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Review Article

Rehabilitation of Proximal Humerus Fractures- A Scoping Review

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Abbreviations AAROM: Active Assisted Range of Motion; AE: Adverse Events; AROM: Active Range of Motion; CINAHL: Cumulative Index of Nursing and Allied Health Literature; CONSORT: Consolidated Standards of Reporting Trials; EQ-5D: Euro Qual 5D; GHJ: Gleno-humeral Joint; HEP: Home Exercise Program; HR-QoL: Health-Related Quality of Life; MeSH: Medical Subject Heading; MOBS: Mobilizations; NR: Not Reported; PHF(s): Proximal Humerus Fracture(s); PHFE: Pulsed High Frequency Electromagnetic Energy; PROFHER: Proximal Fracture of The Humerus: Evaluation by Randomisation; PROM: Passive Range of Motion; PT(s): Physical Therapy/ Physical Therapist(s); RCT: Randomized Controlled Trial(s); RESIST: Resistive; ROM: Range of Motion; SAE: Society of Automotive Engineers; SF-12/36: Medical Outcomes Study Short-Form Health Survey versions 12 or 36; TENS: Transcutaneous Electrical Nerve Stimulation; TRID: Transport Research International Documentation; UK: United Kingdom; USA: United States of America; WK: Week

Abstract

Purpose: This scoping review maps the breadth of rehabilitation literature with specific relevance to the non-surgical management of proximal humerus fractures (PHF) in order to make recommendations for current practice and future research.

Methods: We searched 8 electronic data bases to July 16, 2015 for eligible studies; targeted citation tracking and hand-searches were continued thereafter. Eligibility screening and data charting were conducted in duplicate. Data extraction included publication details, objective, participant characteristics, interventions (and comparator if applicable), outcome measures, and authors' main conclusions. Data were catalogued according to research focus and outcomes assessed.

Results: The search yielded 1599 articles for full-text review; 26 articles (describing 22 unique primary studies and 5 knowledge translation studies) were eligible for inclusion. Dates of publication range from 1979 to 2017. The majority of the studies (88.5%) were conducted in Europe. Half were randomized controlled studies (RCTs). Typically, participants were older women. Research foci included: PT practice patterns in PHF rehabilitation (n=1), effectiveness of a specific PT element (n=3), timing (n=8), methods of delivery (n=3), non-surgical versus surgical management (n=7), and knowledge translation to guide clinical practice (n=5). Few studies provided complete descriptions of both the fracture characteristics and the main elements in the PHF rehabilitation therapy interventions.

Conclusions: Current 'good practice' in PHF rehabilitation is informed by this literature however no definitive evidence-based protocols exist. Using this scoping review technique driven by knowledge users, next steps have been identified such as developing summary sheets for rehabilitation team members and patients with PHF to address options and expectations regarding treatments and outcomes. High quality prospective studies, both prognostic and RCTs, are needed to investigate the effectiveness of key elements of rehabilitation therapy in patient groups with various types of PHF classified according to risk for poor functional outcome.

Introduction

Proximal humerus fractures (PHFs) are common, particularly among older adults, and account for a large proportion of all fragility fractures [1]. A 5-year prospective study of 1,027 people reported that most PHFs are minimally displaced (49%) or are 2-part fractures (28%) at the surgical neck and noted that an inverse relationship between frequency and severity continues across the spectrum [2]. Despite being less common, management of displaced 3- and 4-part PHFs is of great interest due to the complexity of the injury and the patient factors confounding repair and recovery. Most PHFs are treated non-surgically through immobilization and rehabilitation therapy with the goal of maintaining functional independence, which is a major public health concern for older adults. Although no definitive PHF rehabilitation protocols exist, physical therapy (PT) is recognized as an important component in the management regardless of the fracture type or treatment approach.

The most comprehensive attempt to synthesize the effectiveness of surgical and non-surgical PHF treatment is found in the recently updated Cochrane Systematic Review which included 31 randomized trials (1941 participants) [3]. The authors concluded that the evidence was either of high or moderate quality for the results of the surgical versus non-surgical treatment comparison and have confidence in the finding that, compared with non-surgical treatment, surgery does not result in a better outcome at 1 and 2 years after injury for people with displaced PHF involving the humeral neck and that a surgical approach is more likely to result in subsequent surgery [3]. This

finding cannot be generalized to 2-part tuberosity fractures, fractures in young people, high energy trauma, nor the less common types of PHF. Furthermore, the evidence for all other comparisons was of low or very low quality which undermines confidence in those findings [3]. Meta-analysis of data from trials investigating only non-surgical interventions for PHF (11 trials, 630 participants) was limited by the heterogeneity of the population, interventions and outcome measures. Therefore, there continues to be insufficient evidence from randomized controlled trials (RCTs) to inform choices about different PHF rehabilitation interventions.

Given the lack of high quality RCTs to inform definitive protocols for PHF rehabilitation, a scoping review is a viable form of knowledge synthesis aimed at mapping the types of evidence and gaps in research in this field [4]. Slobogean and colleagues [5] brought together a group of researchers, clinicians, and knowledge users interested in improving physical functioning outcomes for people with PHF and conducted a large scoping review to address the question, "What literature is available to guide the management of proximal humerus fractures?". The purpose of this current scoping review is to map the breadth of rehabilitation literature with specific relevance to the non-surgical management of PHF in order to make recommendations for current practice and future research.

Materials and Methods

We followed the 6-stage framework described by Arskey and O'Malley [6] and the recommendations by Levac and colleagues [4] for implementing each stage in the design and systematic conduct of our scoping review as outlined by our group in detail previously [5].

Literature search

A sensitive search strategy to identify all types of publications involving PHFs for the broad scoping review was developed in consultation with a biomedical librarian. The initial search strategies and sources used to identify relevant studies have been described previously [5]. Eight electronic databases were searched: MEDLINE, Embase, Cumulative Index of Nursing and Allied Health Literature (CINAHL), Cochrane Database of Systematic Reviews (CDSR), Web of Science, Proquest, File, Society of Automotive Engineers (SAE) digital library, and Transportation Research Board's Transport Research International Documentation (TRID) database. A combination of keywords and medical subject heading (MeSH) terms describing PHF were used as search terms. For example, the search strategy used in the CINAHL database was (1) MM "Humeral Fractures"; (2) Proximal humerus fracture*; (3) Proximal humeral fracture*; (4) Or/1-3.The search strategies used in each of the electronic databases have been reported [5, see Appendix I]. The searches were performed to October 30, 2012 (November 1, 2012 for Proquest, SAE digital library, and Transportation Research Board's TRID databases) with no language or date restrictions employed. This systematic search strategy was repeated July 16, 2015 to identify subsequent PHF rehabilitation literature. Hand-searching for studies reporting longer follow-up on the same study sample continued to July 2017.

Study selection

Titles from all database searches for the broader scoping review were compiled into a literature review program (Distiller SR). Replicate citations, books and retracted articles were removed and the titles and abstracts of all identified studies were reviewed by pairs of orthopaedic surgeons (GS, HJ, KL) to determine eligibility and classify articles into the rehabilitation theme. Studies were included in the rehabilitation theme if the focus was on rehabilitation therapy of acute PHFs or involved a research question directly relevant to rehabilitation management. Studies were excluded if they involved pediatric fractures, pathologic fractures, or sequelae of acute fractures (such as malunion). Studies focusing on the rehabilitation of fragility fractures or case reports with less than 10 research participants was also excluded. Finally, review articles that were general to shoulder or upper limb trauma or all aspects of PHFs or lacking details regarding the specific elements of PHF rehabilitation were excluded. Additional potentially eligible studies were identified by hand-searching and tracking citations in the included articles and screened for eligibility independently by two reviewers (NJM, LLK). At this stage, articles were excluded if written in a language other than English, if the timing or content of the conservative management provided by rehabilitation therapists was not the focus (for example, studies comparing different types of implant devices or immobilization bandages), if neither PT nor element(s) of a therapeutic exercise program was reported or if the majority of the study subjects treated non-surgically underwent manipulation by an orthopaedic surgeon to achieve closed reduction of the PHF. When the PHF rehabilitation interventions and the study sample were identical, the paper describing the longest follow-up period was included.

Data extraction and charting

Two reviewers (NJM, LLK) independently extracted the data from each rehabilitation article and consensus was achieved through iterative review and discussion. A data extraction form was developed with input from knowledge users to ensure the form would address relevant topics of PHF rehabilitation. The same data extraction form was used for all study designs.

Data analyses

The extracted data were catalogued and grouped according to the research focus. Nominal data were summarized using counts and proportions.

Results

Studies selected

The literature search and screening flow chart for the broader scoping review was reported previously [5]. A total of 5,406 citations were identified. When replicates (n=2,540), book titles (n=7), retracted articles (n=2), and those titles which clearly were not relevant to our research question (n=1,806) were removed, 1,051citations remained. Of these, 17 articles were classified under the rehabilitation theme. Hand searching yielded an additional 11 potentially relevant papers. Nine articles were published in a language other than English (4 German, 3 Slovak, 1 French, 1 Russian) and these were not translated for practical reasons. In the updated search, 1,135 citations were identified, 998 titles and abstracts were screened, 531 full text articles were reviewed and 9 English language articles were classified under the rehabilitation theme. One of these was a 2-year follow up for a trial identified in the initial search and 4 articles classified under the surgical theme were reviewed for potential relevance to the

PHF rehabilitation theme. Two of these described outcomes for the study population in the PROximal Fracture of the Humerus: Evaluation by Randomisation (PROFHER) trial randomized to surgical or conservative management. Hand searching yielded 3 additional papers (2 reviews and 1 reporting the 5-year follow up for the PROFHER trial). Only the article describing the longest follow up period for each trial was included in this review. Of the 10 full-text reviews retrieved, 5 were excluded due to lack of detail regarding the specific elements of PHF rehabilitation. A total of 26 papers were selected for inclusion in this scoping review.

Summary of charted data

Twenty-two papers reported data for unique primary studies. The majority of these primary studies were conducted in Europe (n=20, 90.1%): 7 from the United Kingdom (UK) [7-13], 5 from Sweden [14-18], 2 each from Spain [19,20], and Italy [21,22], and 1 each from Norway [23], France [24], Turkey [25] and multiple European centers (Switzerland, Belgium, Austria, Germany, Italy, and UK) [26]. The 2 non-European studies were conducted in Australia [27] and Canada [28]. One of these primary studies was embedded within a narrative review paper [13]. Including this paper, a total of 5 papers categorized as reviews provided specific guidance regarding PHF rehabilitation. These knowledge translation papers were conducted in the UK (n=3) [3,13,29], France [30], and the United States of America (USA) [31]. Of the 26 papers included, only 8 (30.8%) were published in journals targeting rehabilitation therapy readership.

Figure 1 illustrates the number of publications arising from each country categorized according to study design. Seven different study designs are illustrated for 27 studies reported in the 26 included publications. Half of the publications were RCTs.

Research foci of charted data

Six main research foci were identified: (1) PT practice patterns in PHF rehabilitation; (2) effectiveness of specific PT elements in PHF rehabilitation; (3) timing of PHF rehabilitation therapy; (4) methods of delivering PHF rehabilitation services; (5) non-surgical PHF management as compared with surgical management; and (6) knowledge translation to guide clinical practice.

PT practice patterns in PHF rehabilitation: One primary study, an environmental scan [13], provided novel information regarding PHF rehabilitation practice patterns. In 2002, a survey of 127 UK trauma and orthopaedic treatment centers (70% of UK hospitals with such centers) was conducted to determine PT practice patterns in the treatment of patients older than 40 years with a 2-part minimally displaced PHF [13]. The pen and paper questionnaire was completed by senior physical therapists (PTs) at each center. For this type of PHF, 42% of the centers reported either never or sometimes using immobilization. When immobilization was used, the duration varied from 1 to 7 weeks (55% reported 3 weeks). Most commonly, PT was always prescribed (81%). On the other hand, 19% of the centers prescribed PT only sometimes. Most centers (83%) reported that first contact with the treating PT occurred within 3 weeks of injury. This study highlighted the variability that existed in PHF rehabilitation even among centers specializing in trauma and orthopaedic care.

Effectiveness of a specific PT element in PHF rehabilitation: Table 1 summarizes the elements of PHF rehabilitation therapy reported in 3 small RCTs, with publication dates spanning from 1992 to 2015, investigating 3 different elements of multi-component PT interventions [8,15,19].

Revay and colleagues [15] investigated the effectiveness of hydrotherapy group exercises in addition to a PT-supervised home exercise program (HEP) compared with a PT-supervised HEP alone. Participants (n=48, mean age: 62 years, 81.3% female) with minimally or non-displaced 2-, 3-, or 4-part PHF all had the injured arm immobilized in a sling and received standard instructions regarding removing the sling to exercise 3 to 4 times per day until the first PT visit (which occurred 5 to 10 days following injury). Randomization occurred at this time. The hydrotherapy intervention was administered to groups of 6 to 8 people (30 minutes/session, 2 sessions/week to a maximum of 20) and mobilizing water exercises were progressed from active assisted to resistive gleno-humeral joint (GHJ) flexion, abduction and rotation. Both groups were encouraged to use the hand functionally, educated in relaxation techniques and resting positions, and provided with written HEP instructions including illustrations. The HEP was completed in 10 to 15 minutes per session in 4 or more sessions per day. The initial exercises included active/auto–assisted GHJ flexion, abduction and circumduction and were progressed at 3 weeks by introducing active exercises and adding GHJ abduction and rotation. Although we know that the HEP was progressed at week 3 (suggesting that 2 PT sessions were attended by the control group), the specific number of visits for this group was not reported and the authors described this intervention as 'self-training'. The authors concluded that self-training, as implemented in this trial, is effective for PHF rehabilitation and hydrotherapy did not improve outcomes assessed at 3 weeks, and 2, 3, and 12 months [15].

Livesley and colleagues [8] investigated the effectiveness of pulsed high-frequency electromagnetic energy (PHFE) in the first 10 working days upon referral to a PT. Participants with non-displaced PHF (n=48, mean age 61.7 years (n=4 under the age of 20 years), 77.1% female) were randomized to receive the 'standardized physical therapy regimen' which included early initiation of GHJ abduction with normal scapulothoracic rhythm and either sham or active

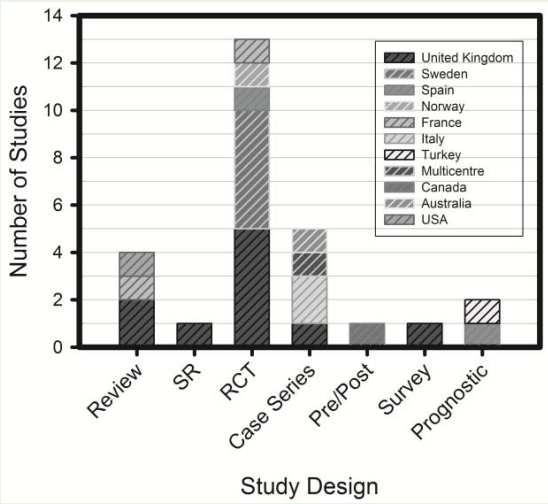

Figure 1: Study design of included studies coded by country of origin. SR: Systematic Review, RCT: Randomized Controlled Trial, USA: United States of America.

PHFE. Assessors and patients were blinded to treatment using this study design. Outcomes were assessed at 1, 2, 3 and 6 months. PHFE did not improve outcomes in this small sample [8].

Arias-Buria and colleagues [19] describe the effectiveness of early treatment with dry needling of active trigger points in the shoulder muscles of 20 patients over the age of 50 years (mean age 58±12 years, 75% female) experiencing their first attack of post-operative shoulder pain. Fifteen participants had PHF surgically repaired via open reduction and internal fixation using the proximal humerus internal locking system plate and 5 had rotator cuff injuries requiring surgical repair. Randomization resulted in 8 participants with PHF (out of 10) in the intervention group (PT plus dry needling) and 7 participants with PHF (out of 10) in the control group (PT only). Both groups attended 5 sessions over the course of 1 week and followed an evidence-based protocol for post-surgical rehabilitation following rotator cuff repair recommended by Conti and colleagues [32]. Table 1 summarizes the PT elements administered to all participants: passive mobilization of the GHJ and scapular regions, soft tissue massage of the shoulder muscles, scar tissue mobilization, shoulder mobilization exercises progressed from passive range of motion (PROM) to active assisted range of motion (AAROM) and active range of motion (AROM) and, within the last 2 sessions, pain free proprioceptive and progressive resistive exercises were added. Dry needling of active trigger points was applied to the intervention group during the first treatment session. At 1 week following the completion of the 5 treatment sessions, the intervention group showed greater improvement in the Constant Shoulder Score (total and subscales for activities of daily living and strength). Both groups experienced similar improvements in pain and range of motion (ROM) subscales. Six patients assigned to the intervention group experienced muscle soreness after treatment, with post treatment soreness resolving within 24 to 36 hours, but denied any increase in symptoms.

Timing of PHF rehabilitation therapy: Table 1 summarizes the elements of PHF rehabilitation therapy reported in 8 primary research studies addressing this research focus. Publication dates varied from 1979 to 2015.

In 1979, Jull reported on the PT treatment she provided for 9 people (ages 58 to 90 years, 88.9% female) with 2- or 3-part PHF (n=7 minimally/non-displaced) and the outcomes she assessed at discharge (7.5 weeks post fracture/20 treatments for older group) [27]. A detailed description of the treatment was reported. Patients were seen 3 times per week. Manual therapy was initiated early: passive accessory mobilizations of the GHJ, graded to treat pain versus stiffness, aimed at achieving 90 of degrees abduction and regaining flexion. Specific hand placements to support the injured limb/fracture fragments and to localize mobilizations to the GHJ were described. Treatment also included PROM, muscle relaxation techniques for shoulder abductor and extensor muscles, and condition–specific education. Instructions in a HEP included full elbow ROM, early functional use of the wrist and hand, and pendulum exercises every hour progressed to active resistive shoulder movements. Jull concluded that early passive joint mobilization of displaced and non-displaced PHF did not delay fracture healing because a good functional level was observed for all older adults within 5 to 10 weeks post injury [27].

In 2005, Urgelli and colleagues [21] reported on a case series of 18 people varying in age from 70 to 98 years (gender not reported) who had 3- or 4-part PHF immobilized in a Desault orthosis for approximately 34 days prior to initiating 'standard rehabilitation'. Participants were categorized according to compliance and outcomes (Constant Shoulder Score - total and subscales, and radiographs) and these data were compared to the literature reporting outcomes for people with similar fracture types treated by arthroplasty. The authors concluded that compliance with rehabilitation was essential to good functional recovery, whereas the quality of 4-part PHF reduction was not [21].

All 3 RCTs addressing this research focus were published in 2007 [9,10,24]. Hodgson and colleagues [9] recruited 86 participants with non-displaced 2-part PHF (n= 74 at 2 year follow-up, mean age 68.4 years, 82.4% female) to compare self-reported disability in the group randomized to initiate PT with in 1 week of injury versus the group immobilized using collar and cuff for 3 weeks prior to initiating the same PT program. In weeks 1 to 2, the participants were educated about the injury, and instructed in HEP including pendulum and pain-free passive shoulder flexion exercises. In weeks 2 to 4, passive flexion and light functional exercises were initiated and progressed. At week 4, functional exercises were progressed. The authors concluded that early mobilization resulted in less disability at 8 and 16 weeks with no difference between groups in the number of treatments. Group differences were not seen at 1 and 2 years post injury [9]. Lefevre-Colau and colleagues [24] completed an RCT in which 74 participants with 1-, 2-, or 3-part PHF (mean age 63±18 years, 73% female) were randomized to a PT-supervised exercise program and HEP initiated within 72 hours of injury or usual care involving 3 weeks of sling immobilization prior to initiating PT. Those randomized to early mobilization received 32 PT- supervised sessions. For 2 weeks, participants attended 5 sessions per week with each session lasting 2 hours. Initial treatment involved pain control (ice, neck massage), sling/pulley suspension, PT- supported shoulder PROM (abduction, flexion and lateral rotation initiated in the first, second and eighth session, respectively). At 3 weeks, the frequency of visits was decreased to 2 sessions per week for 5 weeks and exercises were completed without arm suspension. The sling was worn between PT sessions for approximately 4 to 6 weeks. At 4 to 6 weeks, participants in the intervention group started a daily HEP. At 6 weeks, the frequency of sessions was reduced to once a week and AROM exercises were initiated. Between 3 and 6 months, the intervention group attended 2 sessions per month to complete muscle strengthening exercises. The group receiving usual care attended 33 PT-supervised sessions. For 4 weeks, participants attended 4 sessions per week with each session lasting 2 hours. During these sessions, PT- supported shoulder PROM (abduction, flexion, and lateral rotation) was performed. Between 4 and 6 weeks post injury, the usual care group started the daily HEP. At 4 weeks, PT sessions were attended 2 times per week for 5 weeks. At 6 weeks post injury, AROM was initiated. At 9 weeks, participants attended 2 sessions per month for approximately 17 weeks, with a focus on muscle strengthening exercises. The authors concluded that early mobilization leads to significantly better ROM and shoulder function at 6 weeks and 3 months, and greater pain reduction at 3 months compared to the usual care group. However no differences between the groups were observed at 6 months [24]. Agorastides and colleagues [10] studied 49 participants ages 34 to 85 years with 3- and 4-part PHF (79.6% female) treated with cemented hemiarthroplasty. Treatment for participants randomized to the early mobilization group (n=26; usual care at that center) included sling immobilization

for 2 weeks with elbow exercises and pendulum exercises permitted. During weeks 3 to 6, the exercises were progressed to AAROM. At 7 weeks and onward, active exercises were progressed. Treatment for participants randomized to the late mobilization group (n=23) included sling immobilization for 6 weeks with only elbow exercises permitted. During weeks 7 to 12, pendulum exercises were progressed to AAROM. From week 13 onward, active exercises were progressed. An independent blinded assessor obtained data at 6 and 12 months. No differences were observed between groups randomized to early and late mobilization after hemiarthroplasty for PHF with respect to healing, symptoms, or functional recovery [10].

Amirfeyz and colleagues [11] conducted a case series of 39 patients (74% female) with 3- or 4-part PHF (with or without dislocation) who were treated with hemiarthroplasty and reconstruction of the tuberosities. Past experience with failed reconstruction of the tuberosities during rehabilitation at this center led to a change in practice such that formal PHF rehabilitation exercises were not started until 4 weeks post-surgery. The purpose of the study was to investigate the association between the delay in PHF rehabilitation and the rates of union and shoulder stiffness. Post-surgery, the shoulder was immobilized in an arm sling for 4 weeks. The fingers and wrist could move freely but only limited elbow movements were allowed. During

Table 1: Elements of physical therapy interventions reported in 21 primary research studies addressing the PHF rehabilitation theme.

Author [Study ID] Design	Surgry	Sling Only[a]	Shoulder Exercises					Manual Joint Mobs	Pain Management				Education	Hydro-therapy	PHFE
			PROM	AA	AROM	Resist	HEP		Muscle Relaxation	Ice/ Heat	Massage	Other			
Effectiveness of a specific physical therapy element in PHF rehabilitation															
Revay [15] RCT	×	1 wk		✓	✓	✓	✓		✓				✓	✓[b]	
Livesley [8] RCT	×		nr[c]	nr[c]	nr[c]	nr[c]	nr[c]								✓[b]
Arias-Buria [19] RCT	✓		✓	✓	✓	✓		✓			✓	✓[b]			
Timing of PHF rehabilitation therapy															
Jull [27] Case series	×	≤2wk	✓	nr	✓	✓	✓	✓	✓				✓		
Urgelli [21] Case series	×	28-44d	nr[c]	nr[c]	nr[c]	nr[c]	nr[c]								
Hodgson [9] RCT	×	0wk vs 3wk	✓		✓	✓	✓			✓[b]			✓		
Lefevre-Colau [24] RCT	×	0wk vs 3wk	✓	✓	✓	✓	✓			✓[b]	✓[b]				
Agorastides [10] RCT	✓	6wk vs 0wk	✓	✓	✓										
Amirfeyz [11] Case series	✓	4wk	✓	✓	✓	✓									
Canbora [25] Prognostic	×	1-wk	✓	✓	✓										
Foruria [20] Prognostic	×	2-wk					✓[d]								
Methods of delivering PHF rehabilitation services															
Lundberg [7] RCT	×	1-wk	✓	✓	✓	✓	✓								
Bertoft [14] RCT	×	10-12d	✓	✓	✓	✓	✓	✓[b]	✓[b]						
Tousignant [28] Pre/Post	×		✓	✓	✓	✓	✓		nr[e]	nr[e]	nr[e]	nr[e]	✓		
Non-surgical PHF management compared with surgical management															
Zyto [16] RCT	✓[b]	7-10d	nr[c]	nr[c]	nr[c]	nr[c]	nr[c]								
Olerud [17] RCT	✓[b]	0wk vs 2wk	✓		✓										
Olerud [18] RCT	✓[b]	0wk vs 2wk	✓		✓	✓									
Innocenti [22] Case series	✓[b]	2d vs 2wk	✓	✓	✓										
Hauschild [26] Case series	✓[b]	2d vs 1wk	✓												
Fjalestad [23] RCT	✓[b]	2d vs 2wk	✓	✓	✓	✓	✓								
Handoll [12] RCT	✓[b]	3wk[b]	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	

[a]Duration of immobilization prior to initiating shoulder exercises (sling worn between exercises sessions for various number of weeks)
[b]Intervention component received by one group/ some participants only
[c]Rehabilitation intervention protocol not described ('standardized physical therapy regime (apart from hydrotherapy)'; 'managed non-operatively'; 'standard physiotherapy regimen')
[d]Only HEP described
[e]Specific pain management strategy/strategies not described
Abbreviations: AA: Active Assisted; AROM: Active Range of Motion; HEP: Home Exercise Program; Mobs: Mobilization(s); NR: Not Reported; PHFE: Pulsed High Frequency Electromagnetic Energy; PROM: Passive Range of Motion; RCT: Randomized Controlled Trial; Resist: Progressive Resistive Exercises; WK: Weeks

weeks 5 to 10, exercises were progressed from pendulum to AAROM. At week 11, active exercises were initiated and progressed to rotator cuff strengthening exercises as tolerated. Follow-up occurred at 3, 6, and 12 months and yearly thereafter. The authors concluded that the longer period of immobilization did not result in excessive stiffness. In 5 patients (aged 66 to 92 years), the tuberosity failed to heal [11]. No comparison data were available describing the rate of healing in patients treated prior to this change in practice.

Two prognostic studies were included in this research focus [20,25]. One of these studies investigated the relationship between the functional outcome and radiographic results for 29 patients over the age of 65 years with 2-, 3-, and 4-part displaced PHF managed conservatively and concluded that functional outcome was associated with initial fragmentation but not the deformity that occurs when the fracture heals [25]. The second prognostic study investigated 89 adults aged 26 to 93 years presenting with various types of PHF that were treated conservatively to evaluate the displacement of the main fractured fragments at 1 year follow-up [20]. These authors concluded that deformity increases over time in the same direction as the initial deformity whereas substantial additional displacement of the tuberosities was rare [20]. As seen in Table 1, there is limited information regarding the specific PHF rehabilitation therapy elements used in the prognostic studies and one study reported elements of a HEP with no mention of PT or outcomes describing physical functioning at the 1 year follow-up [20].

Methods of delivering PHF rehabilitation services: Table 1 summarizes the elements of PHF rehabilitation therapy reported in 2 RCTs [7,14] and a pre/post study [28] addressing this research focus. Publication dates varied from 1979 to 2014.

Lundberg and colleagues [7] recruited 42 participants with non-displaced PHF (mean age 65 years - varying from 30 to 89 years, 88% female) to evaluate the effectiveness of PT-supervised HEP compared with usual care (control group). The injured shoulder of all participants was immobilized in a sling for 1 week. Participants randomized to the control group attended 1 to 2 PT sessions each week (20 to 30 minutes/session) for 2 to 3 months. Sessions included PT-supervised exercises, PT-assisted AROM and encouragement to complete the same HEP as given to the intervention group. Participants randomized to the intervention group attended PT sessions at 1 and 4 weeks post injury. At the first visit, they received advice and instructions to complete 4 to 5 exercise sessions each day (10 minutes per session) independently at home. Initially, the HEP included standing pendulum exercises, active movements of the elbow and hand, and active shoulder exercises below 90° of elevation performed in sitting. At the 1 month follow-up visit, the exercises were progressed to active assisted full shoulder elevation in sitting and supine, and strengthening exercises, including active functional movements and isometrics. The HEP was continued for approximately 3 months with final follow-up at 12 weeks post injury. Both groups were similar in the extent and rate of tissue recovery and muscular function. The authors concluded that good results are achievable in non-displaced PHF after one week of immobilization followed by PT-supervised independent exercises [7].

Bertoft and colleagues [14] conducted a RCT to investigate the effectiveness of PT-supervised HEP compared to usual care in 20 participants with minimal or non-displaced PHF (mean age 64 years - varying from 50 to 75 years, 85% female). Prior to seeing a PT, the injured shoulder of all participants was immobilized in a sling for 10 to 12 days. The intervention group attended for 3 visits during which they were encouraged to use the hand functionally, advised regarding relaxation and resting positions and instructed in the HEP to be completed 4 to 5 times per day (4 to 5 minutes per session). The initial exercises included active assisted/active shoulder flexion, extension and abduction, and elbow extension, while the arm was supported on a table. At 3 weeks, advice was given to use the arm functionally and exercises were progressed to include shoulder flexion lifting the elbow off the table and 2 active functional arm movements. At 8 weeks, a 10 second hold was added at the end of shoulder AROM. Outcomes were assessed at 3, 8, 16, 24, and 52 weeks by a blinded assessor. The authors concluded that 3 visits to initiate a PT-supervised home program and progress of the HEP produced short and long-term outcomes similar to 9 visits for PT treatments over 10 to 12 weeks [14].

Tousignant and colleagues [28] conducted a pilot study to assess the feasibility of delivering PHF rehabilitation remotely via telemedicine technology. Participants were screened for eligibility by orthopedic specialists and the characteristics of the fracture were not reported apart from the exclusion of anyone with an intra-articular PHF. All were deemed eligible on the basis of requiring conservative medical treatment and being able to do exercises, understand instructions, complete questionnaires, and access high speed Internet. Participants (n=17 at follow-up, mean age 65±11, 88% female) all received a tele-rehabilitation program over 8 weeks. Daily treatment required 2 sessions per day either supervised by a PT through tele-rehabilitation or unsupervised. Each session was completed in 30 to 45 minutes and was divided into 3 parts: warm-up, treatment program, and question period. The treatment program was tailored for each participant based on the number of weeks post fracture and the orthopedic physician's specifications. Every exercise program involved stretching, pain control, AAROM, AROM and muscle strengthening. The frequency of the tele-rehabilitation sessions varied where by 2 sessions per week were provided in weeks 1, 3 and 5, and 1 session per week was provided in weeks 2, 4, 6, 7, and 8. Participants were assessed at baseline and after the 8 week program. The authors concluded that tele-rehabilitation appears feasible for delivering PHF rehabilitation services. All participants improved and the global score for user satisfaction with the health services received was 82%, however, there was no control group for comparison in this study [28].

Non-surgical PHF management as compared with surgical management: Table 1 summarizes the elements of PHF rehabilitation therapy reported in the 2 case series [22,26] and 5 RCTs [12,16,17,18,23], published between 1997 and 2017,which address this research focus.

Innocenti and colleagues [22] compared outcomes in 51 consecutive patients over the age of 65 years (mean age 75.5 years - varying from 66 to 87 years, 74.5% female) with at least 1 severe comorbidity and a displaced 2-, 3-, or 4-part PHF treated either with percutaneous fixation or non-surgically. Non-surgical treatment consisted of brace immobilization of the shoulder and immediate active mobilization of fingers, wrist, and elbow, plus independent ambulation or sitting as much as possible. After 2 weeks, shoulder passive mobilization (pendulum) exercises were initiated several times daily. At 4 weeks, generally the brace was removed and PT-supervised

active exercises were begun. Participants treated surgically began elbow and wrist mobilization on day 1 post-surgery and pendulum exercises on day 2 post-surgery. After clinical healing of the PHF, active assisted or active shoulder elevation and GHJ internal/external GHJ rotation were initiated. Muscular strengthening exercises were initiated after both clinical and radiological evidence of fracture healing. Outcomes at a minimum of 4 (maximum 9) years were reported. Data for 23 of 28 patients treated surgically and 19 of 23 patients treated non-surgically were available at the final follow-up. Clinical and radiological healing, ROM and Constant Shoulder Score were significantly better in those treated surgically however the 2 groups were not randomized to the intervention and were not directly comparable. The authors concluded that either treatment option is suitable for elderly people with PHF who are not candidates for open surgery although outcomes were better for patients with minimally displaced fractures and with 2- or 3-part patterns as compared with patients with displaced and 4-part PHF [22].

Hauschild and colleagues [26] conducted a secondary analysis of data from 4 prospective multi-centre cohort studies. Data were included for all cases with 2-part surgical neck PHF treated surgically (n=133, 3 trial centers - 1 implant per center: proximal humerus internal locking system, locking proximal humerus plate, or proximal humerus nail) and all cases with a similar fracture pattern treated non-surgically (n=31, 1 trial center). The participants treated surgically had the injured shoulder immobilized in a sling and PROM exercises were started within 2 days post-operatively. Active shoulder exercises with abduction and flexion beyond 90 degrees were started 1 to 3 weeks post-operatively. The participants treated non-surgically may have had closed manipulation of the PHF at the discretion of the surgeon and the number who received this intervention was not reported. In all non-surgical cases, the shoulder was immobilized in a sling for 1 to 3 weeks and PROM exercises were initiated after 1 week. Active exercises were initiated after 4 weeks. Although these groups were not comparable in size, baseline data were similar for age, gender and fracture type. Outcomes assessed at 3, 6, and 12 months were compared. At the final 1-year follow-up, data were available for 103 and 26 participants treated surgically and non-surgically, respectively. The authors concluded that both approaches to managing 2-part PHF were safe and effective and any outcomes that were significantly better in the surgical group were only observed in the first 3 months [26].

The 5 RCTs addressing this research focus were conducted in older adults (mostly female) with displaced PHF and are included in the 2015 updated Cochrane Systematic Review [3]. In fact, the quality of the evidence comparing non-surgical and surgical management of displaced PHF was of sufficient quality for the authors of the systematic review to be confident in these meta-analyzed data and conclude that surgery does not result in a better outcome for the majority of people with this fracture type and may result in a greater need for subsequent surgery. Given the thorough review of these RCTs and the strength of this evidence described elsewhere [3], no further summary is provided here. For the purpose of this scoping review, it is noteworthy that very little detail is provided regarding the PHF rehabilitation therapy protocols used in these RCTs with the exception of the two most recent publications [12,23] (Table 1).

Knowledge translation to guide clinical practice: Table 2 summarizes the objectives, specific guidance, guiding principles and evidence base for 5 knowledge translation papers all published since 2006. In cases where detailed protocols are described, the supporting evidence is based on current best practice and expert opinion taking into consideration the strengths and limitations of the available literature, and the healthcare environment [13,29-31].

Outcome measures used in the PHF rehabilitation literature

Functioning, disability, and health were measured in the included studies using various methods addressing constructs at the level of impairment (body structure and function), physical activity limitations, and restrictions in role participation - including health-related quality of life (HR-QoL) and global satisfaction as shown in Table 3. The number of outcomes evaluating health services use and adverse events are also summarized in Table 3 as these outcomes related to one of the functioning and disability constructs or environmental factors.

Fifteen studies used standardized clinical assessment systems that measure a combination of outcomes at the level of impairment and self-reported and performance-based physical functioning relevant to functional recovery following PHF. The Constant Shoulder Score (also called the Constant-Murley Shoulder Outcome Score) was most commonly used [9-11,16-19,21-26] and this was identified as the primary outcome in 3 studies [19,23,24]. The Constant Shoulder Score sums subtest scores for patient-reported pain and ability to perform activities of daily living (minimum 0, maximum 35) and for clinician-administered assessments of shoulder AROM and muscle strength (minimum 0, maximum 65). The protocol provides options regarding tools used to assess muscle strength and test positions used to assess muscle strength and ROM [33]. Of the 13 studies that administered the Constant Shoulder Score, 2 reported the specific standardized methodology followed (limb position and measurement tool) [11,25]. Agorastides and colleagues [10] did not specify the position of the shoulder however the use of a digital spring balance to quantify muscle force was reported. Four studies described deviations from the standardized protocol [17,18,20,23]. Two studies specified that the measurements of muscle force were made with the shoulder at 90 degrees and if participants did not achieve the position, they were assigned a score of 0; the tool used to quantify muscle force was not reported [17,18]. A third study reported using a spring balance to assess muscle strength with the shoulder at 90 degrees of flexion or at whatever position below 90 degrees of shoulder flexion was painless for the patient [16]. In the trial conducted by Falejstad and colleagues [23], muscle strength was assessed with a strap positioned around the arm at the level of the elbow, the GHJ in 60 degrees of abduction and resisting against a fixed electronic spring balance. Two studies used the original Neer assessment system to assess anatomy, pain, shoulder ROM, muscle strength, functional movements (reaching various body parts) and activities (lifting, throwing, pounding, pushing, holding overhead) [7,26]. One of these studies collapsed the total Neer score into 1 of 4 categories to report the percentage of participants categorized as having an excellent, satisfactory, unsatisfactory, or poor end result at the final 12 month follow-up [26]. One RCT used the European Shoulder Association assessment charts to generate an algo-functional index which is the summation of scores on a pain index, a functional index, muscular strength, and the patient's subjective assessment of their disability on a linear scale [8].

Table 2: Summary of findings from knowledge translation articles providing specific guidance for PHF rehabilitation.

Publication Details	Study Objectives Specific guidance provided	Guiding principles for PHF rehabilitation	Evidence base
Hodgson [13] Clin Orthop Relat Res, UK (Narrative review)	To determine the optimal rehabilitation program for conservatively treated PHFs by reviewing prospective studies that advocate for conservative management & rehabilitation. Detailed descriptions of elements to include (pain control, patient education, manual therapy and exercises) are provided for each of the 3 phases of rehabilitation.	Many patients with PHF managed non-surgically need only advice, education and infrequent monitoring of a HEP over the short term. Those not making anticipated progress or with a high risk of developing long-term shoulder problems need treatments more frequently and over a longer period. Early use of passive accessory and physiological joint mobilizations may be required in those who are not achieving the expected rate of progress.	MEDLINE (1980-2005), CINAHL (1982-2005), PEDro (1990-2005), National Research Register (UK) (Search completed February 2005)
Singleton [31] Tech Shoulder Elb Surg, USA (Narrative review)	To introduce conservative management guidelines and outline current rehabilitation phases for postoperative management. Rehabilitation therapy guidelines are proposed for 4 groups: (1) greater tuberosity fracture (non-surgical), (2) Surgical neck, 3- and 4-part PHF (non-surgical), (3) Open reduction with internal fixation with locking plate, and (4) total and reverse total arthroplasty. Elements are described in text and figures. Modalities for pain control may be used as needed. Manual interventions to the soft tissue and scapular articulations are recommended for all managed surgically.	Aim to manage pain, promote bone healing and early PROM, progress to AROM and subsequent progressive resistive exercises to return to near normal function. Early attention to scapulohumeral rhythm and cueing of the latissimus dorsi and teres major and minor muscles is promoted. If either physiological GHJ ROM or depression of the humeral head is limited, passive accessory joint mobilizations are recommended. Intensity of the exercise program is dependent on the characteristics of the fracture, the patient, and the management approach. More attention to mobility of the cervical spine and surrounding muscles is required when management requires longer periods of arm immobilization in a sling.	Literature informing current best practice
Handoll [29] 2014, Bone Joint Res, UK (Instructional review)	To describe measures taken to assure the quality of the PT protocol received by both the surgical and the non-surgical groups in the PROFHER pragmatic trial A PT protocol is described for the rehabilitation of people with acute, closed and displaced surgical neck PHF whether treated surgically or non-surgically. Protocols for education regarding initial use of the sling and for the PT-supervised HEP are also described.	Emphasis is on providing good standard of care,and using familiar techniques that promote generalizability. Variation in practice was anticipated and acceptable however unusual interventions (potential substantial deviations) such as use of electrotherapy, other than TENS for pain relief, were strongly discouraged.	Accepted good practice was determined through appraisal of current PT practice at the lead trial site, feedback from stakeholders & questionnaires
Rubinik [30] Ann Phys Rehabil Med, France (Care pathway)	To produce a Physical and Rehabilitation Medicine care pathway for patients with PHF repaired using hemiarthroplasty. The care pathway informs future discussions on pricing by providing an overview of the patient's post-operative needs, care objectives, and the required human and material resources. The post-surgical rehabilitation care pathway for patients with PHF + hemiarthroplasty describes the timing and frequency of PT visits but specific elements are only implied in overarching objectives provided.	Post-surgical care timelines for patients with PHF treated with hemi-arthroplasty are related to the patient's health status prior to the trauma, other comorbidities prior to surgery, the time required for bone healing and the surgical technique and implants used. Three phases of rehabilitation (post-operative wk 1-4; post-operative wk 4-6; post-operative wk 7-12) are described which differ in resources/content according to the category of disability severity: 1 impairment vs several impairments. Each category has 6 subcategories (according to the personal and environmental factors most likely to impact the care pathway).	Expert opinion following analysis of the regulations, legislation and guidelines pertinent to France, a literature review, and validation by the Sofmer's Scientific Board.
Handoll [3] Cochrane Database Syst Rev, UK (Systematic review)	To assess the effects (benefits and harms) of treatment and rehabilitation interventions for PHF in adults. In most of the trials evaluating non-surgical management, rehabilitation therapy elements were not described in detail. There is insufficient evidence from RCTs to inform choices between different rehabilitation interventions.	High to moderate evidence suggests that, compared to no surgery, surgical repair of certain types of displaced PHF does not result in better outcomes and is more likely to result insubsequent surgery. Low to very low quality evidence supporting other findings reduces confidence. More emphasis is needed on the effectiveness of the non-surgical management of PHF	Major databases searched: Cochrane Bone, Joint and Muscle Trauma Group Specialized Register, the Cochrane Central Register of Controlled Trials, MEDLINE, Embase and other databases, conference proceedings and bibliographies of trial reports (Search ended in November 2014)

Abbreviations: AROM: Active Range of Motion; CINAHL: Cumulative Index of Nursing and Allied Health Literature; GHJ: Glenohumeral Joint; HEP: Home Exercise Program; PHF: Proximal Humerus Fracture; PROFHER: PROximal Fracture of the Humerus: Evaluation by Randomisation; PROM: Passive Range of Motion; PT: Physical Therapist/Physical Therapy; RCTs: Randomized Controlled Trial; TENS: Transcutaneous Electrical Nerve Stimulation; UK: United Kingdom; USA: United States of America; wk: Weeks

Twelve studies used outcomes to evaluate self-reported physical activity limitations and role participation restrictions (Table 2). Eight of these studies used standardized self-report measures validated to varying degrees for the evaluation of upper extremity symptoms and physical disabilities in people with PHF. Four studies administered a version of the Disabilities of the Arm and Hand (DASH: original [17,18], *Quick* [25], French [28]). Two studies administered the Oxford Shoulder Score [10,12]. One study administered the modified American Shoulder and Elbow Surgeons score [23] and another administered the Croft Shoulder Disability Questionnaire [9]. In 2 studies, self-reported physical functioning was identified as the primary outcome [9,12].

Since the original version of the DASH addresses social and psychological functions in addition to symptoms and physical function, it can be considered a HR-QoL measure. Other validated HR-QoL used in the PHF rehabilitation literature include versions of the Medical Outcomes Study Short-Form Health Survey (SF-36/12), which assesses 8 health-related domains: physical and social function, limitations due to emotional and physical problems, mental health, vitality, bodily pain, and general health [9,12], the EuroQual 5D (EQ-5D), which assesses 5 dimensions of health: mobility, self-care, usual activities, pain/discomfort, and anxiety/depression [12,17,18], and the 15D, which assesses 15 dimensions of health: moving, seeing, hearing, breathing, sleeping, eating, speech, eliminating, usual activities, mental function, feeling discomfort, depression, distress, vitality and sexual activity [23]. In the RCTs conducted by Olerud and colleagues [17,18] both the DASH and EQ-5D were administered. Similarly, in the PROFHER trial [12], both the SF-12 and the EQ-5D were administered.

Every study included at least 1 measure of impairment (Table 2). Twelve studies used imaging to assess fracture healing. Pain, ROM, and/or muscle strength were reported in almost all of the studies. Those studies reporting only items or subscales from the composite measures described above were not included separately in Table 2. In

Table 3: Frequency of outcome measures used to evaluate functioning, disability, and health in the PHF rehabilitation literature.

First Author [year]	Impairment					Physical Activity/ Role Participation		Composite [b]	HR-QoL	Health Services Use or AE	Patient Global Satisfaction
	Healing	Pain	ROM	Muscle Strength	Other [a]	Self-report	Observed				
Jull [1979]			3							1	
Lundberg [1979]		1	2	1	1			1			
Bertoft [1984]		1	1	1		1	1				
Revay [1992]		1	1			1	1				
Livesley [1992]		2	1	1		1					
Zyto [1997]	1					1		1			
Urgelli [2005]	1							1			
Hodgson [2007] [c]						**1**		1	1	1	
Lefevre-Colau [2007]	1	1	2					**1**		2	1
Agorastides [2007]	1					1		1			
Amirfeyz [2008]	1				1			1			
Olerud [2011]	1					1		1	1	1	
Olerud [2011]	1					1		1	1	1	
Innocenti [2013]	1	1	1	1				1			
Hauschild [2013]											
Canbora [2013]]	1	1	1	1		1		1		1	
Fjalestad [2014][c]	1					1		**1**	1	1	
Tousignant [2014]		1	1			1					1
Arias-Buria [2015]								**1**			
Foruria [2015]	2										
Handoll [2017][c]						**1**			2	3	

[a]Upper limb impairment on visual inspection; Cofield System (recovery based on pain and shoulder ROM)

[b]Combination of impairment and physical activity/participation (Constant Shoulder Score, Neer)

[c]Outcome measures reported in papers describing shorter follow-up periods for the trial are included

Bolded numbers denote the primary outcome measure identified by the authors.

Abbreviations: AE: Adverse Events; HR-QoL: Health-Related Quality of Life; PHF: Proximal Humerus Fractures; ROM: Range of Motion

some cases, authors report methods used without reporting validity, reliability or responsiveness of these impairment measures in the PHF population. For example, 1 study assessed muscle strength using clinical inspection and the observed ability of the participants to lift a weight overhead [7]. One case series used the Cofield system to categorize patient outcomes as excellent, satisfactory or unsatisfactory according to the degree of pain and shoulder ROM achieved [11]. Confirmation that outcome measures were validated for use in the PHF population was rarely provided [29].

In this PHF rehabilitation literature, 9 studies reported outcomes describing health services use or adverse events [7,9,12,17,18,23-25,27] and 3 assessed patient global satisfaction [7,24,28].

Discussion

This scoping review presents the most comprehensive summary of PHF rehabilitation literature performed to date using a thematic framework developed by our multi-disciplinary knowledge user collaboration. Overall, we identified that 30.8% of this literature consists of papers addressing the timing of PHF rehabilitation therapy. The next most common research foci were non-surgical compared with surgical management and topic-specific knowledge translation articles (approximately 27% and 19.2%, respectively). The remaining papers addressed the effectiveness of a specific PT element in PHF rehabilitation (11.5%), models of delivering PHF rehabilitation therapy services (11.5%), and PT practice patterns (3.8%). The majority of all included papers were from European centers (88.5%). Our key findings are:

- 26 papers describing 22 primary studies and 5 knowledge translation articles were identified.
- 50% of the PHF rehabilitation literature are RCTs. In general, these are small trials addressing unique research questions that limit the utility of meta-analyses.
- Most of this literature addresses the research foci: timing of PHF rehabilitation therapy interventions and non-surgical compared to surgical PHF management.
- Most studies do not provide detailed descriptions of both the fracture characteristics and the elements in the PHF rehabilitation therapy interventions. Notable exceptions are the RCTs published since 2014 and the topic–specific review papers.
- Only 2 prognostic studies were identified that considered PHF rehabilitation in the care pathway for people with PHF.

The care pathway for patients with PHF is variable depending on the interplay among a number of factors such as characteristics of the fracture pattern, the person, and healthcare providers, the surgical or non-surgical interventions used, and geographic distance between the home and treatment centers. Moreover, there are multiple elements in PHF rehabilitation interventions which may include various types of flexibility and strengthening exercises, movement/posture retraining, manual therapy techniques, physical agents, education, and self-management training. The selection and progression of the elements are tailored to the abilities and needs of the individual in order to restore functional independence. Therefore, variability is reported in the PHF rehabilitation literature and expected in current PT practice. In general, basic elements are consistent although intensity, rate of progression, and strategies for pain control may differ. For example, the 3 phases of rehabilitation for patients with PHF treated conservatively will include early immobilization (for pain relief and bone callus formation) during which time education, advice regarding pain management, self-care, and using normal functional movement patterns, and PT-supervised home exercises are initiated. Consideration is given to the movement patterns of the entire upper quadrant. Passive accessory joint mobilizations may be required if depression of the humeral head is insufficient to permit normal scapulaohumeral rhythm within the first 3 sessions. If indicated, manual joint mobilizations are graded to treat pain versus stiffness at this stage, and there is no clear guidance regarding the effectiveness of other modalities for pain control. Ice or heat is often used; electrotherapy modalities are discouraged with the exception of TENS [29], and future studies may show that dry needling of active trigger points in the shoulder muscles within the first session is helpful. On the other hand, many patients with PHF-particularly if non-displaced may manage independently with 2 or 3 visits for education, advice and instructions in a PT-supervised HEP. At the group level, it appears that early mobilization does not delay healing nor does later mobilization appear to result in significantly greater joint and soft tissue stiffness over the long-term. However, PT must be guided by the patient's pain and communication with the physician with respect to fracture characteristics, interventions used, and evidence of clinical healing. During the intermediate phase, functional activities and exercises are progressed as pain decreases and functional ability increases. Proprioceptive exercises (open and closed chain) are given to improve neuromuscular control of the rotator cuff muscles and shoulder-stabilizing muscles. PTs should monitor for excessive crepitus and pain and communicate any concerns regarding potential adverse events to the physician. There is no restriction on movements during this phase as long as pain is not exacerbated: the goal is to achieve full PROM. Some recommend initiating passive accessory joint mobilizations for the GHJ, acromioclavicular joint, and scapulothoracic articulation as required during this phase. During the later phase of rehabilitation, active and resistive exercises are progressed as tolerated to regain full shoulder functional activity with maximum achievable AROM. Proprioceptive exercises are progressed in conjunction with the increased functional activity and ROM. Passive stretching and soft tissue mobilization techniques may be required if joint contractures persist. The PT protocol used in the PROFHER pragmatic trial of 250 patients with closed, displaced 2-, 3-, and 4-part PHF involving the surgical neck was administered to both the surgical group (surgeon's choice of technique) and non-surgical group within a similar timeframe and duration [12] and elements were consistent with those described above. A small number of patients in each group also received hydrotherapy, acupuncture (dry needling), ice, heat, mobility retraining, or referral to occupation therapy or other specialty [29].

Whereas this PHF rehabilitation literature can be used to advise patients, and inform current practice, we identified several gaps in knowledge. It is clear that there are several ways in which PHF rehabilitation literature remains to be improved. There is a relative lack of studies investigating the effectiveness of specific elements of rehabilitation therapy and methods of delivering rehabilitation therapy services. In general, exercise programs were poorly described in terms of techniques, frequency, intensity, type, criteria for progression, and adherence. Few studies followed the Consolidated Standards of Reporting Trials (CONSORT) criteria for design and reporting

of non-pharmacologic studies. There is uncertainty regarding the validity, comparability, and generalizability of outcomes reported in many of the studies. Only 2 prognostic studies which consider PHF rehabilitation in the care pathway were identified and only 1of these assessed physical activity limitations, and participation restrictions at follow-up. Well-designed prognostic studies are required in order to identify people with PHF at risk for poor functional outcomes who may benefit from PHF rehabilitation therapy tailored to meet their specific requirements. Few studies evaluated patient satisfaction at follow up and no studies aimed to assist with acceptance and adjustment to a different level of functioning following PHF. Most studies report results of rehabilitation protocols in groups of patients treated by non-surgical strategies, fixation by plates, or shoulder joint replacements. These cases represent only a subset of the many PHF. Moreover, surgical techniques in common use today (such as intramedullary nailing and percutaneous pinning) were under-represented and have important implications for PHF rehabilitation. No studies evaluated the cost-benefit of different rehabilitation therapy interventions. These identified weaknesses and gaps in the PHF rehabilitation literature serve to guide future research.

In addition to cataloguing the strengths and weaknesses of the current rehabilitation literature, this knowledge user driven scoping review allowed for identification of other important knowledge user needs to improve experience along the care pathway and functional outcomes for people with PHF. For example, our PT knowledge users identified a need for an environmental scan of current PT practice with respect to PHF rehabilitation in our province. Also, they identified the need for more prospective studies, both prognostic and RCTs, investigating outcomes related to key elements of rehabilitation therapy interventions and models of service delivery in patient groups classified according to risk for poor functional outcomes in order to generate protocols tailored to the specific needs of various patient groups. Our orthopedic surgeon knowledge users identified a need for cost benefit analyses and fact sheets to disseminate a summary of the current evidence to PHF rehabilitation team members. Our patient group representatives identified a need for providing patients with lay summaries so patients have more information regarding the PHF rehabilitation process, options, and the anticipated level of functional recovery.

Limitations

In this scoping review, PHF rehabilitation literature was defined as studies that describe interventions that were (or could be) performed by PTs. Studies were excluded if different methods of upper limb immobilization or different surgical interventions were compared and the subsequent rehabilitation therapy protocols did not differ in content or timing of initiation. For practical reasons, we excluded non-English papers from our review. The final cut-off date of the systematic literature search was July 16, 2015; citation tracking and hand searching since that time was targeted. Also, it is possible that rehabilitation literature was classified to another theme during the study identification process. Therefore, our methodology may have resulted in omitting some relevant papers.

Conclusions

The strengths of this scoping review are a thorough systematic literature search to 2015, targeted hand searching to July 2017, and the process of ongoing consultation with our multi-disciplinary team of researchers and knowledge users to confirm interpretation and relevance of the findings to stakeholders. The current research emphasis should be on multi-disciplinary collaborations to design and conduct large, high quality, multi-center prognostic studies and RCTs that use valid outcome measures of function, disability and health and include an evaluation of the effectiveness of key elements of non-surgical PHF rehabilitation. The PHF rehabilitation scoping review summary is being used as one of the foci of ongoing planning meetings between clinicians, methodologists and other knowledge users to prioritize our research agenda for improving PHF management.

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