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Does the Timing of the Initiation of Physical Therapy Post-Rotator Cuff Repair Impact Shoulder Function?

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ABSTRACT

Background: Rehabilitation typically restores shoulder function after a common rotator cuff repair; however, it is unclear when to initiate physical therapy (PT) post-surgery. To understand effective start times, this study analyzed PT start times and their effect on shoulder function. The most effective shoulder outcomes were hypothesized to occur when PT started 0–4 weeks post-surgery.

Methods: Data from 1002 patients who underwent rotator cuff repair were analyzed retrospectively from 52 outpatient clinics in the years of 2016–2021. The primary data of timings between surgery and the start of PT (0–2 weeks [0–14 days], 2–4 weeks [15–28 days], 4–6 weeks [29–42 days], and 6–14 weeks [43–100 days]), change in functional shoulder scores, number of PT visits utilized, and functional scores changed per visit were analyzed. Regression analyses of the impact of age, sex, payor source, and tear size were completed.

Results: The change in functional scores and functional scores changed per visit are not affected by the initiation timing of PT post-rotator cuff surgery, when controlling for baseline functional scores. This result is revealed despite initial functional scores being significantly different. Functional scores change per visit may have been affected by payor source ($R^2 = 0.004$, $p \leq 0.010$). PT start times may have been impacted by age ($R^2 = 0.010$, $p = 0.007$), payor source ($R^2 = 0.016$, $p = 0.001$), and tear size ($R^2 = 0.007$, $p = 0.026$). Payor source may have influenced the number of PT visits ($R^2 = 0.060$, $p < 0.001$).

Conclusions: After rotator cuff surgery, patients should choose to complete rehabilitation to optimize shoulder function. However, the initiation timing of PT may not affect functional shoulder outcomes.

1 | Introduction

To restore shoulder function after a tendon tear, rotator cuff repair is typically performed in as many as 30% of the United States population older than 60 years and about 60% of the population older than 80 years [1, 2]. This common surgery incurs a cost greater than $7 billion annually in the US alone [1–3]. Moreover, the post-surgery period involves a lengthy rehabilitation program to completely restore shoulder function [4], but the most effective time to start physical therapy (PT) is unclear [4–7]. Lack of sufficient shoulder function can lead to impaired shoulder use for daily activities.

Impaired shoulder use can lead to a tendon retear in 20%–60% of individuals [1–3] and require a revision rotator cuff surgery [8]. Rotator cuff tendon retears usually occur within the first 19 weeks after surgery [3, 8–10], which is the period that frequently coincides with patients' PT. However, there are limited

Abbreviations: FOTO, Focus on Therapeutic Outcomes Inc.; FS, FOTO Upper Extremity Functional Status; PT, physical therapy.

evidence-based guidelines for when to initiate PT post-surgery or protocols for specific treatment modalities to protect the healing shoulder tendons [3, 6, 7, 11].

Several clinical factors related to the patient, surgery, and the specific PT treatments can contribute to a rotator cuff repair success or failure. Some patient-related factors include a patient's physical function such as presurgery shoulder motion [12, 13], muscle quality [14], and preoperative fatty tissue presence [8, 12], and smoking [15, 16]. Patient co-morbidities such as diabetes [17, 18] or osteoporosis [19, 20] may negatively impact rotator cuff repair outcomes. Other patient-related factors could be social determinants of health (e.g., payment source [21] and clinic access). Additionally, surgery-related factors can include complicated repair methods [8, 9, 12] and the need for major reconstructive procedures [12]. Specific exercises and timing of the initiation of shoulder motion [11, 22, 23] may play a role, which is important since these patients spend months in PT as compared to 1 day of surgery. However, scientific evidence is inconclusive about the effectiveness of conservative or accelerated rehabilitative care [4, 11, 24].

To improve patients' clinical outcomes and to efficiently use rehabilitative care after rotator cuff repair, clinical factors and protocols should be investigated. However, there is a paucity of evidence about the most effective PT protocol after rotator cuff repair [5, 11]. We investigated the optimal time to initiate PT after rotator cuff repair surgery and whether the timing influenced patients' shoulder function. It was hypothesized that PT should start within 0 to 4 weeks post-surgery to gain the most effective shoulder function.

2 | Materials and Methods

A retrospective observational analysis was completed with data collected from Focus on Therapeutic Outcomes Inc. (FOTO) and patient electronic health records. Data was provided by a national outpatient PT clinic group of 52 clinics. The study was approved by the lead author's university Institutional Review Board for ethics and given exempt status. This study conforms to all STROBE guidelines and reports the required information accordingly. For this study, 1111 electronic medical records were extracted of patients who had rotator cuff repair.

The study included patients who had rotator cuff repair surgery and completed a series of PT sessions postoperatively. A series of PT included a case with an intake FOTO Upper Extremity Functional Status (FS) score, at least one follow-up FS score, and a closed electronic chart. Patients who started PT later than 98 days were excluded because rehabilitation is typically started before 98 days post-surgery. This exclusion criteria reduced the data set to 1002 patients. Incomplete data sets of the primary variable reduced the data to a range of 768–790. The data set included patients who had rotator cuff surgery between October 2016 to June 2021.

The primary variables included: (1) timings between surgery and the start of PT, (2) the change in functional shoulder scores [25] (final score minus baseline score), (3) the number of PT visits completed, and (4) the change in functional scores per visit. To understand the change in functional scores per visit, the following calculation was utilized: final shoulder functional score divided by the total number of PT visits. Additionally, timings between surgery and the start of PT were categorized in (0–2 weeks [0–14 days], 2–4 weeks [15–28 days], 4–6 weeks [29–42 days], and 6–14 weeks [43–100 days]) to provide a specific guideline for starting PT. Timing between surgery and the start of PT was categorized according to the typical weekly timeframes for PT progression [8, 10].

Confounding (independent) variables were collected for each patient: demographics (age, sex), payor source, and tear size. There were a variety of 12 payor sources and only the primary insurance of each patient was provided in the data set. The payor sources were organized into four categories: Workman's Compensation, indemnity, or automobile insurance, government insurance (Medicare or Medicaid), other insurance or patient pays, and commercial insurance. Tear size was collected from the electronic chart by research clinicians. Tear size was organized into the three categories: tendon tear < 3 cm, tendon tear > 3 cm or unknown tear size. Tear sizes < 3 cm are considered small to medium, and tear sizes > 3 cm are considered large [26–29]. Tear sizes were categorized as stated because patients with larger tendon tears [14] or major reconstructive repairs [12] are not expected to have the best postsurgical outcomes. The number of different surgeons and therapists involved in each patients' care was unknown. The patients' cigarette uses and co-morbidities such as diabetes and osteoporosis were unavailable to the authors.

To determine shoulder function, the FOTO Upper Extremity Functional Status (FS) test was utilized [30]. This 53-item list is a computerized adaptive test that provides an understanding of a patient's perceived physical abilities [25]. Patients self-report their abilities on a scale of 0 (low functioning) to 100 (high functioning) [25]. The test has an internal consistency reliability of $\alpha = 0.99$ [25]. The test includes five stages which indicate a patient's level of disability: "stage 1 (scores 0–24) has exceedingly limited shoulder function, stage 2 (scores 25–43) has poor shoulder function, stage 3 (scores 44–59) has fair shoulder function, stage 4 (scores 60–80) has good shoulder function, and stage 5 (scores 81–100) has excellent shoulder function" [30]. Examples of shoulder function include the ability to dress or bathe, to perform household chores, to perform work or sports, and so forth.

All statistical analyses were performed using the Statistical Package for the Social Sciences software (SPSS) version 27.0 (IBM Corp). The pre-determined level of significance was $p < 0.05$. Data analysis investigation included correlations and differences among shoulder function scores, the number of PT visits completed, and the timing to initiation PT post-surgery with a 95% confidence interval for means. Confounding (independent) variables were investigated as well (age, sex, payor source, and tear size). Levene's tests for homogeneity of variances were not significant for the following variables among the four PT start times: (1) change in functional score (F [3,786] = 0.347, $p = 0.791$); (2) the number of PT visits completed (F [3,764] = 0.7, $p = 0.533$); and (3) the change in functional scores per visit (F [3,639] = 0.994, $p = 0.395$). Therefore, parametric analyses were used. Baseline functional scores were controlled in the analysis.

An ANOVA test was completed to compare differences in the timing categories (0–2 weeks [0–14 days], 2–4 weeks [15–28 days], 4–6 weeks [29–42 days], and 6–14 weeks [43–100 days]). A linear regression analysis was used to understand the influence of age, sex, payor source, and tear size had on change in functional shoulder scores, number of PT visits utilized, and functional scores changed per visit.

3 | Results

Descriptive statistics are available in Table 1 for three primary variables of shoulder functional scores (baseline, final, and change in score), the number of PT visits used, functional shoulder score change per PT visit (final score divided by visit), and secondary variables. The number of patients for each rehabilitation phases initially was 1002 patients, however, missing data for the primary variables reduced the data analyzed for each primary variable. Completed data set numbers were: 790 patients for the change in shoulder functional scores, 768 patients for the number of PT visits used, 643 patients for the functional shoulder score change per PT visit.

Primary analyses included a one-way ANOVA and baseline functional shoulder scores were controlled. There were no significant differences among the PT start times for the change in functional scores ($p = 0.302$) and change per visit scores ($p = 0.910$) when baseline functional scores were controlled. See Table 2 for the detailed results. Baseline scores were controlled because those outcomes were significantly different ($F = 9.54$, $p < 0.001$) among the PT start times. However, final functional scores were not significant different ($F = 1.335$, $p = 0.262$) among PT start times. The number of PT visits utilized between the four timings was statistically significant ($p < 0.001$) between 0 and 2 weeks and 2–4 weeks, and 4–6 weeks, and 6–14 weeks (Table 3). The following tables provide details about the test statistic, effect size, and mean difference.

Regression analyses of the following independent variables were completed: sex, age, payor source, and tear size (Table 4). Sex did not significantly impact the change in functional shoulder scores, the number of PT visits, and the timing of PT post-surgery, and functional shoulder score change per PT visit. Age did not impact the change in functional shoulder scores ($p = 0.275$), and the number of PT visits post-surgery ($p = 0.292$), and functional

TABLE 1 | Descriptive statistics of primary and secondary variables.

Primary variables: Patient shoulder function scores and physical therapy visits						
Rehabilitation phase		**Baseline functional scores**	**End of care functional scores**	**Change in functional score**	**Number of PT visits**	**Functional change per visit**
0–2 weeks (0–14 days)	Mean	23.237	61.754	39.015	26.246	1.756
	N	406	333	333	325	275
	Std. deviation	15.627	13.357	18.877	16.505	1.526
2–4 weeks (15–28 days)	Mean	32.873	63.138	30.504	24.050	1.464
	N	267	232	232	219	196
	Std. deviation	15.897	13.524	18.011	14.094	1.692
4–6 weeks (29–42 days)	Mean	37.058	64.594	27.208	24.086	1.319
	N	137	106	106	105	84
	Std. deviation	14.075	12.466	17.742	15.146	1.195
6–14 weeks (43 days–100 days)	Mean	44.723	62.731	19.252	19.286	1.257
	N	166	119	119	119	88
	Std. deviation	11.597	14.287	16.176	13.391	1.909
Secondary variables – Age, sex, payor source, tear size						
Age						Mean 57.60 ± 11.63 years old
Sex						440 females
						562 males
Payor source						104 work/auto
						263 Medicare/Medicaid
						221 other/patient paid
						414 commercial
Tear size						353 tear < 3 cm
						346 tear > 3 cm
						303 unknown tear size

Abbreviation: PT, physical therapy.

TABLE 2 | Initiation of physical therapy post-surgery versus functional shoulder score ANOVA, Bonferroni comparison.

Rehabilitation phase	Functional score	Overall *F*-value (*p*-value)	Effect size (partial η^2)	Mean difference	Standard error	*p*-value ($\alpha = 0.05$)
0–2 weeks (333 patients) *vs.* 2–4 weeks (232 patients)	Change in functional score	1.217 (0.302)	0.005 (small)	0.357	1.164	1.000
0–2 weeks (275 patients) *vs.* 2–4 weeks (196 patients)	Change in score per visit	0.181 (0.910)	0.001 (small)	−0.015	0.148	1.000
0–2 weeks (333 patients) *vs.* 4–6 weeks (84 patients)	Change in functional score	1.217 (0.302)	0.005 (small)	−0.281	1.533	1.000
0–2 weeks (333 patients) *vs.* 4–6 weeks (84 patients)	Change in score per visit	0.181 (0.910)	0.001 (small)	0.003	0.198	1.000
0–2 weeks (333 patients) *vs.* 6–14 weeks (119 patients)	Change in functional score	1.217 (0.302)	0.005 (small)	2.646	1.543	0.521
0–2 weeks (333 patients) *vs.* 6–14 weeks (88 patients)	Change in score per visit	0.181 (0.910)	0.001 (small)	−0.139	0.204	1.000
2–4 weeks (232 patients) *vs.* 4–6 weeks (106 patients)	Change in functional score	1.217 (0.302)	0.005 (small)	−0.638	1.546	1.000
2–4 weeks (196 patients) *vs.* 4–6 weeks (84 patients)	Change in score per visit	0.181 (0.910)	0.001 (small)	0.018	0.200	1.000
2–4 weeks (232 patients) *vs.* 6–14 weeks (119 patients)	Change in functional score	1.217 (0.302)	0.005 (small)	2.289	1.518	−1.727
2–4 weeks (196 patients) *vs.* 6–14 weeks (88 patients)	Change in score per visit	0.181 (0.910)	0.001 (small)	−0.124	0.200	1.000
4–6 weeks (106 patients) *vs.* 6–14 weeks (119 patients) (88 patients)	Change in functional score	1.217 (0.302)	0.005 (small)	2.927	1.764	0.585
4–6 weeks (84 patients) *vs.* 6–14 weeks	Change in score per visit	0.181 (0.910)	0.001 (small)	−0.143	0.234	1.000

Abbreviation: PT, physical therapy.

TABLE 3 | Initiation of physical therapy post-surgery versus number of PT visits ANOVA, Bonferroni comparison.

Rehabilitation phase	Overall *F*-value (*p*-value)	Effect size (partial η^2)	Mean difference	Standard error	*p*-value ($\alpha = 0.05$)
0–2 weeks (325 patients) *vs.* 2–4 weeks (219 patients)	6.114 (< 0.001)	0.023 (small)	2.196	1.329	0.593
0–2 weeks (325 patients) *vs.* 4–6 weeks (105 patients)	6.114 (< 0.001)	0.023 (small)	2.160	1.707	1.000
0–2 weeks (325 patients) *vs.* 6–14 weeks (119 patients)	6.114 (< 0.001)	0.023 (small)	6.960	1.629	< 0.001*
2–4 weeks (219 patients) *vs.* 4–6 weeks (105 patients)	6.114 (< 0.001)	0.023 (small)	−0.035	1.805	1.000
2–4 weeks (219 patients) *vs.* 6–14 weeks (119 patients)	6.114 (< 0.001)	0.023 (small)	4.765	1.731	0.036*
4–6 weeks (105 patients) *vs.* 6–14 weeks (119 patients)	6.114 (< 0.001)	0.023 (small)	4.800	2.036	0.112

Abbreviation: PT, physical therapy.
*Significant result.

shoulder score change per PT visit ($p = 0.200$). However, age may have influenced the timing of PT post-surgery ($p = 0.007$). Specifically, time to initiation of PT was higher by 0.008 weeks for a 1-year age difference. However, this effect only explained a small amount of the variance in time to initiation of PT ($R^2 = 0.010$, $p < 0.007$). Payor source did not affect the change in functional shoulder scores ($p = 0.427$). However, payor source may have impacted the number of visits ($p < 0.001$), the timing of PT post-surgery ($p = 0.001$), and the functional shoulder score change per PT visit ($p = 0.003$). Similar to the effect of age on initiation of PT, payor source explained only a small amount of the variance in PT visits utilized ($R^2 = 0.060$, $p < 0.001$), the timing of PT ($R^2 = 0.016$, $p = 0.001$), and the functional shoulder score change per PT visit ($R^2 = 0.021$, $p = 0.003$). Tear size did not impact the change in functional shoulder scores ($p = 0.812$), the number of PT visits ($p = 0.520$), and the functional shoulder score change per PT visit ($p = 0.196$). However, there was an effect on the timing of PT ($p = 0.026$). Tear size explained only a small amount of the variance in the timing of PT ($R^2 = 0.007$, $p < 0.026$). The numbers reduced from initial collection to analyses due to missing data. There were 12 different payor sources for the data set but reduced to four categories as mentioned in Section 2.

4 | Discussion

When compared to other timings, the 0–4 weeks' timing category revealed the highest significant functional shoulder score change per PT visit. The change in functional scores of the 0–2 weeks' timing category were 12–20 points higher than the scores of 4–6 week and 6–14 week timing categories. The change in functional scores of the 2–4 weeks' timing category were 11 points higher than the scores of 6–14 week timing category. These scores exceeded the minimal clinically important improvement score for the shoulder, which is 8 [30, 31]. This result indicates that starting PT early leads to the best shoulder function improvement. Similar findings are reported by other researchers, who found that early range of motion (ROM) therapy provided accelerated recovery of postoperative stiffness with small to medium rotator cuff tears [11].

The number of PT visits completed pertaining to each of the four timing categories was significant when the early timing categories were compared to the later timing categories. Patients had an average of 24 visits among the four PT start times. The outcomes showed a small effect size; therefore, the results do not clearly imply that starting PT early will cause a patient to use more PT after rotator cuff surgery. These results suggest that patients will use a similar number of visits whether PT is started early or later post-surgery.

Sex and age had little influence on the primary outcomes. Sex did not significantly impact the change in functional shoulder scores, the number of PT visits, and the timing of PT post-surgery, and functional shoulder score change per PT visit. These results indicate that sex [32] did not play a role in either the patients' functional recovery or their ability to utilize PT. This outcome contrasts with what has been reported in previous literature [8, 12]. Post-surgery, age did not significantly impact the change in functional shoulder scores, the number of

TABLE 4 | Regression analysis of outcomes (change in functional score, PT visits, PT timing, functional change per visit).

Independent variable	N	R^2 value	Unstandardized coefficients (β-value)	p-value ($\alpha = 0.05$)
Age	*N* (mean age)			
Change in functional score	790 (57.69 ± 11.65 years old)	0.006	−0.065	0.275
Number of PT visits	768 (57.45 ± 11.79 years old)	0.021	−0.050	0.292
PT timing	1002 (57.60 ± 11.63 years old)	0.010	0.008	*0.007
Functional change per visit	643 (57.70 ± 11.81 years old)	0.003	−0.007	0.200
Sex				
Change in functional score	346 females, 444 males	0.006	−2.143	0.124
Number of PT visits	331 females, 437 males	0.021	0.530	0.634
PT timing	440 females, 562 males	0.010	0.119	0.093
Functional change per visit	278 females, 365 males	0.0001	−0.015	0.910
Payor source				
Change in functional score	87 work/auto	0.004	−2.872	0.427
	210 Medicare/Medicaid		−0.412	
	188 other/patient paid		1.267	
	305 commercial		0	
Number of PT visits	77 work/auto	0.060	12.226	*< 0.001
	200 Medicare/Medicaid		−0.947	
	189 other/patient paid		2.215	
	302 commercial		0	
PT timing	104 work/auto	0.016	−0.245	*0.001
	263 Medicare/Medicaid		0.170	
	221 other/patient paid		0.217	
	414 commercial		0	
Functional change per visit	66 work/auto	0.021	−0.699	*0.003
	169 Medicare/Medicaid		0.062	
	171 other/patient paid		0.124	
	237 commercial		0	
Tear size				
Change in functional score	277 tear < 3 cm	0.001	−1.073	0.812
	273 tear > 3 cm		−0.791	

(Continues)

TABLE 4 | (Continued)

Independent variable	N	R^2 value	Unstandardized coefficients (β-value)	p-value (α = 0.05)
	240 unknown tear size		0	
Number of PT visits	281 tear < 3 cm	0.002	−1.182	0.520
	256 tear > 3 cm		0.230	
	231 unknown tear size		0	
PT timing	353 tear < 3 cm	0.007	< 0.001	*0.026
	346 tear > 3 cm		0.199	
	303 unknown tear size		0	
Functional change per visit	232 tear < 3 cm	0.005	−0.251	0.196
	219 tear > 3 cm		−0.249	
	192 unknown tear size		0	

Abbreviation: PT, physical therapy.
*Significant result.

PT visits, and functional shoulder score change per PT visit. However, age may have mildly influenced the timing of PT post-surgery. Younger patients participated in PT earlier in this study, but this result had a small effect size.

Previous literature has generally demonstrated that increased age [12, 33], sex (males) [12], and larger tear sizes [8, 33, 34] lead to repeat rotator cuff tendon tears of the same arm. Moreover, surgeons often refer older patients to earlier rehabilitation to prevent loss of motion, but delay rehabilitation referral in younger patients because of re-tear concerns. This study revealed that when younger patients started PT sooner, they appeared to achieve better shoulder function. This finding may suggest that clinicians should consider holistically whether younger patients should start PT sooner. Additionally, tear size was not a predictor of shoulder function in our population. However, tear size demonstrated a small effect on the timing of PT. This finding is in line with previous reports that a larger cuff tear could cause a higher retear rate [11]. Our assessment of tear size may have been limited by our dichotomized variable of greater than or less than 3 cm as opposed to more specific categories of tear sizes.

Payor source may have influenced the number of PT visits, the timing of PT, and the functional shoulder score change per PT visit. As the effect size was small, this result is likely of minimal clinical importance [31, 35]. There were 12 primary payor sources (Medicare to Commercial Insurances), and this variance does not indicate a specific insurance impacted the timing of PT post-surgery.

The study outcomes cannot reflect all factors that can influence shoulder function post rotator cuff surgery and timing to initiation of PT may not be the only factor. All possible variables were not available to the authors for this study's data set. Patient social situations could impact some patients' ability to attend PT promptly after surgery (e.g., needing to be a caregiver, other work commitments, and/or the patient not being able to afford transportation to their clinic of choice). Co-morbidities or other patient lifestyle factors (e.g., osteoporosis [19, 20], diabetes [17, 18], and nicotine use [15, 16]) could have been linked as possible factors limiting these patients' shoulder function and not the timing of PT post-surgery. It is possible there was sample selection bias [36, 37] because one PT organization owned the studied 52 outpatient clinics which could be a geographical limitation. Although the diversity of care from multiple licensed PT providers may reflect the diversity of care provided across the United States (US). The licensed PTs likely adjusted care as needed depending on the patient's needs which is an uncontrolled variable, but a diversity with care across the United States. Unfortunately, there are many factors, and the relative influence of such factors is unknown because very few studies describe the intersection of how these factors and especially rehabilitation factors predict shoulder function. Even with these limitations, the large sample size demonstrates rehabilitation still may play an important role since the recovery time from a rotator cuff repair includes a lengthy PT regime and patients typically retear during the rehabilitation period [8, 10].

5 | Conclusion

The timing of post-rotator cuff surgery PT may not affect functional shoulder score outcomes. The study results may help surgeons and physical therapists consider rehabilitation to improve shoulder function, but PT timing may not be a limiting factor on function post-surgery. Not obtaining adequate shoulder function could lead to retear and the need for a revision rotator cuff repair. Future studies will consider the intersection between PT timing and co-morbidities associated with patients who have repeat rotator cuff tears. In conclusion, this study provided healthcare providers a guideline to not consider the timing to initiate PT post-surgery to gain adequate patient shoulder function.

Author Contributions

Berrios Barillas analyzed the data and prepared the first draft of the manuscript, participated in the conception and design of the study, participated in data organization and supervised the study throughout. Both authors constructively revised the manuscript and share authorship. All authors commented on previous versions of the manuscript and approved the final version.

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Ethics Statement

The study protocol was approved by the Ethics Committee of the University of Pittsburgh (STUDY21010199), and it was compliant with the Helsinki Declaration of 1975, as revised in 2008.

Consent

The authors have nothing to report.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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