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The impact of shoulder pathology on individuals with distal radius fracture

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ABSTRACT

Background: Shoulder pathology can occur concurrently with a distal radius fracture (DRF) but few studies have examined this population.
Purpose: The purpose of this study was to expand the understanding of the impact of shoulder pathology on individuals with DRF. *Study Design:* Mixed Methods Design.
Methods: A total of 45 participants with a DRF were categorized into a DRF only ($n = 29$) and shoulder pathology concurrent with DRF (SPCDRF) ($n = 16$) groups. Quantitative data gathered included demographics, Quick Disabilities of the Arm, Shoulder, and Hand, Tampa Scale of Kinesiophobia-11, Visual Analog Scale, and Compensatory Mechanism Checklist. Qualitative interviews were performed with 7 participants in the SPCDRF group. Within group correlations were analyzed via the Spearman Rank. The Mann Whitney U test was used to compare the two groups. Qualitative analysis was performed to describe the experience of participants in the SPCDRF group. A mixed methods analysis compared quantitative and qualitative data.
Results: Sixteen participants (35.6%) in the sample presented with shoulder pathology; 6 participants (37.5%) presented at initial evaluation due to the fall; 10 participants (62.5%) developed shoulder pathology due to compensation or disuse. Average number of days to develop shoulder pathology after the DRF was 43 days. SPCDRF participants had significantly greater pain levels ($p = .02$) and more activity avoidance ($p = .03$) than the DRF only group. Four qualitative themes emerged: It's difficult to perform occupations and changes had to be made; There is fear and uncertainty; The impact of pain; Tried to be normal but could not Mixed methods analysis found that qualitative data further illuminated quantitative findings.
Conclusions: Individuals with shoulder pathology concurrent with a DRF may present with higher pain levels and avoid activity more. In addition, they may describe fearfulness in using their injured upper extremity especially if they have high levels of pain.
Study Design: Mixed Methods Design.

Introduction

Distal radius fractures (DRFs) are common fractures seen by physicians.[1-2] While there is abundant literature related to DRF rehabilitation, less literature examines the relationship between shoulder pathology and DRF. Two recent studies have explored the relationship between wrist fractures and shoulder pathology.[3-4] Cantero-Téllez et al,[3] identified a strong correlation between shoulder pain and duration of wrist immobilization, advocating that shoulder rehabilitation should be part of the rehabilitation program when wrist immobilization exceeds 3.5 weeks. Cha et al[4] found that a lower bone mineral density and injury to the nondominant side were significant factors for developing shoulder

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stiffness in individuals following DRF surgery. Additional factors that may contribute to shoulder problems following a DRF include injuring the shoulder at the same time,[5] immobilization of the upper extremity,[4] not using the upper extremity due to pain,[6-7] lack of supination causing biomechanical changes to the shoulder,[4,8] and shoulder compensation during every day activities due to lack of motion in the wrist and forearm.[9]

While this literature provides some insight into factors that may impact shoulder function following a DRF, there is a dearth of literature examining this impact on daily function. To our knowledge, only Cha et al[4] have examined the impact on daily function of having a concurrent DRF and shoulder pathology. These authors reported no differences in the Disabilities of the Arm, Shoulder, and Hand (DASH) scores two years post DRF between the shoulder pathology concurrent with a DRF and the DRF only groups.[4] Although there is abundant evidence documenting the inability to perform occupations immediately following a DRF,[10-15] such literature is not available for people with concurrent shoulder pathology. Therefore, examining the impact on function in the short term for this population can help guide rehabilitation.

There is currently no best practice rehabilitation protocol for the inclusion of shoulder motion following a DRF.[16-17] Some protocols include active range of motion to the shoulder[18-20] while other protocols do not.[21-22] In order to improve the protocols used in rehabilitation of individuals post DRF, more information about the phenomena of shoulder pathology in individuals with DRF is needed.

The purpose of this mixed methods study was to expand the understanding of the impact of shoulder pathology on individuals immediately following a DRF. Our primary purpose was to understand if this population differs from individuals with a DRF only in the areas of pain, function, kinesiophobia, and use of compensatory mechanisms. A secondary purpose was to explore relationships among these variables (pain, function, kinesiophobia, use of compensatory mechanisms) with correlation and qualitative analysis.

Methods

Study design

A mixed methods design was used. Qualitative and quantitative data were collected prospectively, analyzed separately, and then results were merged ensuring equal priority to the quantitative and qualitative data. Four constructs guided this study design and analysis: function (as measured by the QuickDASH), kinesiophobia (as measured by the Tampa Scale of Kinesiophobia-11 [TSK-11]), pain (as measured by the Visual Analog Scale [VAS]), and compensation (as measured by the compensatory section of the Adelaide Questionnaire). See Appendix A for the compensatory checklist of the Adelaide Questionnaire.

The quantitative component used a cross-sectional design. Data were collected prospectively for a group of individuals with a DRF. Shoulder pathology was observed as it naturally occurred, and those that developed shoulder pathology were placed in the shoulder pathology concurrent with distal radius fracture (SPCDRF) group. Those that did not develop shoulder pathology remained in the DRF only group. Data gathered for the quantitative component included demographics, QuickDASH, TSK-11, VAS, and the compensatory section of the Adelaide Questionnaire. An a priori power analysis using an effect size = .89, power = .80, alpha = .05 yielded a total sample size of 42 (21 per DRF only group; 21 per SPCDRF). Effect size was based on two prior cross-sectional studies.[23,24]

The qualitative component used phenomenology to guide data collection. Phenomenology is a methodology used when the goal is to describe the human experiences of a group of individuals who experience the same phenomena.[25] Only participants in the SPCDRF group participated in the qualitative portion of the study. These participants were given the opportunity to describe their lived experience with shoulder pathology and a DRF. See Appendix B for the qualitative interview guide.

Procedures

Study approval was obtained through the IRB committee at Nova Southeastern University. Participants were patients at an orthopedic practice who experienced a DRF. Data were collected from January 2017 to January 2018. All participants were followed for a total of 9 weeks. This time frame was chosen based the length of time that individuals with a DRF are closely followed by the hand surgeon at the orthopedic practice. The hand surgeons chose participants for the study based on inclusion and exclusion criteria. Inclusion criteria included a diagnosis of a DRF, 18 years of age or older, proficiency in the English language, and normal shoulder function prior to the DRF as reported by participant. Exclusion criteria included cognitive deficits or physical disabilities that limited the ability to participate or make decisions regarding participation in the study, history of shoulder injury prior to the DRF, medical condition or comorbidity that had negative effects on the shoulder joint prior to DRF such as rheumatoid arthritis or stroke, undiagnosed DRF longer than two weeks from date of injury, bilateral DRFs, or additional injuries other than shoulder pathology that occurred at the time of the DRF.

The hand surgeons recruited participants from their orthopedic practice using an oral recruitment script. Following informed consent, the participants completed a demographic questionnaire (See Appendix C). Each participant then completed follow-up appointments with the hand surgeon, at which time the shoulder was continually assessed by the hand surgeon. Both hand surgeons were given specific criteria that needed to be met in order to diagnose a participant with shoulder pain, shoulder stiffness, adhesive capsulitis or impingement syndrome (See Appendix D). No imaging of the shoulder was performed by the hand surgeons. The hand surgeon saw the participant an average of five times between the date of injury and 9 weeks. If the shoulder pathology became evident during this time, the hand surgeon recorded the date and shoulder diagnosis, and determined whether or not the shoulder pathology was the result of the fall or due to compensation/disuse (See Appendix D). If the participant was being followed by an occupational therapist, the treating occupational therapist evaluated the shoulder weekly for shoulder pathology and referred the participant to the hand surgeon for a formal shoulder evaluation and diagnosis if needed. If a participant was diagnosed with shoulder pathology by the hand surgeon, that participant was placed in the shoulder pathology concurrent with a DRF (SPCDRF) group. If the participant did not present with shoulder pathology over the 9 week duration of the study, the participant was placed into the DRF only group. Any participant that developed shoulder pathology after 9 weeks was not included in the study.

Outcome measures and data collection

Quantitative assessments were given to all participants at 5-7 weeks post DRF injury. It was decided that data collection at 5-7 weeks post injury would best represent pain intensity, functional level, kinesiophobia, and use of compensatory mechanisms of all participants regardless of when shoulder pathology was diagnosed. Quantitative data collectors included the primary investi-

gator (PI), two hand surgeons, and one occupational therapist. All data collectors were trained by the PI to ensure consistency with data collection. Quantitative data collected included demographic questionnaire, the QuickDASH, TSK-11, VAS, and number of compensatory mechanisms used from the Adelaide questionnaire. All consent forms and quantitative data were kept in a locked file cabinet.

QuickDASH

The QuickDASH is a reliable and valid, 11-question instrument to measure physical function and symptoms in patients with upper-limb musculoskeletal conditions.[26-28] A higher score on the QuickDASH indicates worse function while a lower score indicates higher function.

Tampa scale of kinesiophobia

The TSK-11 is an 11-item instrument that measures kinesiophobia and gives an overall score and two subscale scores: avoidance and harm.[29-30] A higher overall score on the TSK-11 indicates that the individual has more kinesiophobia, a higher score on the avoidance subscale indicates that the individual avoids movement in the affected extremity, and a higher score on the harm subscale indicates that the individual felt that movement of the affected extremity caused more harm to the body. The TSK-11 is both reliable and valid in measuring fear of movement/(re)injury.[29-30]

Visual analog scale

The VAS is a widely used measure of pain intensity[31] and has high reliability and validity.[32-33] A higher score on the VAS indicates higher pain intensity. Participants were instructed to rate the pain in their injured upper extremity only.

Adelaide questionnaire

The Adelaide questionnaire is a valid and reliable instrument that assesses compensatory mechanisms used to perform activities after a wrist injury.[34-35] The standard component assesses an individual's ability to perform 25 activities of daily living (ADLs) and an additional component assesses the (1) magnitude of performing the activity, (2) number compensatory mechanisms used, and (3) perceived importance of up to five meaningful ADLs identified by the individual.[11] For this study, the compensatory mechanism checklist from the Adelaide questionnaire was applied to the five activities of daily living/instrumental activities of daily living (IADLs) on the QuickDASH so that compensatory mechanism use could be compared between groups. Those QuickDASH ADL/IADLs included opening a tight or new jar, doing heavy household chores, carrying a shopping bag or briefcase, washing one's back, and using a knife to cut food. Refer to Appendix A.

Qualitative interviews

The PI performed qualitative interviews with the first 7 participants in the SPCDRF group who consented to be interviewed between 5 and 9 weeks post-DRF. All participants interviewed were female. Phenomenological inquiry typically includes 6-10 participants to gain a sense of the lived experience.[25] The time frame of 5-9 weeks post-DRF was chosen so that quantitative data collected from the SPCDRF group at 5-7 weeks post DRF could be more easily mixed with the qualitative data. Ideally, the PI wanted to perform all qualitative interviews at 5-7 weeks post-DRF so that the time frame for qualitative data collection was the same as the time frame for quantitative data collection. Due to scheduling conflicts with participants, an additional 2 weeks were added to the time frame for qualitative data collection. All semistructured interviews occurred in private treatment rooms and were individual and conversational to encourage participants to describe their experiences. Each interview started with broad questions, and then transitioned into subquestions. Refer to Appendix B.

Each interview was recorded on a digital voice recorder. The interview was transcribed and all transcriptions were kept on the password secured computer and backed up with an external hard drive. Microsoft Word was used to manage data transcripts and any observations.

Data analysis

Quantitative data analysis

SPSS was used to analyze all quantitative data. Descriptive statistics were used to report demographic data. The Spearman rank correlation test (r_S) was used to examine all relationships within groups between the DASH, TSK-11, VAS, and use of compensatory mechanisms from the Adelaide questionnaire including the variables surgery/no surgery and handedness within groups. Only significant correlations **($p < .05$)** were reported. **Correlation coefficients of .25-.49 were considered a fair relationship, .50-.74 were considered a moderate relationship, and above .75 was considered a strong relationship.**[36] The Mann-Whitney U test was used to determine differences between the DRF only and SPCDRF group on the DASH, TSK-11, VAS, and use of compensatory mechanisms on the Adelaide questionnaire. **Effect size (ES) was calculated by dividing the Z score by the square root of *n* for statistically significant ($p < .05$) Mann Whitney U tests.**[37] **An effect size of .20-.49 was considered a small effect, .50-.79 was considered a moderate effect, and .80 and above was considered a large effect.**[36]

Qualitative data analysis

Qualitative data analysis procedures used included reading and rereading of the interview transcripts, reflection, and theme development. To start the data analysis process, repeated reading of the interview transcripts occurred along with listening to the audiotapes of the interviews. Statements that reflected each participants' voice were highlighted in the transcripts and grouped into codes.[25] The PI then reflected on the interview transcripts and the codes to find the larger meaning of the data and eliminate any redundant codes.[25] After reflection and interpretation of the codes was completed, codes were clustered and themes were formed.[25]

Data integration

To integrate the quantitative and qualitative data, a merging analysis approach was used,[38] which involved independently analyzing each component, and then comparing, contrasting, and synthesizing the data.[38] The constructs of function, kinesiophobia, pain, and compensation guided the data integration. Tables were used to compare similarities and differences between quantitative results and qualitative themes. Data were synthesized to form meta inferences on the impact of shoulder pathology on individuals with DRF.

Results

Quantitative data analysis

A total of 45 participants with a DRF participated in this study (DRF only = 29; SPCDRF = 16). Refer to Table 1 for demographic data. The mean age was 65 years old (SD = 9.0) for the SPCDRF group and 68 years old (SD = 16.2) for the DRF only group. Among the 10 participants in the SPCDRF group whom the shoulder pathology was caused by compensation or disuse, the mean

Table 1
Demographic data between DRF only and DRF + shoulder pathology groups.

*		DRF only $n = 29$ (%)	SPCDRF $n = 16$ (%)	Total$n = 45$ (%)
Fracture side	Right	9(31)	4(25)	13(29)
	Left	20(69)	12(75)	32(71)
Hand dominance	Right	26(89.7)	16(100)	42(93.3)
	Left	2(6.9)	0(0)	2(4.4)
	Ambidextrous	1(3.4)	0(0)	1(2.2)
Is dominant side fracture side	No	18(62.1)	12(75)	30(66.7)
	Yes	11(37.9)	4(25)	15(33.3)
Sex	Male	6(20.7)	1(6.2)	7(15.6)
	Female	23(79.3)	15(93.8)	38(84.4)
Type of shoulder pathology	SI	0(0)	2(12.5)	2(4.4)
	SI, SP	0(0)	3(8.8)	3(6.7)
	SI, SS	0(0)	1(6.3)	1(2.2)
	SP	0(0)	6(37.5)	6(13.3)
	SS	0(0)	4(25)	4(8.9)
	AC	0(0)	0(0)	0(0)
Causation of shoulder pathology	C/D	0(0)	10(62.5)	10(22.2)
	Fall	0(0)	6(37.5)	6(13.3)
Had a willing and able caregiver	No	14(48.3)	4(25)	18(40)
	Yes	15(51.7)	12(75)	27(60)
Productive role- paid employment	Yes	15(51.7)	11(68.8)	26(57.8)
Ability to perform paid employment role	Full	10(34.5)	7(43.8)	17(37.8)
	Modified	4(13.7)	3(18.8)	7(15.5)
	Unable	1(3.4)	1(6.3)	2(4.4)
Productive role- homemaker	Yes	18(62.1)	9(56.3)	27(60)
Ability to perform homemaker role	Full	5(17.2)	1(6.3)	6(13.3)
	Modified	13(44.8)	8(50.1)	21(46.6)
Productive role- volunteer	Yes	10(34.5)	2(12.5)	12(26.7)
Ability to perform volunteer role	Full	4(13.8)	0(0)	4(8.9)
	Modified	5(17.2)	2(12.5)	7(15.6)
	Unable	1(3.4)	0(0)	1(2.2)
Productive role- student	Yes	2(6.9)	1(6.3)	3(6.7)
Ability to perform student role	Full	2(6.9)	1(6.3)	3(6.7)
Surgery	No	15(51.7)	4(25)	19(42.2)
	Yes	14(48.3)	12(75)	26(57.8)
Sling use	No	14(48.3)	3(18.8)	17(37.8)
	Yes	14(48.3)	13(81.3)	27(60)
	Did not answer	1(3.4)	0(0)	1(2.2)
Osteoporosis	No	24(82.8)	11(68.8)	35(77.8)
	Yes	5(17.2)	5(31.3)	10(22.2)

* SI = Shoulder Impingement; SP = Shoulder Pain; SS = Shoulder Stiffness; AC= Adhesive Capsulitis; C/D = Compensation/Disuse.

number of days before the shoulder symptoms started was 43 days ($SD = 25.8$). In the SPCDRF group, 13 participants (81.3%) used a sling after their DRF and the mean number of days in sling was 10 days ($SD = 8.5$). In the DRF only group, 14 (48.3%) used a sling after their DRF and the mean number of days in sling was 8 days ($SD = 8.9$).

Correlations within DRF only group

Significant negative correlations were found in the DRF only group between not having surgery and the kinesiophobia avoidance score $r_s(27) = -0.38$, $p < .05$ and between not having surgery and the kinesiophobia total score $r_s(27) = -0.40$, $p < .05$. There was a positive relationship between kinesiophobia avoidance score and pain intensity $r_s(27) = 0.43$, $p < .05$ and between the QuickDASH and the compensatory mechanism avoid activity score $r_s(27) = 0.83$, $p < .01$. There was a negative correlation between kinesiophobia harm score and compensatory mechanism used total score $r_s(27) = -0.48$, $p < .01$ (Refer to Table 2).

Correlations within SPCDRF only group

In the SPCDRF group, there was a positive relationship between QuickDASH score and pain intensity $r_s(14) = 0.59$, $p < .05$, between kinesiophobia harm score and pain intensity $r_s(14) = 0.61$, $p < .05$, kinesiophobia total score and pain intensity $r_s(14) = 0.62$, $p < .05$, compensatory mechanism total score and pain intensity $r_s(14) = 0.52$, $p < .05$, and compensatory mechanism avoid activity

Table 2
Synopsis of Mann Whitney *U* and Correlation testing; only significant findings reported.

Correlations within DRF only group			
Variables compared		Finding	Result Spearman rank correlation
No surgery	TSK-11 avoidance score and TSK-11 total score	More avoidance behaviors and fear of movement when patients did not have surgery	r_s (27) = -0.38, $p < .05$ & r_s (27) = -0.40, $p < .05$.
VAS score	TSK-11 avoidance score	More avoidance behavior when pain was increased	$r_s(27) = 0.43$, $p < .05$
QuickDASH score	Compensatory mechanism—avoid activity (# used for 5 ADL/IADL tasks)	Less function with increased activity avoidance	$r_s(27) = 0.83$, $p < .01$
TSK-11 harm score	Compensatory mechanism (total # used for 5 ADL/IADL tasks)	Less fear of harm to body with increased compensatory mechanisms	$r_s(27) = -48$, $p < .01$
Correlations within SPCDRF group			
Variables compared		Finding	Result Spearman rank correlation
VAS score	QuickDASH score	Less function with increased pain	$r_s(14) = 0.59$, $p < .05$
VAS score	TSK-11 harm score	Increased fear of harm to body when pain was increased	$r_s(14) = 0.61$, $p < .05$
VAS score	TSK-11 total Score	More fear of movement when pain was increased	$r_s(14) = 0.62$, $p < .05$
VAS score	Compensatory mechanism (total # used for 5 ADL/IADL tasks)	Increased compensatory mechanisms when pain was increased	$r_s(14) = 0.52$, $p < .05$
VAS score	Compensatory mechanism-avoid activity (# used for 5 ADL/IADL tasks)	Increased activity avoidance when pain was increased	$r_s(14) = 0.77$, $p < .01$
QuickDASH score	Compensatory mechanism-avoid activity (# used for 5 ADL/IADL tasks)	Less function with increased activity avoidance	$r_s(14) = 0.62$, $p < .05$*
QuickDASH score	TSK-11 total Score	Less function when fear of movement was increased	$r_s(14) = 0.54$, $p < .05$
Comparison between DRF only group and DRF/SPCDRF group			
Finding	Result	Z value	Effect Size
Increased pain (VAS score) in shoulder pathology group	*Mann-Whitney U* = 136.50, $p = .02$	-2.268	0.34
Increase in compensatory mechanism-activity avoidance (#used for 5 ADL/IADL tasks) in shoulder pathology group	*Mann-Whitney U* = 143.50, $p = .03$	-2.170	0.32

* Variables compared that were significant in both groups.

and pain intensity $r_s(14) = 0.77$, $p < .01$. There was also a positive relationship between the QuickDASH and the compensatory mechanism avoid activity score r_s (14) = 0.62, $p < .05$ and between kinesiophobia-total score and QuickDASH score $r_s(14) = 0.54$, $p < .05$ (Refer to Table 2).

Comparison between DRF only and SPCDRF groups

There was a significant difference in pain levels between the SPCDRF group and the DRF only group (*Mann-Whitney U* = 136.50, $p = .02$), t**he ES (0.34) of having shoulder pathology on the VAS was small**. A significant difference was observed in the number of *compensatory mechanism avoid activity* used for 5 ADL/IADL tasks (*Mann-Whitney U* = 143.50, $p = .03$) between SPCDRF group and DRF only group, t**he ES (0.32) of having shoulder pathology on the compensatory mechanism avoiding activity for 5 ADL/IADL tasks was small.** There was no significant difference between groups on the QuickDASH, TSK-11, or total # of compensatory mechanisms used for the 5 ADL/IADL tasks (Refer to Table 2).

Qualitative content data analysis

Seven female participants were interviewed. The following themes emerged from the qualitative analysis. Refer to Figure 1 for codes associated with themes.

Theme one: It's difficult to perform occupations and changes had to be made. Theme One emerged when participants described difficulties performing a variety of everyday occupations, and how adaptations or compensatory strategies were used.

Theme two: There is fear and uncertainty. Theme Two emerged when participants discussed the emotions they felt in relationship to their injury. Some participants reported feeling fearful and described themselves as cautious or tentative.

Theme three: Impact of pain. Theme Three emerged when participants described how pain impacted their recovery, or their experience with pain from their injury. All participants described having pain but at different locations and different severities, and some participants reported that they had pain with movement, with weight bearing or with use of the injured upper extremity.

Theme four: Tried to be normal, but couldn't. Theme four emerged when participants talked about the effect of their injury on their daily life. Additionally, theme four represented a feeling

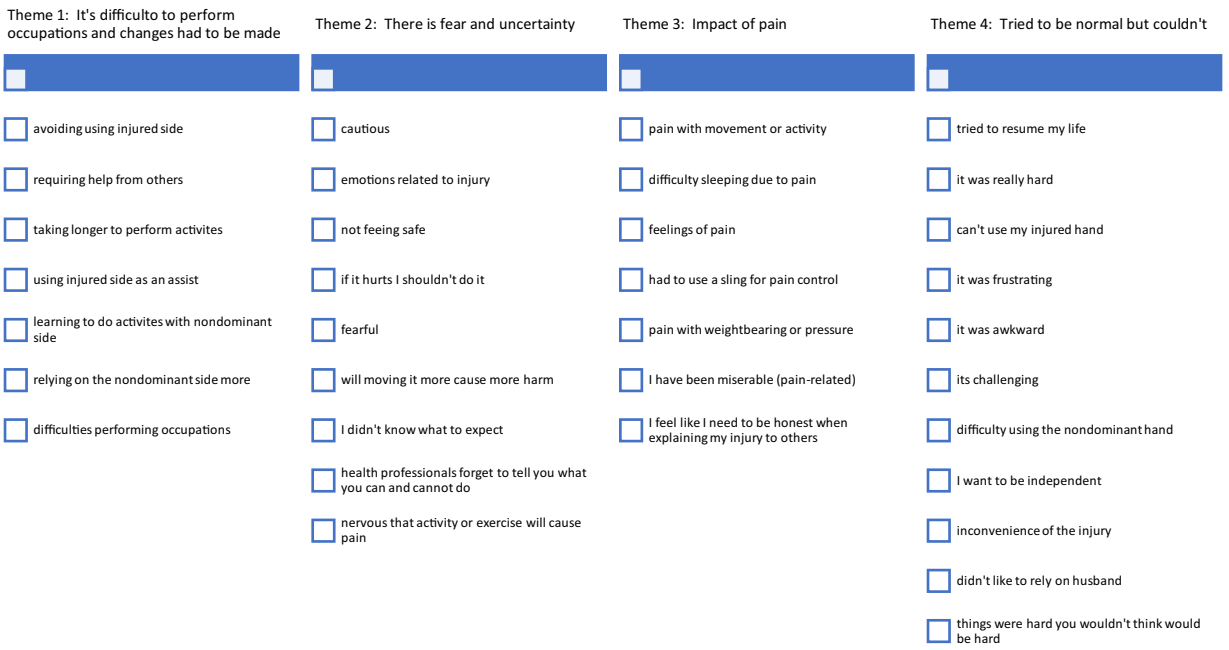

Fig. 1. Codes associated with qualitative themes.

of loss participants had; either a loss of identity and/or a loss of function. Theme four represented the theme that did not specifically relate to the four constructs of the study.

Mixed methods data analysis

Quantitative and qualitative data from the SPCDRF group were merged to gain a deeper understanding of the experience for this patient population. The quantitative and qualitative data were examined to identify how the qualitative data either coincided, elaborated, disagreed, or expanded on the quantitative findings (Refer to Table 3).

Quantitative data analysis found that increased pain correlated to worse kinesiophobia in the SPCDRF group. Qualitative data highlighted one participant's experience of kinesiophobia, *"I'm concerned about not lifting too much...I'm nervous about doing some of [my exercises], that it'll cause the pain."* Another participant described this when she reported: *"I think it's more in fear of having pain. No, just some things. I think it's more things that involve my hand and I'm concerned about not lifting too much or just I don't feel as physically out there or aggressive or normally as aggressive as I was before."* Additionally, in this group, quantitative data analysis found those individuals who had worse kinesiophobia also had worse function. One participant illuminates this finding by saying *"So, I think maybe I'm just not ready for that. Or should I keep trying that? I think that's a question I go through daily."*

Quantitative data analysis found that increased pain correlated to worse function and more use of compensatory mechanisms in the SPCDRF group. Qualitative data illuminated the quantitative results by describing how a participant couldn't perform bathing because of pain: *"I could start to do things like even with the cast on, like maybe take the shampoo cap off or something right? I couldn't do that the majority of the time because it hurt."* Other participants described how they had to compensate due to pain *"I can't really stop my life because of pain. And I have a high pain tolerance so I just change the way I do things."* Another participant described this with when she said: *"The shoulder has not let up. I can't put my (right) arm behind my back to do simple like do simple exercise like hook a bra, hair care. I have become very skilled with my left hand."*

One unexpected finding in the qualitative component was that many participants described how pain impacted their ability to sleep. Sleep is a part of daily function, and in this study, high pain was correlated with worse function in the SPCDRF group. Many participants described difficulty sleeping, having to adapt their sleep positions due to pain, and fearfulness of causing injury while sleeping. One participant described this when she said *"My shoulder and upper chest were really sore. No matter what I did. A couple of times I actually thought I had chest pain. I was terrified I'd actually lie on the side I broke, right? Other than that, lying on my back or anything else was very uncomfortable."* Another participant also described how her high pain intensity affected her ability to sleep *"But I can honestly say I have what I would describe as a chronic ache at best all day, every day. Made it impossible to sleep comfortably through a whole night. And then in addition to that, certain movements, then I would get that ax feeling here and back here. But it has been miserable. I mean, frankly, it was miserable. Degrees of misery every day. No relief from the shoulder. And I thought it's funny, I broke my wrist, the wrist is the least of it. The pain has almost all been in the shoulder."*

Discussion

This prospective study found that 36% of participants that sustained a DRF presented with shoulder pathology and of those, 75% fractured their nondominant side. This result may indicate that some participants were naturally less likely to utilize their injured side for daily activity following the DRF. Nondominance has been found to be a predictor of shoulder stiffness following operative fixation of a DRF.[4] Additionally, 75% of the participants in the SPCDRF had surgery. Thus, elements such as pain and edema following surgery may have contributed to fearfulness in moving the injured upper extremity early. In the group that developed shoulder pathology due to compensation/disuse, 70% took 7 weeks or longer for shoulder symptoms to become evident. This finding suggests that shoulder pathology may develop over time and supports the need for consistent shoulder screening during rehabilitation.

Table 3
Merged analysis of quantitative and qualitative results, SPCDRF group only; Refer to Table 2 for quantitative data.

Constructs	Quantitative analysis	Qualitative analysis
Pain/Function	Less function with increased pain as measured by correlating the VAS to the QuickDASH *(Spearman rank correlation $r_s(14) = 0.59$, $p < .05$)*	Theme 1: It's difficult to perform occupations and changes had to be made Theme 3: Impact of pain Theme 4: Tried to be normal but couldn't *"But anyways, turning the wheel too much could aggravate it because you have to hold on to it."* (Participant 1)
Pain/Kinesiophobia	More fear of movement when pain was increased as measured by correlating the TSK-11 total score to the VAS *(Spearman rank correlation $r_s(14) = 0.62$, $p < .05$)* and TSK-11 harm score to the VAS *(Spearman rank correlation $r_s(14) = 0.61$, $p < .05$)*	Theme 2: There is fear and uncertainty Theme 3: Impact of pain *"The shoulder gives me pain, but usually the exercises for it don't. The fingers don't give me pain, but the exercises do. So, when I have something that I think, "Oh, that didn't hurt. That didn't hurt. Why don't I do it again?" I don't know if that's a good idea or not."* (Participant 7)
Pain/Compensatory mechanism	Increased compensatory mechanisms when pain was increased as measured by correlating compensatory mechanism (total # used for 5 ADL/IADL tasks) to the VAS score *(Spearman rank correlation $r_s(14) = 0.52$, $p < .05$)* and compensatory mechanism avoid activity to the VAS *(Spearman rank correlation $r_s(14) = 0.77$, $p < .01$)*	Theme 1: It's difficult to perform occupations and changes had to be made Theme 3: Impact of pain *"At first it was really painful and it seemed really awkward to do anything with my left hand."* (*Participant 5*)
Function/Compensatory mechanism	Less function with increased activity avoidance as measured by correlating compensatory mechanism avoid activity to the QuickDASH *(Spearman rank correlation $r_s(14) = 0.62$, $p < .05^*$)*	Theme 1: It's difficult to perform occupations and changes had to be made Theme 4: Tried to be normal, but couldn't" *"I didn't have to cook, but I had to heat things up. I tried to slice some meat at one point, couldn't do it. The only thing I could do is eat cereal and go back to bed."* (Participant 4)
Function/Kinesiophobia	Less function when fear of movement was increased as measured by correlating the TSK-11 to the QuickDASH *(Spearman rank correlation $r_s(14) = 0.54$, $p < .05$)*	Theme 1: It's difficult to perform occupations and changes had to be made Theme 2: There is fear and uncertainty Theme 4: Tried to be normal but couldn't *"I couldn't exercise, which bothered me . . . My knees hurt. It's like if you're not regularly working out your joints and stuff…The doctor says I can exercise, but I'm kind of afraid."* (Participant 2)

To our knowledge, this is the first prospective study that specifically examined if the shoulder pathology was due to the fall ($n = 6$) or due to compensation and/or disuse ($n = 10$), and to categorize the shoulder pathology as impingement syndrome, shoulder pain, adhesive capsulitis, or shoulder stiffness. In our study, 6 participants were diagnosed with shoulder impingement. Yoo et al[39] found that when healthy subjects wore a wrist orthosis and performed assembling operations that required shoulder movement that they had significantly more muscle activity in the upper trapezius and serratus anterior than subjects with no wrist immobilization. Numerous studies report that being immobilized in a cast or wrist orthosis has the potential to cause biomechanical changes to the glenohumeral joint of the shoulder [8, 39-44] while one study has described altered scapular kinematics such as increased medial rotation, upward rotation, and anterior tipping in individuals 6-8 weeks post DRF with no wrist immobilization. [9] Although literature varies slightly on how muscle activity changes in individuals with impingement syndrome, studies support that increased upper trapezius activity [45-48] and changes in scapular kinematics such as increased anterior tipping and medial rotation are seen in individuals with shoulder impingement syndrome.[48] Additionally, evidence supports that a number of compensatory mechanisms are utilized during occupational performance following a DRF.[11] Therefore, there may be value to examining compensatory patterns when someone sustains a DRF to decrease the chance of developing subsequent shoulder pathology.

Those participants that developed shoulder pathology had significantly more pain than the DRF only group at 5-7 weeks post injury. This finding is consistent with the Cha et al[4] study that found significantly more pain in the shoulder pathology group at both 3 month and at 2 years post DRF. Cantero-Téllez et al[3] also found that shoulder pain intensity was correlated with length of wrist immobilization. While this study supports previous findings that individuals with shoulder pain concurrent with DRF experience more pain,[3-4] the correlational analysis and qualitative components of this study illuminates some factors related to this increased pain. In the SPCDRF participants, this increased pain correlated with reporting less function, increased overall kinesiophobia, and increased compensatory mechanisms. These same correlations were not found in the DRF only group indicating that SPCDRF participants with high pain intensity experience more fear of movement and greater functional problems. This fear of movement and greater functional problems were highlighted in the qualitative analysis. Thus, if the shoulder pathology is not recognized or diagnosed, then some DRF patients may struggle to resume daily activities and the reason for this struggle may not be identified or addressed.

Findings of this study suggest that individuals who had shoulder pathology concurrent with a DRF and had greater levels of pain also experienced worse function and worse fear of movement. Although our study did not find these relationships in the DRF only group, other literature shows that individuals post DRF who have high pain intensity have worse functional outcomes[14, 49-50] and worse fear of movement.[51] Therefore, the findings of this study suggest that individuals who had shoulder pathology concurrent with a DRF have very similar attributes to individuals with a DRF only that experience greater pain.

To our knowledge, this is the first study that examined the construct of kinesiophobia with this patient population. Participants in the SPCDRF group who had higher pain reported more difficulties performing daily activities, more fear of moving the injured limb and more use of compensatory mechanisms, specifically, avoiding certain activities. This represents a fear avoidance model of pain. In the fear avoidance model of pain, pain can be interpreted two

different ways: that the pain is nonthreatening and daily activity can be performed; or that pain is dangerous and activities are to be avoided.[52] When pain is misinterpreted as dangerous it can promote pain-related fear and associated safety seeking behaviors such as avoidance and hypervigilance.[52] There is value for therapists understanding the circular role kinesiophobia may play in the overall rehabilitation for this population, as kinesiophobia may contribute to nonuse, which may contribute to compensatory patterns, which may contribute to the development of shoulder pain. A more in depth study examining this variable is crucial to really understanding the impact of kinesiophobia and its role in rehabilitation for both patients with a DRF only and those that also experience shoulder pain.

An interesting finding discovered during the qualitative analysis was how sleep was negatively impacted in the SPCDRF group. Sleep plays an important role in health, overall well-being, and occupational participation.[53] In addition, poor sleep quality has been found to be related to worse hand function in patients with carpal tunnel syndrome when controlling for pain intensity and carpal tunnel syndrome severity.[54] Therefore, when performing an initial assessment or occupational profile, there may be a benefit to evaluating sleep quality.

Limitations and Future research

Limitations of this study include a small sample size, convenience sampling and multiple univariate analysis being performed. Convenience sampling makes it difficult to generalize findings about the population of individuals who experience DRFs due to the fact that all participants came from three clinics in the same geographical location. Hand surgeons recruiting their own patients could have also exhibited bias in participant selection.

Another limitation of the study was that no outcome measures were collected at baseline therefore no comparisons could be made between groups over time. The shoulder could have been injured at the time of the fall and diagnosed later making it seem like the shoulder pathology is due more to compensation/disuse rather than from the fall. This may have occurred with two participants in this study. Two participants reported to the hand surgeon that they did not have pain in the shoulder at the time of the fall but that shoulder symptoms started 3 and 4 days post injury. Those individuals were placed in the compensation/disuse category instead of the fall category.

Individuals were excluded from the study if they had any preexisting shoulder conditions or multiple injuries to the upper extremities in order to accurately distinguish those who experienced shoulder pathology due to the DRF. However, this may have limited the data set in that individuals with prior injuries may have experienced worsening shoulder symptoms and individuals with multiple injuries may have also experienced shoulder pathology. Further, participants could have developed shoulder pathology after 9 weeks.

Another limitation was that the Adelaide questionnaire was adapted from its original form. Compensatory mechanism use was applied to the five activities of daily living/instrumental activities of daily living (IADLs) on the QuickDASH instead of five meaningful ADLs identified by the individual. This was done so that compensatory mechanism use could be compared between groups. Further, participants who had a DRF only were not interviewed for the qualitative component. Therefore, direct comparisons of their experiences could not be performed and the DRF only group could have described similar experiences as the SPCDRF group. Additionally, the one male with SPCDRF was not interviewed only females were interviewed.

Further research is recommended to focus on understanding how a home exercise program for the shoulder may help prevent the development of shoulder pathology after a DRF. Future research could also include whether early screening of the shoulder post DRF may be effective in early treatment and recovery of shoulder pathology post DRF. The effectiveness of patient education after fracture could also be an additional area of research. Handouts or a website explaining safe use of an injured wrist after DRF may assist individuals in using fewer compensatory mechanisms and having less kinesiophobia. Patient education on what overuse of a shoulder looks or feels like (ie, shoulder shrugging or pain in the shoulder) may prevent shoulder pathology from occurring or assist in early diagnosis. There would also be benefit to a longitudinal study that follows individuals post DRF to see when shoulder pathology symptoms start, and if having surgery, injuring the dominant side, length of time in a sling, length of time wrist is immobilized, range of motion of the wrist, or the severity of the fall is related to specific outcomes. Finally, another study examining the relationship between DRFs, sleep, pain intensity, and occupational performance may be beneficial.

Conclusions

This study described the population who experienced shoulder pathology concurrent with a DRF. Protocols for treatment of DRFs should include screening the shoulder throughout the rehabilitation process so that these individuals can be identified early. Individuals with shoulder pathology concurrent with a DRF may present with higher pain levels and avoid activity more. In addition, they may describe fearfulness in using their injured upper extremity especially if they have high levels of pain. It may be beneficial to include activities which encourage use of the injured upper extremity and shoulder exercises such as periscapular strengthening in rehabilitation programs for individuals post DRF.

Declaration of competing interest

No authors in this study have any conflicts of interest to report.

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Appendix A. The compensatory section of the Adelaide questionnaire

Have you changed the way that you perform the activities listed? If you do the activity in the exact same way as you did before your wrist injury, circle "no." If you have changed the way that you do an activity circle, circle "yes" and specify the way you have changed. Below is a list of compensatory mechanisms that have been mentioned by other wrist injured patients. Circle all that apply.

Activities come from the QuickDASH.

1. Open a tight or new jar
   No Yes
   a. Avoid activity

b. Do activity with both hands
c. Hold jar between knees
d. Take rest breaks
e. Use a wrist brace when doing the activity
f. Do activity with one hand
g. Change the way I lift or grip
h. Take longer to perform the activity

2. Do heavy household chores (eg, wash wall, floors)
No Yes
a. Avoid activity
b. Do activity with both hands
c. Take rest breaks
d. Use a wrist brace when doing the activity
e. Do activity with one hand
f. Change the way I lift or grip
g. Take longer to perform the activity

3. Carry a shopping bag or briefcase
No Yes
a. Avoid activity
b. Do activity with both hands
c. Take rest breaks
d. Use a wrist brace when doing the activity
e. Do activity with one hand
f. Change the way I lift or grip
g. Take longer to perform the activity

4. Washing your back
No Yes
a. Avoid activity
b. Do activity with both hands
c. Take rest breaks
d. Use a wrist brace when doing the activity
e. Do activity with one hand
f. Change the way I lift or grip
g. Take longer to perform the activity

5. Use of knife to cut food
No Yes
a. Avoid activity
b. Do activity with both hands
c. Take rest breaks
d. Use a wrist brace when doing the activity
e. Do activity with one hand
f. Change the way I lift or grip
g. Take longer to perform the activity

Appendix B. Qualitative interview

Broad questions

- What is the lived experience of having shoulder pathology at the same time as a DRF?
- What is it like living with your injury?

Detailed subquestions, based on the four constructs that guided this study

- Has your injury affected your ability to perform the activities that you do everyday? If so, how?
- Has your injury affected your ability to fulfill your roles with family, community, or other groups? If so, how?
- Has your injury affected your ability to perform your job? If so, how?
- Can you describe how you feel when you try moving or using your injured arm?
- Do you have pain? If so, can you describe your pain? How does pain effect your day? How does pain effect your ability to do what you need or want to do?
- How have you had to change the way you do things since your injury? If so, can you describe what has been different or how you have had to change how you do things?

Appendix C. Demographic questionnaire

1. What was the date of your injury? _____

2. What side did the fracture occur? Please circle

Right Left

3. What side is your dominant side?

Right Left

4. What is your age? _____

5. What is your gender? Please circle

Male Female

6. What is your race? Please circle

Caucasian African American Hispanic Other

7. If Other Please Specify _____

8. Do you have a willing and able caregiver providing assistance to you at this time? Please circle

Yes No

9. What is your productive role at this time? Please circle all that apply and rate the ability to perform each role

Paid Employment	Full	Modified	Unable to Perform
Homemaker	Full	Modified	Unable to Perform
Volunteer	Full	Modified	Unable to Perform
Student	Full	Modified	Unable to Perform

10. Did you have surgery? Please circle

Yes No

11. Did you use a sling? Please circle

Yes No

12. Approximately how many days did you use the sling? _____

Have you been diagnosed with osteoporosis? Please circle

Yes No

13. How has your injury impacted your activities of daily living?

Appendix D. Hand surgeon shoulder diagnosis and injury categorization criteria

Criteria for shoulder pathology diagnosis

Shoulder pain- Criteria included a report of pain in the shoulder at rest and/or with shoulder motion.

Shoulder stiffness- Criteria included observation by the hand surgeon of restriction of glenohumeral joint motion when compared to the noninjured shoulder.

Adhesive capsulitis- Criteria included limited glenohumeral joint motion with both active range of motion and passive range of motion especially in external rotation and complaints of high pain when passively moving the glenohumeral joint.

Impingement syndrome- Criteria included presence of positive Neer impingement test and/or Hawkins Kennedy impingement test and weakness during manual muscle testing to the rotator cuff muscles.

Criteria to categorize shoulder pathology as due to fall or compensation/disuse

To identify if the shoulder pathology was the result of the fall, the hand surgeon interviewed the participant to learn if he or she had pain at the shoulder at initial evaluation due to the fall. Those that met that criteria were categorized as shoulder pathology due to fall.

To identify if the shoulder pathology was or due to compensation/disuse, the hand surgeon interviewed the participant to learn if the shoulder pathology had occurred over time and/or if the participant was avoiding using the injured upper extremity. Those that met those criteria were categorized as shoulder pathology due to compensation/disuse.

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1. The study design is
   a. prospective cohort
   b. case series
   c. mixed methods
   d. RCTs

2. Quantitative data were derived from the
   a. QuickDASH
   b. DASH
   c. Mayo Hand-Wrist-Shoulder Survey
   d. Sydney Shoulder Questionnaire

3. Regarding onset of shoulder complaints
   a. none of the shoulder problems presented at the time of the fall
   b. all shoulder problems were noted at the time of the fall
   c. a greater % of participants developed shoulder problems at the time of the fall
   d. a greater % of participants developed shoulder problems after the fall

4. The average time it took to develop secondary shoulder complaints was approximately
   a. 6 months
   b. 2 months
   c. 45 days
   d. 25 days

5. It is common for patients with concomitant DRFx and shoulder problems to be fearful of participating in activities
   a. not true
   b. true

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