REVIEW ARTICLE

Functional Recovery of Distal Radius Fracture (DRF): a Scoping Review

Mohd Azam Abdul Halim[1,2], Kounosuke Tomori[3], Nor Faridah Ahmad Roslan[4], Ahmad Zamir Che Daud[1]

[1] Centre of Occupational Therapy, Faculty of Health Sciences, Universiti Teknologi MARA (UiTM), UiTM Kampus Puncak Alam, 43200 Bandar Puncak Alam, Selangor, Malaysia
[2] Rehabilitation Medicine Department, Occupational Therapy Unit, Hospital Shah Alam, 40000 Shah Alam, Selangor, Malaysia
[3] Department of Occupational Therapy, School of Health Science, Tokyo University of Technology, 1404-1 Katakuramachi, Hachioji City, Tokyo 192-0982, Japan
[4] Department of Rehabilitation Medicine, Faculty of Medicine, Universiti Teknologi MARA (UiTM), UiTM Kampus Sungai Buloh, 47000 Sungai Buloh, Selangor, Malaysia

ABSTRACT

Distal Radius Fracture (DRF) affects an individual's ability to perform daily activities. This article aimed to identify any existing gap in the knowledge of functional recovery following DRF and to identify key features or relevant factors to the concept of DRF functional recovery. This review was guided by PRISMA-Scoping review. Published articles between 2013 and October 2020 were retrieved from six databases includes; PubMed, CINAHL, ProQuest Central, MEDLINE (Ovid), Cochrane library and Scopus. Findings were summarised into domains of the International Classification of Functioning, Disability and Health (ICF). The quality of reviewed articles has been assessed using the Crowe Critical Appraisal Tool (CCAT). Twenty-two articles were included in the review with CCAT scores ranged between 70% and 90%. Recovery of body functions and structures takes approximately three to nine months, particularly for Range of Motion (ROM), grip strength and dexterity. Recovery in daily activities takes approximately three months to one year. In conclusion, determining the functional recovery pattern of DRF using a longitudinal study warrants further exploration.

Keywords: : Recovery of function, Hand function, Distal radius fracture, International classification of functioning, hand therapy

Corresponding Author:
Ahmad Zamir Che Daud, PhD
Email: zamir5853@uitm.edu.my
Tel: +603-32584568

INTRODUCTION

Distal Radius Fracture (DRF) is a common incidence of orthopaedic injury reported in the emergency department where one out of every six cases of fractures (1). Usually, DRF occurs within 1.5 inches of the wrist joint because of the displacement of the lower end of the radius (2). It has a bimodal distribution, with a peak incidence of high-energy trauma in young clients and low-energy falls in older clients (3,4,5). Recently, there has been an increasing interest to study on the rehabilitation of DRF client's worldwide. Data from the National Health Insurance of Taiwan revealed that DRF incidence has increased to 42.2% over the eight years of the study from 2000 until 2007 (6). Most of the studies reported and discussed the functional recovery of DRF more than one year after the injury (7). The recovery process of DRF is marked by a reduction in function at the initial stage of injury and progressed over time (7). Generally, DRF clients are referred to the rehabilitation department to improve their hand functions with a primary aim towards managing pain, grip strength and range of motion (ROM) (8). Typically, hand rehabilitation mostly focuses on body functions and structures compared to activity and participation (9,10,11). However, the authority of the medical model in the healthcare sector limits occupational therapists to focus on remediating impairments with minimal emphasis on activity and participation in their therapy (9,10).

Despite the high incidence and many associated DRF complications, there is still a lack of systematic studies conducted to recommend the optimum rehabilitation

due to DRF (12). Moreover, it is unclear what kind of information is available in the literature about the optimum timeframe for recovery of functions following DRF. Thus, the optimum rehabilitation and timeframe for recovery of functions warrant further investigations. Although the predicted functional problems after DRF are not as serious as hip or vertebral fractures, hands play a crucial role in the performance of Activities of Daily Living (ADL) and Instrumental Activities of Daily Living (IADL), which can affect certain levels of functional restoration (13). To our knowledge, this is the first study discussed and reported about functional recovery following DRF. Subsequently, to spearhead detailed investigations there is a need for a scoping review with the aims 1) to review and synthesise research literature and identify any existing gap in the body of knowledge related to functional recovery of DRF and 2) to identify key features or relevant factors to the concept of DRF functional recovery.

MATERIALS AND METHODS

Study design

The scoping review design pursued by this study uses the PRISMA-ScR checklist that includes identifying the title and structured summary, identifying rationales and objectives, methodology, -documenting the data, analysis and reporting of findings and finally discussing about the findings (15).

Search strategy

The following databases are used to search relevant published articles namely; PubMed, CINAHL, ProQuest Central, MEDLINE (Ovid), Cochrane library and Scopus. The keyword term for this topic is based on the medical subject heading (MESH). The search keywords, terms and boolean operator used in the database search strategy are; "Radius Fracture" OR "Distal Radius Fractures" OR "Wrist Injuries" OR "Wrist Fractures" OR "Colles Fracture" OR "Smith Fracture" AND "Function" OR "Recovery of Function".

Eligibility criteria of the study

The inclusion criteria include; 1) articles or studies that are published from the year 2013 until October 2020, 2) focusing on DRF, 3) studying adult clients' population and 4) examining the recovery of hand function especially on body functions and structures, activity limitation and participation in line with the ICF endorsed by WHO (14). However, some articles are excluded if they are: 1) published studies in other languages except English, 2) systematic review and scoping review papers and 3) published in non-peer reviewed journals such as abstracts, paper presentations and e-books. There are five authors involved in the review process. The first and the last authors searched for relevant articles using MeSH headings and variations of text word [tw]. Then, the process continues with removing of duplicate articles from the selected databases. Articles were then screened by titles, abstracts and full texts according to the inclusion and exclusion criteria by the first and last authors. Finally, the admissibility process was performed individually and manually by all authors and any disagreement is resolved through discussions until consensus is achieved. Data were extracted and reviewed by all authors.

Data extraction

The study design, subjects, critical evaluation and findings in the theme of published studies are extracted. Each study was critically evaluated using the Crowe Critical Appraisal Tool (CCAT) (16) and was summarised in Table II. The CCAT offers better reliability scores and may assist readers with different levels and types of knowledge to create similar conclusions regarding the research paper (16). The reviewed papers were stated and described in Table I.

Data analysis

The findings are analysed according to the components of ICF (14). The ICF comprises body function elements (physiological and psychological processes of the body systems) and body structures (anatomical parts of the body), activities (clients' acts and tasks) and participation (involvement in a life situation) (37). The component in body function and structure include: i) ROM, ii) grip strength, iii) dexterity and iv) pain. They are: i) ADL, ii) IADL, iii) leisure and recreation, iv) driving and v) productivity, for activity and participation. Summary of each study is made and integrated in the findings and discussions sections.

RESULT

From the systematic searching of the electronic databases, a total of 383 potential articles are found. Twenty-two articles are included in this review after removing duplication and screening articles according to the inclusion and exclusion criteria. The selection process is as shown in Figure 1. All the studies discuss the recovery of hand function following DRFs. The findings are described in detail according to specific themes.

Overview of study characteristics

i. Study Design

From the reviewed literatures, twenty studies use the quantitative approach method, while two studies use the qualitative approach. More than half of the reviewed studies (n=11) use the prospective cross-sectional design. Three studies use a longitudinal design while three studies use the retrospective cross-sectional data collection method. The remaining three study each uses the observational study, cross sectional study and normative cohort respectively. For the qualitative approach, the two studies used individual interview for data collection.

Table I: Description of articles in the scoping review

Authors & Study Location	Study Design	Samples	Main Findings	Critical Evaluation/Limitations	CCAT Score X/40 (%)
Porter, 2013 (Sweden) (12)	Longitudinal study	Clients with Colles', Smith or Barton fracture were treated conservatively. 18 years old and above. N=27	The grip strength was close to average after six months, with no improvements between those who were treated either using cast with closed reduction or cast alone. A wide distribution of the findings in activity performance suggesting the possibility of multi-dimensional explanations for the problems.	i. Barriers to participants' enrolment. ii. The difficulties in activity and participation were still present after six months, which lead to the gap of future study regarding this issue.	35/40 = 88%
Nielsen & Dekkers, 2013 (Denmark) (17)	Observational study	Elderly Danish Women with unilateral DRFs treated with external fixation or plaster cast. 18 years old and above. N=37	At 12 months, the outcomes of the Canadian Occupational Performance Measure (COPM) significantly increased in performance (8.6) and satisfaction (9.2). The Disability Arm Shoulder and Hand (DASH) score also increased substantially, to 14.2.	i. The majority of the 37 participants were in the average age group of women with DRF, and the disparity in the DASH score and activity performance due to the transition change in the general health of women. ii. This study only included women as samples.	32/40 = 80%
Egol et al., 2014 (United States) (18)	Prospective Cohort study	Clients with DRF underwent closed reduction and application of a sugar tong splint. N=260	Clients with finger stiffness have lower grip strength after 12 months of DRF as compared to non-stiff clients ($p<0.05$).	i. The scale of stiffness used to classify clients: "Tip to palm distance "may not be the only measure of finger stiffness. ii. No specific test was used for hand function assessment, i.e., Jebsen-Taylor Hand Function Test (JHFT)	30/40 = 75%
Ydreborg et al., 2015 (Sweden) (19)	Prospective Study	All clients with DRF who underwent plate fixation. 18 years old and above. N=101.	ROM and grip strength increased over time. The pain level decreased up to six months after surgery, but deteriorated significantly from six to 24 months.	i. The dropout rates are the significant constraint. ii. This study did not measure intervention fidelity.	34/40 = 85%
Mehta et al., 2015 (Canada) (20)	Prospective cohort study	All clients with DRF recruited between 1996 and 2009. 18 years old and above. N=386.	A baseline score of 35 out of 50 on the Patient Rated Wrist Evaluation (PRWE) assessment pain subscale had the highest sensitivity (85%) and specificity (79%) cut-off point after one year of DRF in predicting chronic pain.	i. This study could not explain a significant amount of variation over one year in chronic pain among the clients. ii. The types of fracture (displaced versus non-displaced) or treatment method (conservative versus surgical) were considered.	34/40 = 85%

CONTINUED

Table I: Description of articles in the scoping review (CONT.)

Authors & Study Location	Study Design	Samples	Main Findings	Critical Evaluation/Limitations	CCAT Score X/40 (%)
Nelson et al., 2015 (United States) (21)	Cross sectional study	Unilateral DRF and minimum one year follow up. 65 years and older N= 96.	Significant changes in Visual Analogue Scale (VAS)s (difference 0.5, p = 0.04) between malunion and well-aligned fractures groups. There were no significant differences in Quick DASH scores, strength, and wrist motion.	i. This study only establishes that the final results of client rated outcome, grip strength and ROM (one year after DRF) were similar among those with malunion and well-aligned fractures. ii. Only the older adult population was included in this study.	28/40 = 70%
MacFarlane et al., 2015 (United Kingdom) (22)	Retrospective study	Unstable fracture of DRF treated by internal fixation using Volar Locking Plate (VLP) Adult population. N= 187.	The median timeframe for returning to work was five weeks (interquartile 1-8 weeks). This study showed an early return to work, a low complication rate, and highly favourable functional results at an average of 30 months postoperatively.	i. The retrospective nature of the outcome measures used meant that a higher proportion of cases were lost to follow-up than hoped. ii. The lack of a research control group has also restricted the conclusions that can be drawn.	28/40 = 70%
Golec et al., 2015 (Poland) (23)	Prospective Study	Clients with Non-Comminuted DRF after 1-3 days 18 to 80 years' old. N= 71.	Clients with DRF have the most significant problems in physical function (82.8/100) and general health (78.1/100); 100 indicating the worst possible health-related quality-of-life (HRQoL).	i. The inclusion/exclusion criteria may have biased the HRQoL score. ii. Clients with comminuted fracture were excluded from the study.	34/40 = 85%
Ploegmakers et al., 2015 (Netherlands) (24)	Normative cohort	Client with DRF underwent open reduction and VLP fixation Adult female clients (mean age 47 years old). N=29	Mean supination strength was significantly reduced and associated with lower PRWE scores in all testing positions, demonstrating the importance of supination in wrist function.	i. Sample size was small. ii. Only the younger and the female clients were evaluated. Therefore, the result cannot be generalised.	33/40= 83%
Lauder et al., 2015 (United States) (25)	Retrospective Study	Clients who underwent treatment of a unilateral DRF using a dorsal bridge plate from 2008-2012. 18 years old and above. N=18.	There was a significant reduction in wrist flexion (43 vs 58), extension (46 vs 56), and ulnar deviation (23 vs 29) were observed as compared with the uninjured contralateral wrist.	i. Small sample size cohort resulting from clients either missing or hard to follow-up. ii. There is no baseline difference in strength or motion based on the dominance of the grip strength ratios as used in this research.	33/40 = 83%

CONTINUED

Table I: Description of articles in the scoping review (CONT.)

Authors & Study Location	Study Design	Samples	Main Findings	Critical Evaluation/Limitations	CCAT Score X/40 (%)
Vergara et al., 2016 (Spain) (13)	Prospective Cohort study	Clients with wrist fracture. 65 years and older. N= 680.	In 33% of participants, the Barthel Index and/or Lawton IADL scores dropped six months after the fracture.	i. In this study, the most significant limitation is that the clients' data on functionality and health status were retrospectively obtained. ii. Lack of client follow-up over time, although the response rate (74%) may be appropriate	31/40 = 78%
Takeuchi et al., 2016 (Japan) (26)	Prospective Cohort study	Clients with DRF between September 2011 and March 2013. Aged 20-89 years old. N=20.	The ROM ratio in pronation and supination recovered more rapidly than in any other ROMs within six months after operation (p = 0.0205).	i. The samples were heterogeneous from young adults to an elderly population. ii. The number of cases was relatively small.	28/40= 70%
Wadsten et al., 2017 (Sweden) (27)	Prospective study	Clients with unilateral DRF who were conservatively treated from October 2009 to September 2011 at an emergency department. 15-74 years old. N=175.	There were significant differences in the loss of ROM and grip strength between those with minimally displaced and late displaced fracture, where the worse outcome in the late displacement clients as compared to the non-injured hand. Late displacement was seen in 28% of cases and was correlated to a loss of grip strength and ROM.	i. The late displaced fractures significantly decreased ROM and grip strength in this prospective multicentre analysis. There does not, however seem to be any significant client-reported improvement in function or impairment.	32/40 = 80%
Lalone et al., 2017 (Canada) (28)	Prospective study	Clients with DRF. N= 65.	Most of the participants (85%) showed no difference in their long-term follow-up relative to their one-year PRWE assessment, or had decreased pain and impairment.	i. A low level of participation was anticipated given the duration of follow-up and the low incidence of recurrent complications after the injury. ii. Participants who either did not remember that they had a fracture or had no long-term problems were not encouraged to participate.	33/40 = 83%
Bobos et al., 2017 (Canada) (29)	Prospective cohort study	Clients sustained DRF. Aged 18-85 years old. N=154.	Clients (n=154) had mean grip strength discrepancies between the injured and the uninjured hand at three months (12.09 kg) follow-up and six months (7.47 kg).	i. The participants' visual acuity, which was not measured or monitored for, is a possible disadvantage that could impact the dexterity scores. ii. This study suggests for dexterity assessment and management after DRF.	35/40 = 88%

CONTINUED

Table I: Description of articles in the scoping review (CONT.)

Authors & Study Location	Study Design	Samples	Main Findings	Critical Evaluation/Limitations	CCAT Score X/40 (%)
Roh et al., 2017 (Korea) (30)	Prospective study.	Clients with DRF who were treated with volar plate fixation between June 2014 and October 2015. 50 years and older. N=157l	The low recovery of the Michigan Hand Questionnaire (MHQ) scores due to multifactorial factors such as age factor, lower grip power, and lower appendicular lean mass on multivariate regression analysis, and these three factors accounted for 37% of the variance in the MHQ scores.	i. No follow-up scores were obtained between 12 months after surgery on functional assessment, resulting in an insufficient perception of long-term recovery. ii. Only one questionnaire was used to measure the functional performance of the clients. iii. Therefore, there is need for a functional assessment and combination of an outcome measure to determine the functional recovery of DRF over a year.	28/40 = 70%
Jones et al., 2017 (United States) (31)	Prospective study	Clients who had undergone VLP fixation after DRF. 50-85 years old. N=23.	15 clients were able to return to independent driving (average, in 11.3 days) in the first evaluation. Out of the seven who failed, six reported being able to handle the car in an emergency situation and two reported not feeling comfortable and feel safe to drive.	i. The sample size was relatively small (23 clients). ii. There is limited study regarding driving among DRF clients.	31/40 = 78%
Nazari et al., 2018 (Canada) (32)	Prospective cohort study	Clients with DRF. Age between 18 and 75 years old. N=160.	Wrist ROM (flexion and extension) and grip strength were both statistically significant ($p<0.05$) in predicting the performance of hand dexterity after one-year follow-up.	i. The sample size was small for males than for females.	36/40 = 90%
Watson et al., 2018 (Australia) (33)	Qualitative study	Clients with DRF with or without ulna fracture, treated with VLP, and stable after open reduction internal fixator. 18 years or older. N=31.	Most clients felt their cast as an obstacle to perform work tasks. DRF imposed restrictions on daily activities such as driving, work and sports.	i. Clients with radius and ulna fracture were included. ii. Future research should use the combination of self-reported findings from clients to determine the impacts of wrist fracture.	33/40 = 83%

CONTINUED

Table I: Description of articles in the scoping review (CONT.)

Authors & Study Location	Study Design	Samples	Main Findings	Critical Evaluation/Limitations	CCAT Score X/40 (%)
Shimura et al., 2018 (Japan) (34)	Retrospective study	Clients with unstable DRF, and treated with VLP. Above 65 years old. N=32.	Mayo Wrist Score (MWS) and grip intensity indicate substantial changes between 12 and 24 months, but not 24 months to the last follow-up (mean 39.1 months). The wrist ROM between 12 and 24 months was not substantially improved.	i. The study's limitation was that the sample was small, and pain intensity scores were not recorded. ii. This study did not evaluate client-related functional outcomes using DASH or JHFT.	33/40 = 83%
Yang et al., 2018 (Singapore) (35)	Longitudinal study	Clients with unilateral DRF, and treated conservatively from April-June 2015. Mean age range 59 years old. N=138.	The wrist extension, active thumb opposition and full composite grip were among the highest ROM variables correlated with functional scores over time. Nonetheless, functional scores were not significantly correlated with wrist radial deviation and forearm pronation.	i. The study used only self-reported questionnaires without any performance-based assessments such as the JHFT. ii. Future study should concentrate on ADL changes and pattern over a year after DRF.	34/40= 85%
Andreasson et al., 2019 (Sweden) (36)	Qualitative study	Clients with symptomatic, and radiographically verified malunion DRF. 16 years or older. N=20.	In all clients, daily activities were affected, very much in a few highly valued things like sports and work, while the hand in use, or even at rest.	i. The findings can only be attributed to clients suffering from a malunited DRF or other wrist conditions. ii. It is important to note that daily life constraints are uniquely encountered, resulting from physical limitations.	35/40 = 88%

COPM: Canadian Occupational Performance Measure
JHFT: Jebsen Taylor Hand Function Test
DASH: Disability Arm Shoulder and Hand
PRWE: Patient Rated Wrist Evaluation
VAS: Visual Analogue Scale
HRQoL: Health Related Quality of Life
MHQ: Michigan Hand Questionnaire
MWS: Mayo Wrist Score

ii. Study location

By and large, the study location is widespread. Some of the studies were done in Canada (n=4) and United States (n=4), Sweden (n=4), Netherlands (n=1), Australia (n=1), Denmark (n=1), Spain (n=1), Poland (n=1), United Kingdom (n=1) and in Asia i.e. Singapore (n=1), Korea (n=1) and Japan (n=2).

iii. Assessment tools used in the articles

A variety of evaluation tools and outcome measures were used in those studies, including standardised and non-standardised tools. Standardised assessments used in the studies are portrayed in detail in Table II.

Summary of findings based on the ICF

Body Functions and Structures

i. Range of Motion

Five studies (19,26,32,34,35) discussed the recovery of ROM following DRF clients. Most studies showed that ROM progressed overtime at all injured hand joints. The mean pronation score for the first six weeks was 65 to 71 degrees (19,35). This pronation ROM gradually improved until 12 months to 82 degrees (19). For supination, the mean scores were ranged from 62 to 76 degrees at six weeks after injuries (19,35) and improved

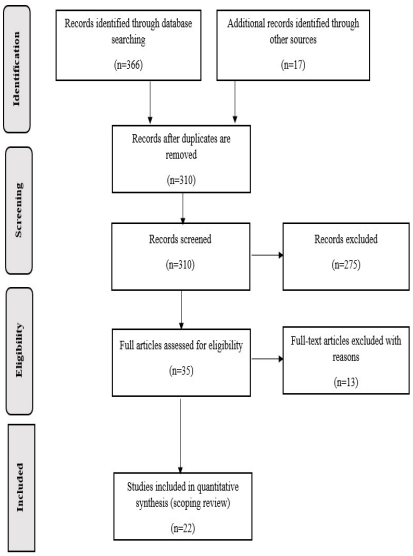

Figure 1: Flow Diagram for the search and study selection process in the scoping review

to 97 degrees at 12 months (19). This is complying with a report by Shimura et al. (34) that revealed the recovery of pronation and supination ROM after 12 months were between 77.2 % and 80.9 % respectively. The recovery of radial deviation at six weeks ranged from 11.5 degrees to 22.6 degrees (26,34,35). At 12 months, radial deviation ROM improved between 22.6 and 23 degrees (26,35). For ulna deviation ROM, the score ranged from 20 to 30.8 degrees at six weeks after DRF (19,26,35). Ulna deviation ROM then improved between 30 and 39.4 degrees at 12 months (19,26). For wrist flexion, the scores ranged from 41 to 42.9 degrees at six weeks after the injuries (19,26). A longitudinal study among 138 samples divulged that for the first three months Active Range of Motion (AROM) wrist flexion were 28 degrees (35). ROM wrist flexion improved at 12 months ranged from 54.6 to 59 degrees (19,26,32,34). The wrist extension scores at six weeks ranged from 37 to 46.1 degrees (19,26). A longitudinal study by Yang et al. (35) revealed that AROM for wrist extension was 35 degrees during the first three months after injuries. At 12 months, the wrist extension score ranged between 48.0 and 62.6 degrees (19,26,32,34).

ii. Grip strength

Eight studies (18,19,24,25,26,27,29,34) discussed and reported the recovery of grip strength following DRF clients. A study revealed the hand stiffness following DRF significantly decreased grip strength after one-year post fracture (18). Another study reported that the grip strength improved at six months after DRF in both older and younger clients whereby the score was at 20.6kgf and 23.9kgf (19). Lauder et al. (25) described that the recovery of grip strength (79%) and finger extension strength (65%) were observed in injured hands among the 18 clients under study following their bridge plate fixation for DRF. Another study found that the grip strength recovered at 50% after four weeks of surgery and 91% after six months compared to the uninjured non-dominant hand while the recovery for the uninjured dominant hand was at 52% after four weeks and 84% after six months (26). Wadsten et al. (27) reported that the loss of grip strength differed significantly between the minimal and late displacement group after three months to one-year follow-up. The recovery of grip strength for the injured hand is 15.60kg at three months and 21.57kg at six months (29). The retrospective study found that there was a substantial increase in grip strength between 12 and 24 months (88.6% to 93.6%) among the 32 clients after DRF, but not between 24 months and the final follow-up (39.1 months) (34). Ploegmakers et al. (24) revealed that by using baseline hydraulic dynamometer, the supination and pronation strength in all test positions for the injured wrist demonstrated a consistent weakness with the tremendous loss in supination at 60 degrees'.

iii. Pain

Three studies (19,20,28) reported the recovery of pain following DRF clients. Two quantitative papers discussed the baseline pain severity as the predictor for the recovery of functions after DRF. Mehta et al. (20) disclosed in their study that the intensity of pain is the strong predictor of chronic pain among the 386 samples, explaining 22% of the variance. On the PRWE pain subscale, a baseline score of 35 out of 50 had the best sensitivity (85%) and specificity (79%) cut-off values for estimation of chronic pain at one year after DRF. The PRWE scores were found to be predictive (19.1%) of the variability in the long-term PRWE score ($p<0.05$) (28) in another analysis. Ydreborg et al. (19) disclosed that the recovery of pain improved at six months after surgery but critically worsened between six months to two years.

iv. Dexterity

Two studies (29,32) reported and discussed hand dexterity of clients with DRF. Bobos et al. (29) found that the most important difference in mean scores for hand dexterity between the affected and unaffected hands were observed within three months. Males had better (faster) hand dexterity scores to manipulate of large and medium objects in both hands two years after DRF as compared to females. On the contrary, females had better (faster) hand dexterity for small objects than males in both hands across the time frame. Another study reported that grip strength and ROM were the independent variables to foresee hand dexterity abilities at three different subtests (large, medium and small objects) among DRF clients at one-year follow up and were statistically significant ($p<0.05$) (32). After two years, the only statistically significant ($p<0.001$) independent variable in predicting hand dexterity functions at all levels remained grip strength.

Activities and Participations

i. ADL

Table II: Standardised assessment used in the DRF studies

Authors	Standardised Assessment Used							
	PRWE	DASH	QUICK DASH	COPM	VAS	GONIOM-ETER	DYNA-MOMETER	SHFT
(Porter, 2013)	√	√			√			√
(Nielsen & Dekkers, 2013)		√		√	√			
(Egol et al., 2014)		√			√	√		
(Ydreborg et al., 2015)		√		√	√	√	√	
(Mehta et al., 2015)	√							
(Nelson et al., 2015)			√		√	√	√	
(MacFarlane et al., 2015)	√							
(Ploegmakers et al., 2015)	√		√				√	
(Lauder et al., 2015)	√		√			√	√	
(Takeuchi et al., 2016)		√				√	√	
(Lalone et al., 2017)	√							
(Bobos et al., 2017)						√	√	
(Roh et al., 2017)						√	√	
(Jones et al., 2017)					√			
(Wadsten et al., 2018)		√			√	√	√	
(Nazari et al., 2018)						√	√	
(Shimura et al., 2018)						√	√	
(Yang et al., 2018)		√		√		√		

PRWE: Patient Rated Wrist Evaluation
DASH: Disability Arm Shoulder and Hand
COPM: Canadian Occupational Performance Measure
VAS: Visual Analogue Scale
SHFT: Sollerman's Hand Function Test

Three studies (13,17,36) discussed and reported ADL recovery of clients with DRF. Nielsen and Dekkers (17) reported that 97% of clients still reported ADL performance problems during the first three months while 78% experienced problems at 12 months. The total of 268 ADL difficulties were found at cast removal, 109 ADL difficulties at three months, and 46 ADL difficulties at 12 months. The most disclosed self-care difficulties during the first assessment period were personal hygiene and dressing up. Andreasson et al. (36) in their qualitative study revealed that the clients had difficulty in daily tasks for examples personal hygiene, handling electronic gadgets and work-related tasks. Quality of sleep was affected due to the difficulty to find comfortable positions during sleep. Another study reported that the Barthel Index's score fell at six months after the fracture in 33 % of the elderly respondents (13). This functional predictor was more common in respondents with comorbidity issue ($p < 0.0001$), polypharmacy ($p < 0.0001$), lower health-related quality of life prior to the fall ($p < 0.0001$) and lower level of education ($p = 0.009$).

ii. IADL

There are three studies (12,13,17) that discussed about the recovery of IADL among clients with DRF. The most difficult IADL to perform were home chores and cooking activities such as opening a new jar or a tight-fitting lid with the affected hand, carrying a 5 kg object in the affected hand and cutting meat using a knife in the affected hand at three to four weeks and six months after the DRF incident. All the items are based on PRWE specific subscale.

iii. Driving

Only one study (31) reported about safe driving after volar plating of DRF. This prospective study reported that 15 clients could independently return to driving within 11.3 days. However, out of 15, two clients confessed not feeling safe to drive. The main reason was due to surgery pain. For those who failed to drive, the VAS was 2.4 out of 10 compared to 1.3 among those who passed to drive. To conclude, the result confirmed that most clients could return to driving safely after three weeks of surgery.

iv. Leisure or recreational activities

Two studies (12,17) discussed the recovery of leisure or recreational activities among clients with DRF. Nielsen and Dekkers (17) found that recreational and leisure activities affected clients with DRF. Women with DRF reported 88, 50 and 12 problems in leisure or recreational activities after cast removal, at three months and at 12 months based on Canadian Occupational Performance Measure (COPM) evaluation respectively. After 12 months, the major problems include performing sports activities (38%) and gardening (21%). Another study by Porter (12) reported that among the most challenging self-activities in the DASH score include recreational activities, which are related to the force from the arm, shoulder and hand.

v. Work and Productivity (n=1)

Only one study (17) reported about work and productivity among clients with DRF. Nielsen and Dekkers (17) disclosed a total of 348 performances difficulties at cast removal, 174 at three months, and 108 at 12 months as far as work and productivity are concerned. In this study, productivity is categorised into ironing, cooking, cleaning, meal preparation, laundry, daily routine activities while work means paid work. During the assessment period, it was found that the most affected activity is cooking and cleaning performances. At 12 months, heavy activities involving cooking and cleaning accounted for 81% of the productivity difficulty.

DISCUSSION

Twenty-two articles have been examined in this scoping review that specifically mentioned and identified the functional recovery affecting clients with DRF. Discussions are done based on the ICF domains. It appears that generally, recovery of body functions and structures takes between three to nine months, particularly for ROM, grip strength and dexterity. Nevertheless, it takes a year to regain pain after DRF. Recovery of ADL and IADL is approximately three months to a year but a limited study is done on this area.

Body Functions and Structures

Recovery of ROM is the most difficult to achieve because DRF involved a lot of joint movements and functions of the hand (35). Stiffness of fingers and wrist due to cast application within three to four weeks will result in poor ROM restoration and function. Therefore, to avoid stiffness and permanent impairments, DRF must be treated quickly and vigorously (38). Ikpeze et al. (39) mentioned that the recovery process is often complex and prolonged recovery times, distress, pain, and lack of mobility of hands and fingers. However, early intervention and home exercise by clients such as passive ROM and active assisted motion could prevent from stiffness and limitations of ROM during the early stage of recovery (40). Unfortunately, fewer than 10% of clients with DRF are referred to therapy during this crucial phase of immobilization (8). Although the wrist is immobilized, early therapy services should focus on increasing ROM of the fingers, wrist, and forearm (41). As a result, even though the hand is mobilized in a cast, the patient will benefit from early therapy to increase digit motion (41). In clinical practice, fracture healing is assessed using various methods, including physical examination, conventional radiography, and patient self-evaluation (42). This is to ensure that the bone is united and there is callus formation for early ROM and functions. As reported, ROM measures were associated with functional scores such as Quick DASH and improved over time after the injuries (35).

This scoping review from some studies conclude that clients still have pain after DRF for one to two-year duration after the injury. Macdermid et al. (43) hypothesised that only a minority of clients with DRF experienced mild pain during rest and very severe pain during active movement for the first two months after DRF. In a recent review, Ydreborg et al. (19) recorded that DRF clients showed significant improvement in pain score during the first six months following operation, which deteriorated significantly throughout follow-up periods until two years. Similarly, a study in United Kingdom reported that clients with DRF still suffer moderate (11%) to very severe pain (63%) and had some degree of pain even after one year of injury (44). Therefore, therapists should prescribe pain management techniques during rehabilitative exercise for better compliance to the rehabilitation program and thus fasten the functional recovery process.

Consistently with previous literature, recovery of grip strength could be achieved optimally within six months to one year. Previous researches on recovery of grip strengths at affected hand had proven improved grip strengths within six months among younger and older

clients at 20.6kgf and 23.9kgf respectively (19). These results match those observed in recent studies reported by Bobos et al. (45), the range score of grip strength is 15.60kgf (three months) and 21.57kgf at six months' following DRF with a mean age of samples was 53.5 years. Similarly, Lee et al. (46) discovered that grip strength on the injured side was 65% at six months and improved over time. To conclude, the recovery of grip strength relatively increased and comparable with the contralateral side after the injuries.

Hand dexterity has not been the primary focus in the previous studies. According to practice analysis, dexterity or performance-based hand function evaluations were rarely used in hand rehabilitation (47). Moreover, dexterity is not regard as important in the practice guidelines (47). However, recently researchers have discussed hand dexterity to predict the optimum hand function following DRF. There are many personal factors influence hand dexterity, including age, gender, educational level, and hand dominance (48). ROM and grip strength can influence the optimum recovery of hand dexterity. The need for dexterity standardised outcome measure is important to predict hand dexterity among clients. Findings from a six-month prospective cohort study revealed that the average score of NK hand dexterity for the small object is 54.3 ±27.5 seconds, whereas the completion time for large objects is 27.1 ±9.4 seconds (45). One of the studies found that dexterity decreases with age (49). Therefore, decreasing dexterity function is considered normal unless the individuals practice hand dexterity as routine skills, which embedded in their job tasks such as musicians and knitters (50).

Activity and Participation

Engagement and participation in ADL after fracture is complicated, especially activities associated with hand function. Compensatory techniques were used by most clients with DRF to cope with ADL issues including asking someone else to do the ADL, using the other side, and using other parts of the body to raise or grasp (51). This review found that dressing up and personal hygiene are the two most difficult activities to perform during the early recovery stage of DRF. These difficulties could be due to the fact that the optimum position of the wrist could not be achieved by clients as it is the most distal component responsible for hand positioning when performing all activities (51). Return to leisure and sports form the most challenging activities because they depend on the stability of the fracture site and the movement of wrists. A study by Halim and Weiss (52) disclosed that non-contact athletes could return to sports quickly after internal fixation as compared to high-impact athletes. The high-impact athletes can return to sports when there is clinical and radiographic evidence of fracture healing (53).

Driving is essential to some clients as they have to drive to the workplace. Driving post DRF within first two weeks after surgery will still cause pain and limited ROM because the bone is still on the remodelling process. Occupational therapists should assess and address the driving ability among clients with DRF to ensure that specific requirements for safe driving are met. Fleury et al. (54) disclosed that the upper extremities immobilisation, regardless of the type of splint or cast either side involved (right/left), and whether the elbow or thumb is or is not immobilised, significantly decreased driving abilities and performance (55). The ability to control the steering wheel while driving will be disrupted especially in emergency situation, even though the affected hand was not the dominant side. Meanwhile, Caldwell et al. (56) in their preliminary study reported that two weeks after DRF volar plating, clients with DRF were able to maintain lane position, but with overall lower speed and lesser steering inputs, and with 75% struggled to avoid collision on a crash-avoidance activity. Another critical finding was reported that 50% of orthopaedic surgeons usually advise clients to drive especially those with left Colles' plaster, and their dominant hand were the right hand (57). However, there were limited studies on return to safe driving following DRF. Therefore, this review highlights the need of more studies in this area to investigate and explore in depth.

Implications of the findings

This study provides significant implications in musculoskeletal practice especially in hand therapy, because the evidence of optimum time frame in the recovery process following DRF is still insufficient and debatable. To the best our knowledge, this is the first report showing the broad and extensive review about functional recovery following DRF guided by ICF. Furthermore, this scoping review adopted PRISMA-ScR checklist which is the international standard guideline for comprehensive overview and reporting the results. It also offers the initial suggestion for the development of guidelines for therapists on the cut-off point for the recovery of hand functions following DRF. In addition, the up-to-date analysis of researchers around the world shows the tremendous contribution as regards functional recovery following DRF. Therefore, this research may be useful for the occupational therapists' perspective to explore and carry out new contributions in the knowledge gap and rehabilitation in the domain of activity and participation especially ADL and IADL.

Limitations of the study

Nonetheless, there are some limitations of this scoping review. To make this study more up-to-date, the researcher concentrates only on studies conducted within the last seven years. However, the scope of study only limits itself to the recovery of function among DRF populations and cannot be generalised to other conditions of fracture. However, this might be used for a variation of distal ulna fractures that are closely connected to the area of the wrist. Future research can

also be further detailed out by using the systematic review analysis on functional recovery after DRF.

CONCLUSIONS

This scoping review may be considered laudable because it is primarily based on published articles that are solely related to post-DRF functional recovery. It also provides useful information on recently published DRF recovery studies that systematically categorised their findings based on ICF domains. To highlight one crucial point is that the functional ability of clients with DRF is still constrained, although the injury occurred more than six months ago. For therapists and clients, the target norm about functional recovery of each domain of ICF after DRF is very critical. Hence, knowledge gaps that have been identified by this review could trigger potential researches primarily focusing on the pattern of DRF functional recovery after a year of hand rehabilitation by integrating activity-based and impairment-based assessment approaches especially in Malaysian adult populations.

ACKNOWLEDGMENTS

The first author was funded by Majlis Amanah Rakyat (MARA), Malaysia under Graduate Excellent Programme (GrEP) 2018. The study was supported by BESTARI GRANT (ref no: 600-IRMI/DANA 5/3/BESTARI (064/2017), Universiti Teknologi MARA.

REFERENCES

1. Testa G, Vescio A, Di Masi P, Bruno G, Sessa G, Pavone V. Comparison between surgical and conservative treatment for distal radius fractures in patients over 65 years. J. Funct. Morphol. Kinesiol. 2019;4(2):26-36.
2. Young BT, Vernal UT, Rayan GM, City O. Outcome following nonoperative treatment of displaced distal radius fractures in low-demand patients older than 60 years. J. Hand. Surg. Am. 2000;25(1):19-28.
3. Diamantopoulos AP, Rohde G, Johnsrud I, Skoie IM, Hochberg M, Haugeberg G. The epidemiology of low- and high-energy distal radius fracture in middle-aged and elderly men and women in Southern Norway. PLoS One. 2012;7(8):1-6.
4. Lofthus CM, Frihagen F, Meyer HE, Nordsletten L, Melhuus K, Falch JA. Epidemiology of distal forearm fractures in Oslo, Norway. Osteoporos Int. 2008;19(6):781–786.
5. Nellans KW, Kowalski E, Chung KC. The epidemiology of distal radius fractures. Hand Clin. 2012;28(2):113-125.
6. Sebastin SJ, Chung KC. An Asian perspective on the management of distal radius fractures. Hand Clin. 2012;28(2):151-156.
7. Van Leerdam RH, Huizing F, Termaat F, Kleinveld S, Rhemrev SJ, Krijnen P, Schipper IB. Patient-reported outcomes after a distal radius fracture in adults: a 3–4 years follow-up. Acta Orthop. 2019;90(2):1–11
8. Michlovitz SL, LaStayo PC, Alzner S, Watson E. Distal radius fracture: Therapy practice patterns. J. Hand Ther. 2001;14(4):249-257.
9. Robinson LS, Brown T, O'Brien L. Embracing an occupational perspective: Occupation-based interventions in hand therapy practice. Aust. Occup. Ther. J. 2016;63(4):293–296.
10. Wilding C, Whiteford G. Occupation and occupational therapy: Knowledge paradigms and everyday practice. Aust. Occup. Ther. J. 2007;54(3):185–193.
11. Daud AZC, Yau MK, Barnett F, Judd J. Occupation-based intervention in hand injury rehabilitation: Experiences of occupational therapists in Malaysia. Scand. J. Occup. Ther. 2016;23(1):57–66.
12. Porter, S. Occupational performance and grip function following distal radius fracture: A longitudinal study over a six-month period. Hand Ther. 2013;18(4): 118–128.
13. Vergara I, Vrotsou K, Orive M, Garcia-gutierrez S, Gonzalez N, Hayas CL, et al. Wrist fractures and their impact in daily living functionality on elderly people: a prospective cohort study. BMC Geriatr. 2016;16(11):1–8.
14. World Health Organization. International Classification of Functioning, Disability, and Health: ICF. World Health Organization. 2001. Available from: https://apps.who.int/iris/handle/10665/42407.
15. Tricco AC, Lillie E, Zarin W, O'Brien, KK, Colquhoun H, Levac D, et al. PRISMA extension for scoping reviews (PRISMA-ScR): Checklist and explanation. Ann. Intern. Med. 2018;169(7):467–473.
16. Crowe M, Sheppard L, Campbell A. Comparison of the effects of using the Crowe Critical Appraisal Tool versus informal appraisal in assessing health research: a randomised trial. Int. J. Evid. Based. Healthc. 2011;9(4):444-449.
17. Nielsen TL, Dekkers MK. Progress and prediction of occupational performance in women with distal radius fractures: A one-year follow-up. Scand. J. Occup. Ther. 2013; 20(2):143–151.
18. Egol KA, Karia R, Zingman A, Lee S, Paksima N. Hand stiffness following distal radius fractures: who gets it and is it a functional problem? Bull. Hosp. Jt. Dis. 2014;72(4):288–293.
19. Ydreborg K, Engstrand C, Steinvall I, Larsson E. Hand function, experienced pain, and disability after distal radius fracture. Am. J. Occup. Ther. 2015;69(1):1-7.
20. Mehta SP, MacDermid JC, Richardson J, MacIntyrem NJ, Grewal R. (2015). Baseline pain intensity is a predictor of chronic pain in individuals

with distal radius fracture. J. Orthop. Sports. Phys. Ther. 2015;45(2):119-127.
21. Nelson GN, Stepan JG, Osei DA, Calfee RP. The impact of patient activity level on wrist disability after distal radius malunion in older adults. J. Orthop. Trauma. 2015;29(4):195–200.
22. MacFarlane R, Miller D, Wilson L, Meyer C, Kerin C, Ford D, & Cheung G. Functional outcome and complications at 2.5 years following volar locking plate fixation of distal radius fractures. J. Hand Microsurg. 2016;07(01):18–24.
23. Golec P, Depukat P, Rutowicz B, Walocha E, Mizia E, Pełka P, et al. Main health-related quality-of-life issues in patients after a distal radius fracture. Folia Med. Cracov. 2015;55(2):23–32.
24. Ploegmakers J, The B, Wang A, Brutty M, Ackland T. Supination and pronation strength deficits persist at 2-4 years after treatment of distal radius fractures. Hand Surg. 2015;20(03):430–434.
25. Lauder A, Agnew S, Bakri K, Allan CH, Hanel DP, Huang, JI. Functional outcomes following bridge plate fixation for distal radius fractures. J. Hand Surg. Am. 2015;40(8):1554–1562.
26. Takeuchi N, Hotokezaka S, Okada T, Yuge H, Mae T, Iwamoto Y. Recovery of wrist function after volar locking plate fixation for distal radius fractures. J. Hand Surg. Asian-Pac. Vol. 2016;21(02):199–206.
27. Wadsten MA, Sjudйn GO, Buttazzoni, GG, Buttazzoni C, Englund E, Sayed- Noor A S. The influence of late displacement in distal radius fractures on function, grip strength, range of motion and quality of life. J. Hand Surg. Eur. Vol. 2017;43(2):131-136.
28. Lalone E, MacDermid J, Grewal R, King G. Patient reported pain and disability following a distal radius fracture: a prospective study. Open Orthop. J. 2017;11(1):589-599.
29. Bobos P, Lalone EA, Grewal R, MacDermid JC. Recovery, age, and gender effects on hand dexterity after a distal radius fracture. A 1-year prospective cohort study. J. Hand Ther. 2017;31(4):465-471.
30. Roh YH, Noh JH, Gong HS, Baek GH. Effect of low appendicular lean mass, grip strength, and gait speed on the functional outcome after surgery for distal radius fractures. Arch. Osteoporos. 2017;12(1):41-45.
31. Jones CM, Ramsey RW, Ilyas A, Abboudi J, Kirkpatrick W, Kalina T, et al. Safe return to driving after volar plating of distal radius fractures. J. Hand Surg. Am. 2017;42(9):700-704.
32. Nazari G, Bobos P, MacDermid JC, Lalone EA, Grewal R. Physical impairments predict hand dexterity function after distal radius fractures: A 2-year prospective cohort study. Hand Ther. 2018;23(2):64-69.
33. Watson NJ, Martin SA, Keating JL. The impact of wrist fracture, surgical repair and immobilization on patients: a qualitative study. Clin. Rehabil. 2018;32(6):841–851.
34. Shimura H, Nimura A, Fujita K, Miyamoto T. Mid-Term functional outcome after volar locking plate fixation of distal radius fractures in elderly patients. J. Hand Surg. Asian-Pac. 2018;23(2):238–242.
35. Yang Z, Lim PPH, Teo SH, Chen H, Qiu H, Pua YH. Association of wrist and forearm range of motion measures with self-reported functional scores amongst patients with distal radius fractures: A longitudinal study. BMC Musculoskelet. Disord. 2018;19(1):142-147.
36. Andreasson I, Kjellby-Wendt G, Fagevik-Olsйn M, Karlsson J, Carlsson G. Life has become troublesome–my wrist bothers me around the clock: an interview study relating to daily life with a malunited distal radius fracture. Disabil. Rehabil. 2019;42(16):2344-2350.
37. Cieza A, Fayed N, Bickenbach J, Prodinger B. Refinements of the ICF linking rules to strengthen their potential for establishing comparability of health information, Disabil. Rehabil. 2016;41(5):574-583.
38. Kasch MC, Walsh JM. Hand and upper extremity injuries. In Pendelton, H. M. & Schulz-Krohn, w. (Eds), Pedretti's occupational therapy practice skills for physical dysfunction. 2013 (p. 1037-1073). St. Louis, MO: Elsevier
39. Ikpeze TC, Smith HC, Lee DJ, Elfar JC. Distal radius fracture outcomes and rehabilitation. Geriatr. Orthop. Surg. Rehabil. 2016;7(4):202–205.
40. Lal RK, Bhat K, Sanjay P. Efficacy of passive mobilization and home exercises in post immobilization period of distal radius fracture. Int. J. Health. Sci. Res. 2017;7(2):189–193.
41. Valdes K. A retrospective pilot study comparing the number of therapy visits required to regain functional wrist and forearm range of motion following volar plating of a distal radius fracture. J. Hand Ther. 2009;22(4):312-319.
42. Fisher JS, Kazam JJ, Fufa D, Bartolotta RJ. Radiologic evaluation of fracture healing. Skeletal Radiol. 2019;48(3):349-361.
43. MacDermid JC, Roth JH, Richards RS. Pain and disability reported in the year following a distal radius fracture: A cohort study. BMC Musculoskelet. Disord. 2003;4(1):1-13.
44. Moore CM, Leonardi-Bee J. The prevalence of pain and disability one year post fracture of the distal radius in a UK population: A cross sectional survey. BMC Musculoskelet. Disord. 2008;9(1):1–10.
45. Bobos P, Lalone EA, Grewal R, MacDermid JC. Do impairments predict hand dexterity after distal radius fractures? a 6-month prospective cohort study. Hand. 2017;13(4):441-447.
46. Lee HJ, Gong HS, Song CH, Lee JE, Lee YH, Baek GH. Evaluation of vitamin D level and grip strength recovery in women with a distal radius fracture. J. Hand Surg. Am. 2013;38(3):519–525.
47. Lichtman DM, Bindra RR, Boyer MI, et al. American Academy of Orthopaedic Surgeons clinical

practice guideline on: the treatment of distal radius fractures. J. Bone Joint Surg. Am. 2011;93(8):775-778.
48. Wang YC, Bohannon RW, Kapellusch J, Garg A, Gershon RC. Dexterity as measured with the 9-Hole Peg Test (9-HPT) across the age span. J. Hand Ther. 2014;28(1):53-59
49. Martin JA, Ramsay J, Hughes C, Peters DM, Edwards MG. Age and grip strength predict hand dexterity in adults. PLoS ONE. 2015;10(2):1-19.
50. Krampe RT. Aging, expertise and fine motor movement. Neurosci Biobehav Rev. 2002;26(7):769-776.
51. Bialocerkowski AE. Difficulties associated with wrist disorders - A qualitative study. Clin. Rehabil. 2002;16(4):429–440.
52. Halim A, Weiss APC. Return to play after hand and wrist fractures. Clin. Sports Med. 2016;35(4):597–608.
53. Morgan WJ, Slowman LS. Acute hand and wrist injuries in athletes: Evaluation and management. J. Am. Acad. Orthop. Surg. 2001;9(6):389-400.
54. Fleury TR, Favrat B, Belaieff W, Hoffmeyer P. Resuming motor vehicle driving following orthopaedic surgery or limb trauma. Swiss Med. Wkly. 2012; 142:1–5.
55. Stinton SB, Edgar DW, Moloney NA, Refshauge K, Pappas E. When can I drive? return to driving following a wrist fracture: A critical review. Hand Ther. 2015;20(3):95–101.
56. Caldwell L, Brown T, Glass N, Schmitt R. Driving after distal radius fractures. University of Lowa, United States: SAFER-SIM University Transportation Center; June 2017. 20 p. Report No.:19. Available from: http://safersim.nads-sc.uiowa.edu/final_reports/UI-3-Y3_ReportFinal.pdf.
57. Von Arx OA, Langdown AJ, Brooks RA, Woods DA. Driving whilst plastered: Is it safe, is it legal? a survey of advice to patients given by orthopaedic surgeons, insurance companies and the police. Injury. 2004;35(9):883–887.