that, nearly half of their studied samples were employed. Also, these results were in agreement with **Ibrahim et al. (2021)** who reported that; manual workers represented more than half of their studied patients, where, more than one third were employed as accountants and photographers.

**As regards the place of residence**, the finding revealed that the majority of patients in both study groups were from urban area. This could be interpreted as; this hospital serves urban population more frequently than those in rural, being more accessible, they also known to be slimmer and smoking more frequently, whereas populations living in rural areas have a higher body mass index accompanied with poor dietary health predisposing them to lower bone mineral density and in turn increase the risk factor for fracture. Similarly, **Sultan et al. (2017)** found that urban residents showed the highest percentage of DRFs versus rural residents; justifying the reason that this may be due to limited access of rural individuals to city hospitals in local situation secondary to increased distance and time of transportation.

**Regarding mechanism of injury**, the present study revealed that "simple falling" was the most common cause of DRFs among the two studied groups (I&II); representing one third, less than half respectively. This could be attributed to increases in risk of falling with age due to changes in balance and vision; reflexes slow down and additionally worsen coordination. Moreover, as persons struggle to remain active being either manual workers or employee, predisposing to increased fractures caused by relatively minor traumas. However, these study results agree with **Court-Brown et al. (2017), Yang et al. (2018) & Refai et al. (2019)** who found that; majority of DRFs in their study were due to a low energy falls. On the other hand, this finding is inconsistent with **Khan et al. (2016)** & **Candela et al. (2022)** who reported that; the commonest cause of trauma in DRFs was resulting from road traffic accident and sports, which represented more than one fifth of their study participants.

**In relation to type of treatment,** the present study findings revealed that; the highest percentages of the two studied groups patients were treated via volar ORIF. Supporting this finding; **Esposito, Shoap, Freibott, and Strauch (2021) & Strelzow (2021)** mentioned that; volar plating is an excellent surgical treatment option for unstable DRFs, displaying successful reduction and excellent intraarticular DRFs functional outcomes.

Regarding **pain level and functional ability assessment,** results of the current study verified that; no significant differences were found between the two studied groups at pre exercises period. However, after 6 and 8 weeks from exercises performance there was statistically significant difference in pain score and the function ability PRWE score between the two studied groups, in which patients in the study group (I) experienced better outcomes compared with patients in study group (II). However, results representing the lowest pain and functional ability score were observed in the study group (I), indicating better wrist function. According to the researchers' view, this could be attributed to the application of two types of exercises, bur specifically implementing the active shoulder girdle muscles exercises on the non-affected joints (shoulder, elbow, and fingers) for study group (I) which were initiated immediately after DRF surgeries.

Moreover, from the researcher point of view this; early application of active shoulder girdle exercises during wrist joint immobilization period was a key factor for improving wrist joint function and reducing pain level (acute or chronic). Whereas; physical exercises improve blood flow to the affected site by vasodilating blood vessels, allowing more oxygen, nutrients and growth factors to flow to the fracture site. Moreover, early exercises can aid in reconstructing and strengthening the weaken wrist joint; beside preventing its stiffness and decrease swelling. In this regards **Jančíková et al. (2017)** observed that; exercises of the shoulder girdle muscles after DRF while the wrist is immobilized, can evidently improve functional capability and speed up the injured wrist's hand function. As well, early researchers' rehabilitation combining shoulder girdle muscles and hand exercises also support the significant improvement of surgical functional outcomes.

**Regarding to ROM,** the finding in current study illustrated that; at the 6th and 8th week post exercises the results revealed a highly significant improvement of all the affected wrist's measured ROM parameters in the study group (I) than study group (II). Where, it was improved from an observed no motion to normal motion compared to the pre exercises interval. From the researchers' point of view, this could be attributed to; the strengthening and stretching effect of exercises performed on the affected wrist joint during this scheduled time period. Furthermore, this improvement in the affected wrist ROM in study group (I) may be owed to the types of exercises utilized, namely active shoulder girdle muscles exercises which was performed on non-affected joints (shoulder, elbow, and fingers) accompanied with active hand exercises for study group (I) early immediately after DRFs surgeries.

In this context **Hinkle and Cheever (2018)** mentioned that; post DRFs active exercises assist in maintaining muscle strength and joint function, improving circulation, enhancing ROM, preventing deformity and disabilities and promoting bone healing. In addition, **Gutiérrez-Espinoza et al. (2022)** emphasized that; following DRFs surgeries therapeutic exercises has to be prescribed to decrease pain, maintain ROM, and improve muscle strength and functions.

**Concerning to hand grip strength score,** the present study shown that; 6 weeks post exercises application of the affected hand; more than half of patients in study group (I) experienced good hand grip strength compared to one fifth of patients in study group (II) who had good hand grip strength. Furthermore, at the 8th week post exercises application; around half of patients in study group (I) experienced excellent hand grip strength while only low percentage in study group (II) had excellent hand grip strength. It is possibly refined to as; the study group (I) who performed the two researchers' implemented exercises involving both the affected and non-affected joints of the affected hand than study group (II) who performed one type of exercise. This may be attributed to the benefits of these two accompanied exercises, which in turn have contributed to the better outcomes observed in this study group. In this regards, **Bennie, Shakespear-Druery, and De Cocker (2020)** stated that; muscle strengthening exercises have a greater effect on physical health outcomes, reducing risk of complications and enhancing joints function. This was in line also with **Lizaur-Utrilla et al. (2020)** who stated that; their study group patients with Type-C fractures had a significantly better hand grip strength with a mean difference at the final 24 months follow up; than the other group.

**Regarding the total intraarticular DRFs postoperative complications mean score,** the present study showed that; the majority of patients in study group (I) had no complications at the three assessment intervals; while only less than two thirds of patients in study group (II) had no complications at three assessment intervals. Moreover, the total intraarticular DRFs postoperative complications mean score, was significantly higher in study group (II) than study group (I). From the researchers' point of view, the fact that the majority of patients in study group (II) were female appeared to increase the risk of postoperative complications; where nearly one third of them were in their forties and fifties, which was a major risk factor for developing postoperative complications as a result less estrogen production after menopause predisposing them to loss of bone density, and excessive bone breakdown. In contradiction with this result **Quadlbauer et al. (2022)** found in their unstable distal radius fractures studied patients, who were stabilized with volar angular stable locking plate; no significant difference in complications rate between the two studied groups after 6 and 8 weeks of performing intense practiced wrist exercises from the first postoperative day.

Moreover, the current study showed that; there were highly statistically significant differences between study group (I) & (II) regarding their **intraarticular DRFs union** at the sixth week and three months' post exercises practice; in which patients in the study group (I) had experienced faster bone healing, indicating better wrist function, compared with those in study group (II). This could be related to the exposer of the study group (I) patients to more than one type of exercises; which were performed immediately following DRFs surgeries to both the affected and non-affected joints of the affected extremity. However, the effect of these two exercises type may have contributed to the better outcomes seen in wrist joint union in study group (I).

Supporting this finding, **Yang et al. (2018) & Østergaard et al. (2021)** mentioned that; physical exercises triggers the release of an energy molecule called "adenosine triphosphate" which stimulates the formation of new bone, being the most vital step to bone healing. They also declared that; practicing early preoperative and continue on postoperative exercises result in osteocytes activation by the muscle contractions accordingly predispose to rapid bone union. This then causes the osteocytes to create new and stronger bone tissue allowing them to patch the edges of the broken bone. Supporting this finding also **Benedetti, Furlini, Zati, and Letizia Mauro (2018)** stated that; early returning of joint motion has shown to maintain physiologic viscoelasticity and homeostasis of connective tissue; further early movement and physical exercises after injury appears to stimulate and improve bone healing significantly in long bone or DRFs. Thus, this study achieved its research aim and confirmed its hypotheses.

## Conclusion:

**Based on the current study findings, it can be concluded that:**

Therapeutic exercises practices following intraarticular DRFs surgeries are considered the primary rehabilitation strategy aimed for restoring wrist joint mechanics during its immobilization period. However, improvements in the study group (I) participants' functional abilities, pain level score, joint ROM, muscle strength of the affected wrist in following the researchers' exercises training were observed at the sixth and eighth weeks compared with the study group (II). Subsequently, the first and second researchers' hypotheses were approved, where post intraarticular DRF surgeries patients who received shoulder girdle muscles, elbow and hand exercises exhibited improvement in the mean scores of functional abilities, ROM, muscle strength and less pain of the affected wrist; than those patients who received hand exercises only.

The study group(I) continued to demonstrate further better improvement than the study group(II) in terms of: bone healing of the affected wrist at the sixth week and three months' post exercises performance; in which patients in the study group (I) experienced faster bone healing compared with patients in study group (II) which pointed out the enhanced wrist function. Moreover, the third hypothesis was achieved in the studied post intraarticular DRFs surgeries patients where statistically significant differences between group I and II with regard to their total intraarticular DRFs postoperative complications score were observed in the sixth week and three months' post exercises as patients in the study group (I) experienced less total complications score compared with those in study group (II).

## Recommendations

**Based on the findings of the present study, the following recommendations are derived:**

- The developed researchers' booklet concerning therapeutic shoulder girdle and hand exercises should be distributed to all patients undergoing intraarticular DRFs surgeries; as well to all orthopedic nurses caring for such patients.
- Therapeutic shoulder girdle and hand exercises should be considered in the rehabilitation of the

affected and non-affected joints immediately post DRFs surgeries.

- It is recommended that orthopedic health team members namely: surgeons, nurses, and physical therapists; consider incorporating active shoulder girdle exercises into DRFs' treatment program.
- An educational program about therapeutic shoulder girdle and hand exercises should be implemented for nurses at various orthopedic units.
- Replication of the study on a larger sample from different geographical areas is important to help results generalization.
- As, there is clear evident lacking in studies concerned with early mobilization following DRF surgeries on the improvement of wrist joint function; thus future studies are urgently needed.

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