



# Effects of slow and accelerated rehabilitation protocols on range of motion after arthroscopic rotator cuff repair

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**Objective:** The aim of the study was to investigate the effects of the early initiation of passive and active range of motion exercises following arthroscopic rotator cuff repair.

**Methods:** The study included 40 patients who underwent arthroscopic rotator cuff repair. Patients were quasi-randomly assigned into accelerated (ACCEL) protocol (n=19) and slow (SLOW) protocol (n=21) groups. Patients in both groups were treated with the same protocol. Active range of motion was begun at the 3<sup>rd</sup> week in the ACCEL group and the 6<sup>th</sup> week in the SLOW group. Range of motion was recorded at postoperative weeks 3, 5, 8, 12, and 24.

**Results:** While active range of motion for all measurements improved across weeks, there were no differences between groups, with the exception of active total elevation which was greater at all time point measurements in the ACCEL group (p<0.05).

**Conclusion:** The early initiation of passive and gentle controlled active motion exercise following rotator cuff repairs does not appear to affect range of motion in the first 6 postoperative months.

**Key words:** Exercise; manual therapy; rehabilitation; rotator cuff.

The indication for surgical treatment of rotator cuff tear is a documented partial or full-thickness tear that has not responded to conservative treatment and produces symptoms that interfere with the patient's normal functioning.<sup>[1]</sup> Postoperative rehabilitation goals for patients are to decrease pain, increase range of motion (ROM) and return to normal functional activities at the earliest time while preventing rerupturing of the repaired tissues.

Controlled and gradually increased loading of movements and exercises are prerequisites for optimal tendon healing.<sup>[2]</sup> Collagen that is stressed regains its forma-

tion and tensile strength better than collagen that is not stressed.<sup>[3]</sup> Recent literature suggests that a period of immobilization improves the quality of rotator cuff tendon healing.<sup>[4-6]</sup> Peltz et al. reported detrimental effects on passive shoulder mechanics of immediate postoperative passive motion in an animal model and speculated that decreased ROM and increased joint stiffness are caused by increased scar formation in the subacromial space due to passive motion.<sup>[5]</sup> However, others have suggested that active ROM should not be initiated until the 6<sup>th</sup> postoperative week and emphasized the importance of

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passive ROM exercises within the limitation of the healing tissues and pain in the first week after rotator cuff repair.<sup>[7-9]</sup> Passive ROM exercises initiated the first day after surgery followed by active ROM exercises at the 4<sup>th</sup> week was found to have no adverse effects.<sup>[10]</sup>

These contrasting findings indicate that postoperative care is not definitive, as it is unknown if earlier motion is detrimental or beneficial to the postoperative goal of reduced pain and improved function. Therefore, the aim of this study was to determine and compare the effects of an early rehabilitation protocol on ROM and function following arthroscopic rotator cuff repair.

### Patients and methods

Forty-eight subjects with Stage 2 or 3 rotator cuff tear as determined by MRI<sup>[11]</sup> who underwent arthroscopic rotator cuff repair for a full-thickness tear were included in the study. Patients presenting with a central nervous system disorder (n=1) or a peripheral nerve disorder (n=3), who were not willing to cooperate with the rehabilitation duration (n=1) or who self-reported psychological disorder (n=1) were excluded. All the patients had non-traumatic degenerative tears.

Excluding two other patients lost to follow-up, the remaining 40 patients who underwent arthroscopic rotator cuff repair and were referred for rehabilitation by a single orthopedic surgeon to the Sports Physiotherapy Unit were enrolled in this study. Of these, 29 subjects were recruited directly from a previous study by Düzgün et al.<sup>[11]</sup> and 11 from the Sports Physiotherapy Unit (Fig. 1).

Written informed consent (Hacettepe University Ethics Committee; FON 05/15-30) was obtained from all patients. Both rehabilitation protocols, including all possible risks and potential advantage were explained in detail to patients following surgery.

Patients were quasi-randomly assigned to one of the two groups based on their year of enrollment in the study. The 19 patients presenting in the 1<sup>st</sup> year were placed in the accelerated (ACCEL) protocol group (17 females, 2 males) and the 21 in the 2<sup>nd</sup> year were placed in the slow (SLOW) protocol group (17 females, 4 males). Surgery was performed according to the procedure described by Düzgün et al.<sup>[11]</sup> The orthopedic surgeon with 19 years of experience was blinded to the rehabilitation protocol until the end of the study.

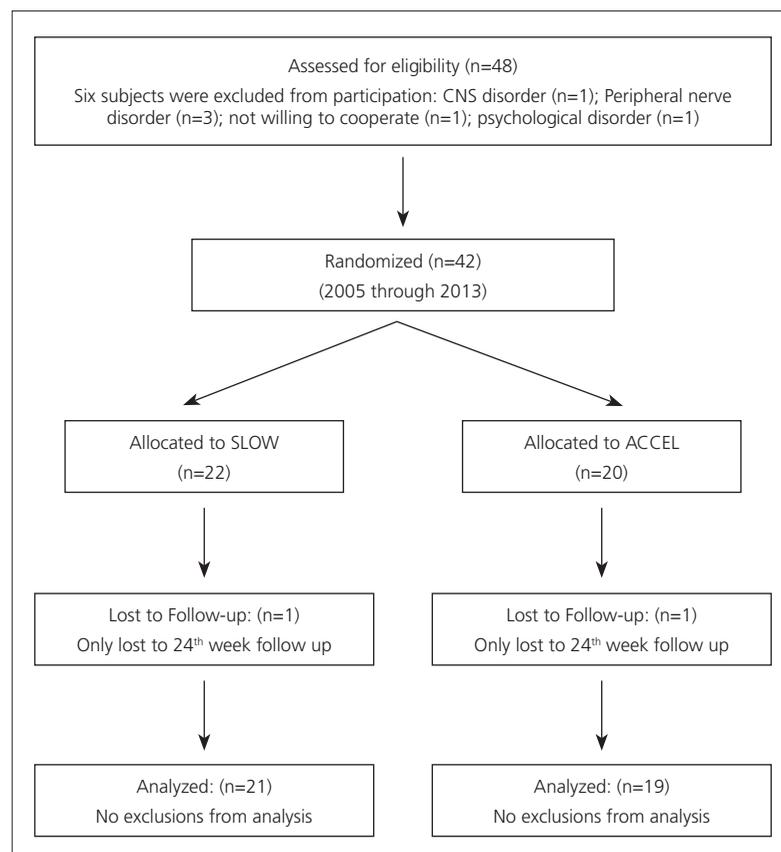


Fig. 1. Flowchart diagram.

**Table 1.** Physical characteristics of subjects.

	ACCEL (n=19)		SLOW (n=21)		p
	Mean±SD	Min.-Max.	Mean±SD	Min.-Max.	
Age (year)	57.68±7.8	40-69	57.2±10.1	39-75	0.864
Height (m)	1.56±0.07	1.5-1.7	1.59±0.08	1.5-1.8	0.294
Weight (kg)	75.05±9.45	55-92	73.72±12.17	54-100	0.702

Treatments were performed by a single physiotherapist (İ.D.) with 10 years of experience and who was blinded to the patients' rotator cuff tear size and surgical technique. Evaluations were performed by a single physiotherapist (G.B.) with 13 years of experience and who was blinded to group membership.

Patients enrolled in the ACCEL group were given 6 weeks of preoperative rehabilitation. The ACCEL protocol was initiated at the 2<sup>nd</sup> postoperative week and included soft tissue mobilization for the scapulothoracic and glenohumeral joint along with motion exercises. Active ROM exercises with scapular plane elevation, flexion and abduction was initiated at the 3<sup>rd</sup> week as long as the patient reported no pain at rest with their surgically repaired shoulder. Active exercises were delayed by 1 week in 1 patient due to pain upon removal of the support which later resolved. Light resistive elastic resistance (Thera-Band, red color-coded) exercises were initiated at the 4<sup>th</sup> postoperative week.<sup>[11]</sup> The ACCEL protocol was applied 3 days a week for 6 weeks.<sup>[9]</sup>

In the SLOW group, soft tissue mobilization for the scapulothoracic and glenohumeral joint along with passive ROM exercises were initiated at the 4<sup>th</sup> postoperative week. Active ROM in scapular plane elevation, flexion and abduction was initiated at the 6<sup>th</sup> week and light resistive elastic resistance exercises at the 8<sup>th</sup> week.<sup>[11]</sup> The protocol was applied 3 days a week for 14 weeks.<sup>[9]</sup>

Shoulder flexion, abduction, external and internal rotation were measured using a manual medical goniometer with the patient in the supine position.<sup>[12]</sup> Active total elevation was determined with the patient seated to avoid spinal tilting. Reference points were the axis of the arm and the spinous processes of the thoracic spine. Patients actively elevated their arm in the sagittal plane<sup>[13]</sup> and active internal rotation was performed by having the patients lift their thumb up their back. A tape measure was draped down the spine with the zero value placed at T5. The distance from the tip of the thumb to T5 was recorded to the nearest centimeter. Improving internal rotation was indicated by a decreasing value in centimeters.<sup>[12]</sup> All measurements were performed at the 3<sup>rd</sup>, 5<sup>th</sup>, 8<sup>th</sup>, 12<sup>th</sup>, and 24<sup>th</sup> postoperative week by the same blinded physiotherapist.

Statistical analysis was performed using repeated measures analysis of variance. Range of motion was compared between the protocols at each time point using the Student t-test. The level of significance was set at  $p < 0.05$ .

## Results

There were no significant differences in descriptive characteristics between the two groups ( $p \geq 0.05$ ) (Table 1).

There were no surgical complications or adverse responses reported throughout the duration of the rehabilitation protocol in either group.

With the exception of internal rotation, active total elevation and active internal rotation shoulder ROMs improved across weeks but there were no differences between protocols by week (Figs. 2 to 7). The ACCEL group had significantly greater internal rotation than the SLOW group when weeks were analyzed for all time point measurements ( $p < 0.05$ ) (Table 2). Peak differences between both groups in terms of internal rotation were detected at the 8<sup>th</sup> and 12<sup>th</sup> weeks ( $p = 0.03$ ).

## Discussion

The timing for the initiation of postoperative motion following arthroscopic rotator cuff repair remains controversial. Similar to studies on postoperative ACL rehabilitation,<sup>[14,15]</sup> patients in the current study received the same rehabilitation protocol with passive, active, and resistive exercises introduced at either the earlier (ACCEL) or later (SLOW) postoperative period. All patients demonstrated improvement in ROM through the course of rehabilitation.

Previous studies have shown that rotator cuff repair followed by rehabilitation significantly relieve pain, improve functional activity level and ROM between a 1 and 5 year follow-up period.<sup>[16-22]</sup> A large portion of these studies have focused on the effect of tear size, surgery technique or physical characteristics<sup>[16,21,23]</sup> and appear to suggest that active motion be initiated at the 6<sup>th</sup> week because of tendon healing.<sup>[5,8,18]</sup> Fewer studies have investigated the effect of different rehabilitation protocols on postoperative responses.<sup>[10,24]</sup> Long-term follow-up stud-

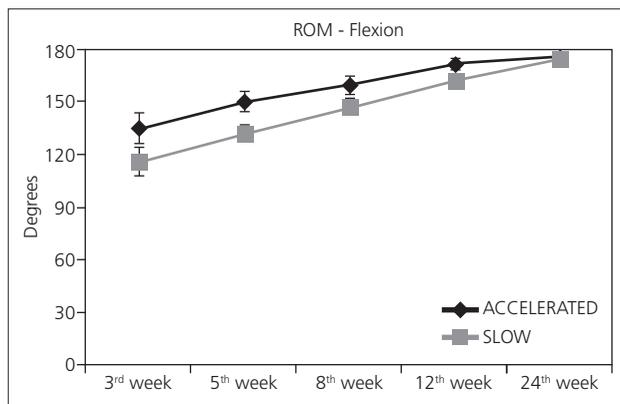


Fig. 2. ACCEL vs. SLOW flexion.

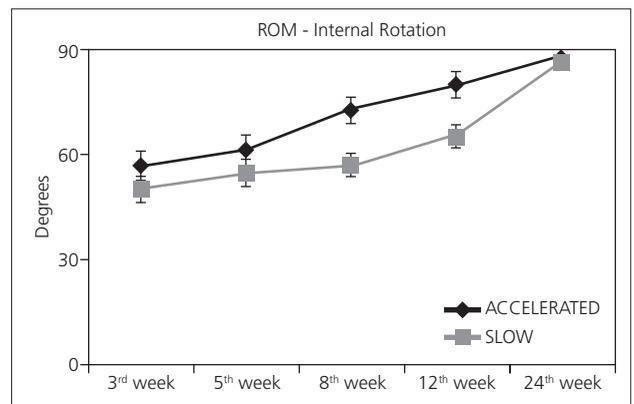


Fig. 5. ACCEL vs. SLOW internal rotation.

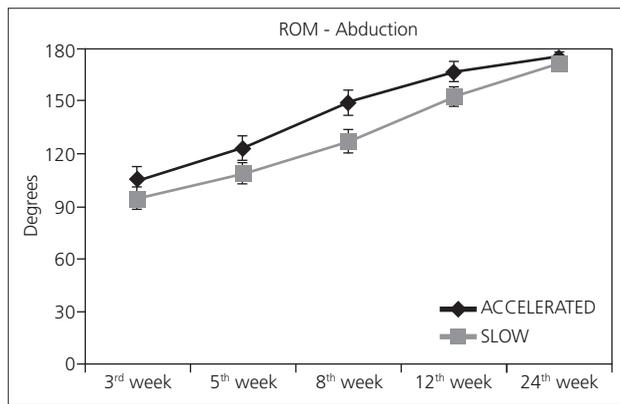


Fig. 3. ACCEL vs. SLOW abduction.

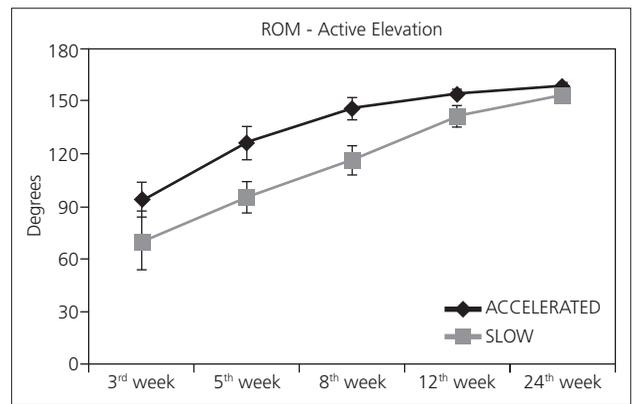


Fig. 6. ACCEL vs. SLOW active total elevation.

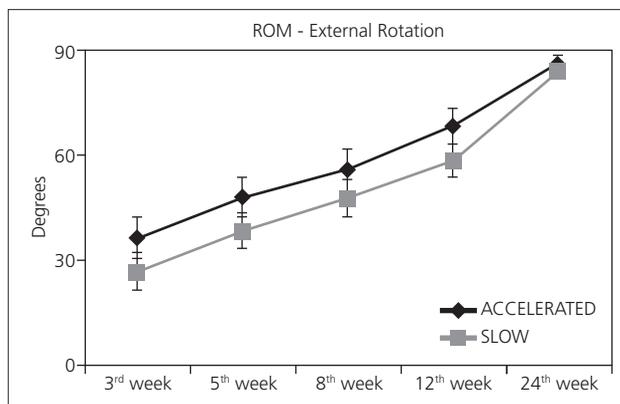


Fig. 4. ACCEL vs. SLOW external rotation.

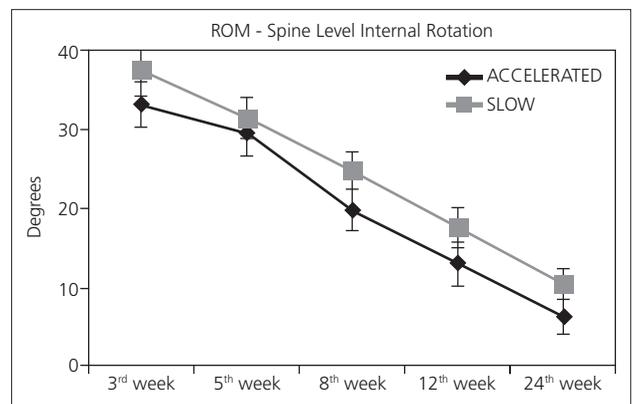


Fig. 7. ACCEL vs. SLOW active internal rotation.

ies have indicated the durability of surgical intervention but are often unable to adequately represent the effects on the patient during the first six postoperative months. Typically, patients are treated for less than 4 months in an outpatient orthopedic physical therapy setting following rotator cuff repair.<sup>[25]</sup> This early time window is important as it has a major impact on the patient as they are attempting to return to normal functional activities

with minimal pain without causing long-term damage to the repaired tissues. Several surgical intervention studies have focused on technique and results, with minimal detail provided about the utilized rehabilitation protocol. In contrast, the current study outlines the rehabilitation protocol in detail.

Animal model studies have provided scientific evidence of the beneficial effects on the structural quality

**Table 2.** Mean and standard deviation values for range of motion in active elevation, spine level internal rotation, external, internal rotation, abduction and flexion between two rehabilitation protocols through postoperative period.

Postop weeks	3 <sup>rd</sup> week	5 <sup>th</sup> week	8 <sup>th</sup> week	12 <sup>th</sup> week	24 <sup>th</sup> week
	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD
Active Elevation (degrees)					
ACCEL Group	94.3±9.9	126.3±9.8	145.9±6.3	154.4±2.2	158.9±1.8
SLOW Group	70.9±17	95.6±9.2	116.4±8.3	141.4±5.9	153.7±4
Spine Level Internal Rotation (centimeters)					
ACCEL Group	33.1±2.9	29.5±2.9	19.7±2.6	13±2.9	6.3±2.2
SLOW Group	37.5±3.2	31.5±2.6	24.8±2.3	17.6±2.5	10.5±2
External Rotation (degrees)					
ACCEL Group	36.5±6	48.2±5.6	55.8±6	68.3±5.3	86.3±2.4
SLOW Group	26.9±5.4	38.5±5.1	47.9±5.4	58.6±4.7	84.1±2.2
Internal Rotation (degrees)					
ACCEL Group	56.9±4.3	61.3±4.3	72.7±3.7	80±3.7	88.2±2.1
SLOW Group	50.1±3.8	54.9±3.9	57.2±3.4	68.2±3.3	86.5±1.9
Abduction (degrees)					
ACCEL Group	104.9±7.3	122.5±6.8	148.5±7.3	166±5.9	173.6±3.4
SLOW Group	94±6.6	108.3±6.1	126.5±6.6	151.9±5.3	171±3.1
Flexion (degrees)					
ACCEL Group	134.9±8.7	150.1±5.6	159.6±5.3	171.3±3.1	175.6±1.8
SLOW Group	115.9±7.9	131.7±5	146.9±4.8	161.8±2.8	174.2±1.6

and strength of the healing tissue of a period of immobilization and that it is not detrimental to ROM.<sup>[5,6]</sup> However, as the mechanism of tissue damage and site are different in the animal models than human subjects, healing processes differ. In addition, the repair procedure is also different between animal models and human subjects and both factors affect the healing process. During passive ROM, humans do not contract the rotator cuff musculature while animals may isotonicly or eccentrically contract these muscles unless they are anesthetized. Tendon bone healing tissue quality is improved with decreased loading.<sup>[26]</sup> Increased collagen organization at the insertion site has been observed after 4 weeks of immobilization and produces superior mechanical properties at weeks 8 and 16.<sup>[4,27]</sup> Koh et al. concluded that 8 weeks of immobilization did not yield a higher rate of healing of medium-sized rotator cuff tears compared with 4 weeks.<sup>[28]</sup> In both protocols, a period of 7 days of immobilization was observed to protect the newly forming network of capillaries.<sup>[9]</sup> Cold application was applied in both groups for the first 7 postoperative days to reduce pain and inflammation and passive ROM exercises were then initiated. Immobilization plays a role in allowing healing and the natural phases of inflammation and proliferation.<sup>[15,29]</sup> The clinical question is when to start movement following rotator cuff surgery to determine what benefits and adverse events may

occur. Neither approach has been studied in an adverse event during the first 6 months. However, long-term follow-up and diagnostic imaging would reveal further information on the durability of the repaired tissue following each protocol.

Active ROM in our patients was greater when exercises were initiated in the early postoperative period. This data agrees with those of Klintberg et al.,<sup>[10]</sup> who initiated active motion at the 4<sup>th</sup> postoperative week while it is in contrast to an animal model that initiated passive motion following 2 weeks of immobilization.<sup>[5]</sup> Researchers reported increased stiffness and less ROM in those animals undergoing passive motion early compared to the continuously immobilized group.<sup>[5]</sup> One explanation for these differing results may be in the volume of exercises prescribed. Those animals undergoing passive motion intervention underwent 300 and 600 repetitions a day applied to their limbs compared to the continuous immobilization group. The authors suggest that the increased stiffness and less motion observed in the motion group were due to excessive scar matrix formation at the tendon insertion sites.<sup>[5]</sup> In the present clinical study, patients were only subjected to 90 repetitions of movement on any one day, assuming the patient complied with the home exercise program on the days they visited the clinic for treatment. During the 2<sup>nd</sup> week, this volume was doubled in the ACCEL group with the

addition of more exercises. However, the 50 to 66% increase in the volume of exercise may account for the differing results of increased motions and reduced pain in those individuals initiating early passive and active motions in the ACCEL protocol. Despite these differences, it is important to note that by 6 months, the amount of elevation and internal rotation were basically the same in all patients regardless of the initial protocol. Harris et al. showed that restoring full external rotation takes 1 year after rotator cuff repair and full forward elevation 3 to 6 months in their study.<sup>[30]</sup> These results may be related to the frequency of exercises in our rehabilitation protocol.

On the other hand, patients with accelerated protocol received 18 and the patients in slow protocol 42 sessions of rehabilitation. Patients in the ACCEL group, therefore, benefited in terms of cost-effectiveness and such considerations maybe of importance to both the patient and insurance.

This study had several limitations, including the lack of baseline assessment and 1 year follow-up. The lack of baseline assessment leaves in question whether the protocol or the individual in the groups accounted for the differences observed. However, a preoperative baseline is difficult to establish when performing clinical research on rehabilitation as in clinical practice patients are not often referred before surgery. In addition, the effect of the two rehabilitation programs on tissue quality was not addressed due to the lack of ultrasound or MRI assessment. It is acknowledged that a clinical report of good function and minimal pain does necessarily indicate the absence of a re-tear of the rotator cuff.<sup>[31]</sup> Longer term follow-up may reveal further insight on the benefits and adverse effects of each protocol but were not feasible in this study. Therefore, the 6-month follow-up duration could be considered another limitation of this study. However, its primary aim was to report the early results of the two different protocols.

Power characteristics of our study have shown post-operative changes in the early period until the 24<sup>th</sup> week (3<sup>rd</sup>, 5<sup>th</sup>, 8<sup>th</sup>, 12<sup>th</sup>, and 24<sup>th</sup> weeks). No data with such time frame was found in the literature. Frequently performed evaluations in this study present us the changes in active ROM which in turn may give us an idea about the repaired tissue.

In conclusion, in both early and late initiation of the rehabilitation protocol, ROM eventually reaches normal values by 6 months. The initial 6 months following surgery is critical to reestablish normal function. Rehabilitation protocols and their effects on tissue repair quality require further investigation to determine which approach results in the greatest benefits.

**Conflicts of Interest:** No conflicts declared.

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