ACTA
ORTHOPAEDICA
et
TRAUMATOLOGICA
TURCICA

ORIGINAL ARTICLE

Acta Orthop Traumatol Turc 2011;45(1):23-33
doi:10.3944/AOTT.2011.2386

Comparison of slow and accelerated rehabilitation protocol after arthroscopic rotator cuff repair: pain and functional activity

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Objectives: In this study, we sought to compare the effects of the slow and accelerated protocols on pain and functional activity level after arthroscopic rotator cuff repair.

Methods: The study included 29 patients (3 men, 26 women) who underwent arthroscopic repair of stage 2 and 3 rotator cuff tears. Patients were randomized in two groups: the accelerated protocol group (n=13) and slow protocol group (n=16). Patients in the accelerated protocol group participated in a preoperative rehabilitation program for 4-6 weeks. Patients were evaluated preoperatively and for 24 weeks postoperatively. Pain was assessed by visual analog scale, and functional activity level was assessed by The Disabilities of The Arm Shoulder and Hand (DASH) questionnaire. The active range of motion was initiated at week 3 after surgery for the accelerated rehabilitation protocol and at week 6 for the slow protocol. The rehabilitation program was completed by the 8th week with the accelerated protocol and by the 22nd week with the slow protocol.

Results: There was no significant difference between the slow and accelerated protocols with regard to pain at rest ($p>0.05$). However, the accelerated protocol was associated with less pain during activity at weeks 5 and 16, and with less pain at night during week 5 ($p<0.05$). The accelerated protocol was superior to the slow protocol in terms of functional activity level, as determined by DASH at weeks 8, 12, and 16 after surgery ($p<0.05$).

Conclusion: The accelerated protocol is recommended to physical therapists during rehabilitation after arthroscopic rotator cuff repair to prevent the negative effects of immobilization and to support rapid reintegration to daily living activities.

Key words: Arthroscopy; pain; rehabilitation; rotator cuff.

Surgical treatment for rotator cuff problems is preferred in the case of partial or full-layer ruptures that do not respond to conservative treatment and if the symptoms established affect the patient's normal function.[1]

A good rehabilitation program is required to increase the likelihood of successful outcome after surgery, to ensure that the patient returns to functional activities, and to improve the patient's quality of life after surgery.

Published reports advise against active shoulder movements for up to about 6-8 weeks, in order to allow tendon-bone healing.[2] However, the negative impacts of immobilization during this time period are unavoidable. After long-term immobilization, levels of water and glucosaminoglycans in the cell

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Submitted: November 18, 2009 **Accepted:** October 8, 2010

decrease, fibrous fat infiltration increases, collagen cross-bridges become irregular, and fiber orientation inside the ligament becomes disorganized.[3]

Passive movement or the application of stress to the tissue can help to prevent such changes and to ensure continued tissue hemostasis. Mobilization of the hinge during the early period of recovery helps to prevent adhesion and reduces the frequency of complications that could occur. Hinge mobilization during rehabilitation restores the mobility of the hinge, improves the biomechanical compatibility of affected tissues, and ensures stimulation of peripheral mechanoreceptors and inhibition of nociceptors.[3]

Few published studies examine rehabilitation after rotator cuff repair; most focus on surgical technique and the size of the rupture. Most of the study protocols involve the initiation of active movements during the sixth week of rehabilitation and forced exercises in the third month. Cohen et al.[2] proposed the initiation of active movements during the sixth week. Regarding the efficacy of rehabilitation, it has been reported that there is no difference between clinical rehabilitation and physical exercise programs performed at home.[4] In recent years, the rehabilitation timeline has been the focus of debate. Klintberg et al.[5] had patients engage in an active range of motion during the fourth week, and two years later, there was no negative impact resulting from early active movement. Patients have been followed for up to one year prior to surgery. However, no study has examined the changes during the early postoperative period. Nevertheless, the consensus in the literature dictates that an active range of motion be allowed in the sixth week. No study has yet investigated the combination of manual therapy techniques with a rehabilitation program prior to surgery. The effect of initiating an active range of motion during the early postoperative period on long-term mobilization remains to be investigated.

This study aimed to compare the efficacy of slow and accelerated rehabilitation protocols on pain and functional activity level in patients whose rotator cuff rupture was repaired arthroscopically. We also sought to document changes during the early postoperative period through frequent follow-up visits.

Patients and methods

The study included 29 patients (26 women, 3 men) between the ages of 39 and 75 years, diagnosed with rotator cuff rupture, and submitted to arthroscopic surgery. Each patient with rotator cuff rupture was submitted to either the slow or the accelerated protocol. The surgical treatment and rehabilitation program to be applied after surgical treatment were explained to the patients. The patients who elected to undergo treatment and provided informed consent were included in the study. The patients were followed at Hacettepe University Faculty of Health Sciences, Department of Physiotherapy and Rehabilitation, Sports Health Unit. The study was approved by Hacettepe University Faculty of Medicine, Medical, Surgical, and Drug Research Ethical Board (FON 05/15-30).

All patients were right-handed; surgery was performed on the left shoulder in 6 patients and on the right shoulder in 23 patients. Patients with phase 2 (1-3 cm) or 3 (3-5 cm) ruptures, for which arthroscopic rotator cuff repair had been completed; with no neurological problems; no disc hernia at the cervical site; amenable to therapy; and with no psychological problems were included in the study. Patients participating in the study were diagnosed as rotator cuff rupture by an orthopedic surgeon, through the use of clinical tests and magnetic resonance imaging (MRI). Exclusion criteria were unwillingness to maintain the rehabilitation program and absence from two or more rehabilitation sessions.

The patients included in the study were divided randomly in two groups to be followed-up with arthroscopic rotator cuff repair, according to the accelerated protocol (n=13) or the slow protocol (n=16). The accelerated protocol was applied to patients presenting during the first year of the study, and the slow protocol was applied to patients presenting during the second year of the study. The accelerated protocol was defined as early active movement in combination with preoperative rehabilitation. The slow protocol was the classical rehabilitation protocol proposed in the literature. Patients followed-up with the accelerated protocol committed to a rehabilitation program for 4-6 weeks prior to surgery. The preoperative rehabilitation program aims to decrease pain, to increase the painless range of motion, and to increase the strength of muscles in the shoulder area. Patients participated in manual therapy at the clinic once a week; exercises were to be performed both at the clinic and at home. The preoperative rehabilitation program is shown in Table 1.

Table 1. Preoperative rehabilitation program used in association with the accelerated protocol.

Week	Application	Frequency
1st week	Cold application	4 times/day, 20 min
	Posterior capsule stretching	1 time/hour
	Rest of the shoulder joint	
2nd week	Continue 1st week of protocol	
	Scapular mobilization and manual posterior capsule stretching	1 time/ week, at clinic
	Scapular retraction with elbow flexion	4 times/day, 10 repeats
	Scapular retraction with elbow extension	4 times/day, 10 repeats
	Scapular retraction on the wall	4 times/day, 10 repeats
3rd week	Continue 2nd week of protocol	
	Shoulder muscle strengthening with 0.5-kg weight	
	Flexion	4 times/day, 10 repeats
	Abduction	4 times/day, 10 repeats
	Full-can (arm elevation at scapular plane)	4 times/day, 10 repeats
4-6 weeks	Continue third week protocol	
	Arm flexion, abduction, and full-can (increased weight)	4 times/day, 10 repeats
	External and internal rotation at 0°, arm abduction with Thera-band®	4 times/day, 10 repeats

The assessments were the same in both groups and were repeated before surgery and at weeks 1, 3, 5, 8, 12, 16, and 24 after surgery. Overall well-being, pain and functional activity level of the patients were determined.

The visual analogue scale (VAS) was used for pain assessment. This scale involves a horizontal line, 10 cm long, such that 0 defines no pain, and 10 defines unbearable pain. The patient is asked to mark the strength of his/her pain at rest, during activity and at night, on the horizontal line. The reliability of this measure was determined by Clark et al.,[6] who found r=0.79 and re-test=0.97.

The Disabilities of The Arm Shoulder and Hand (DASH) questionnaire was used to determine the functional activity level.[7] The questionnaire is filled in by the patient to reflect the functional state and symptoms of the patient from his/her perspective. DASH evaluates the disability arisen as a result of upper extremity injury, as well as the limitations to leisure and work-related activity. The DASH questionnaire yields a result between 0-100 (0=no disability, 100=maximum disability). The questionnaire has been proven to be valid and reliable.[8] The questionnaire was developed in English and translated into many different languages.[9-11] The Turkish version of DASH elaborated by Düger et al.[12] was utilized in this study to determine the functional activity level of patients.

Either the accelerated protocol or the slow protocol was used jointly with preoperative rehabilitation. Even though the exercise program and manual therapy techniques are identical in these protocols, the timing differed. While active movement was initiated during week 3 in the accelerated protocol, it was started during week 6 in the slow protocol. While the accelerated protocol is completed in 8 weeks, the slow protocol is completed in 22 weeks (Table 2).

Statistical analysis

The Mann-Whitney U test was used to compare groups, and Wilcoxon's signed-rank test was used to interpret changes over time. Statistical level of significance was defined as $p<0.05$.

Results

There was no difference between the groups in terms of physical characteristics (Table 3). The physiotherapist was blinded with respect to the phase of the patients operated upon, number of anchors used, use of the "side-to-side" technique, and extent of biceps activation. The phases of the patients, the applied anchor, and "side-to-side" techniques are shown in Table 4.

Pain at rest, during activity, and at night is shown in Fig. 1. The two protocols did not differ in terms of their effects on pain at rest. Among patients treated

Table 2. Accelerated and slow protocols after rotator cuff repair.

FAST	PROTOCOL			SLOW
Week	**Exercise**	**In clinic**	**At home**	**Week**
0-1 weeks	Cold pack (before treatment)		every 2 hours, for 20 min	0-1 weeks
1-2 weeks	Cold pack	Once every 20 min	every 2 hours, for 20 min	1-4 weeks
	Deltoid and biceps soft-tissue mobilization	Kneading, 5 min		
	Standing passive flexion near the table	10 repeats x 1 set	10 repeats x 2 sets/day	
	Standing passive abduction near the table	10 repeats x 1 set	10 repeats x 2 sets/day	
	Standing passive exercise with stick	10 repeats x 1 set	10 repeats x 2 sets/day	
	Active elbow flexion	10 repeats x 1 set	10 repeats x 2 sets/day	
	Active elbow extension	10 repeats x 1 set	10 repeats x 2 sets/day	
	Gripping exercises for hand	10 repeats x 2 sets	10 repeats x 2 sets/day	
	Active cervical flexion-extension	10 repeats x 1 set	10 repeats x 2 sets/day	
	Active cervical lateral flexion	10 repeats x 1 set	10 repeats x 2 sets/day	
	Active cervical rotation	10 repeats x 1 set	10 repeats x 2 sets/day	
2-3 weeks	Cold pack	Once every 20 min	20 min x 4 times/day	4-6 weeks
	Supine passive flexion with stick	10 repeats x 1 set	10 repeats x 2 sets/day	
	Supine passive scaption with stick	10 repeats x 1 set	10 repeats x 2 sets/day	
	Passive exercise with stick	10 repeats x 1 set	10 repeats x 2 sets/day	
	Active elbow flexion	10 repeats x 1 set	10 repeats x 2 sets/day	
	Active elbow extension	10 repeats x 1 set	10 repeats x 2 sets/day	
	Scapular mobilization	Superior-inferior and medio-lateral directions, 5 min		
	Glenohumeral mobilization	Grade 1-2 anterior-posterior gliding, 5 min		
	Scapular clock	10 repeats x 1 set		
3-4 weeks	Cold pack	Once every 20 min	20 min x 3 times/day	6-8 weeks
	Scapular mobilization	Add rotational component, 5-10 min		
	Glenohumeral mobilization	progress grade 3 to 4, 10 min		
	Manual scapular resistiveexercise	retraction-protraction, up-downward rot, 10 repeats x 1 set		
	If no resting pain			
	Active shoulder flexion until 90°	6 repeats x 1 set	6 repeats x 2 sets/day	
	Active shoulder internal rotation at 0° abduction	6 repeats x 1 set	6 repeats x 2 sets/day	
	Active shoulder abduction until 90°	6 repeats x 1 set	6 repeats x 2 sets/day	
	Active shoulder 45° exercise at 0° abduction	6 repeats x 1 set	6 repeats x 2 sets/day	
	Scapular retraction during elbow flexion with light Thera-band®	10 repeats x 2 sets	10 repeats x 2 sets/day	
	Scapular retraction during elbow extension with light Thera-band®	10 repeats x 2 sets	10 repeats x 2 sets/day	
	Resistive biceps with light Thera-band®	10 repeats x 1 set	10 repeats x 2 sets/day	
	Resistive triceps with light Thera-band®	10 repeats x 1 set	10 repeats x 2 sets/day	
	Supine serratus anterior strengthening	10 repeats x 1 set with 1 kg	10 repeats x 2 sets/day	
4-5 weeks	Cold pack	Once every 20 min	20 min x 2 times/day	8-10 weeks
	If necessary, continue scapular and glenohumeral joint mobilization			
	Shoulder flexion with light tb until 90°	10 repeats x 1 set	10 repeats x 2 sets/day	
	Shoulder abduction with light Thera-band® until 90°	10 repeats x 1 set	10 repeats x 2 sets/day	
	Shoulder internal rotation with light tb at 0° abduction	10 repeats x 1 set	10 repeats x 2 sets/day	
	Shoulder external rotation with light tb at 0° abduction	10 repeats x 1 set	10 repeats x 2 sets/day	
	Active shoulder flexion up to 90°	10 repeats x 1 set		

Table 2 [*continued*]. Accelerated and slow protocols after rotator cuff repair.

FAST	PROTOCOL			SLOW
Week	**Exercise**	**In clinic**	**At home**	**Week**
	Active shoulder abduction up to 90°	10 repeats x 1 set		
	Active shoulder internal rotation at 45° abduction	10 repeats x 1 set		
	Active shoulder external rotation at 45° abduction	10 repeats x 1 set		
	Scapular retraction during flexion with moderate Thera-band®	10 repeats x 1 set	10 repeats x 2 sets/day	
	Scapular retraction during extension with moderate Thera-band®	10 repeats x 1 set	10 repeats x 2 sets/day	
	Posterior capsule stretching	3 repeats x 1 set, for 30 sec	3 repeats x 2 sets/day	
	Scaption thumb-up, with light Thera-band®	10 repeats x 1 set	10 repeats x 2 sets/day	
5-6 weeks	Cold pack	Once every 20 min	20 min x twice/day	10-14 weeks
	If necessary, continue scapular and glenohumeral joint mobilization			
	Shoulder flexion with moderate Thera-band®	10 repeats x 1 set	10 repeats x 2 sets/day	
	Shoulder abduction with moderate Thera-band®	10 repeats x 1 set	10 repeats x 2 sets/day	
	Shoulder internal rotation with moderate Thera-band®	10 repeats x 1 set	10 repeats x 2 sets/day	
	Shoulder external rotation with moderate Thera-band®	10 repeats x 1 set	10 repeats x 2 sets/day	
	Scapular retraction during elbow flexion with moderate Thera-band®	10 repeats x 1 set	10 repeats x 2 sets/day	
	Scapular retraction during elbow extension with moderate Thera-band®	10 repeats x 1 set	10 repeats x 2 sets/day	
	Posterior capsule stretching	3 repeats x 1 set, for 30 sec	3 repeats x 2 sets/day	
	Scaption thumb-up with moderate Thera-band®	10 repeats x 1 set	10 repeats x 2 sets/day	
	Prone horizontal abd thumb-up	10 repeats x 1 set	10 repeats x 2 sets/day	
	Side-lying internal rotation stretching	3 repeats x 1 set, for 30 sec	3 repeats x 2 sets/day	
	Side-lying external rotation with 1 kg		10 repeats x 1 set	
	Stabilization training on the ball	5 min		
	Wall shoulder press-up	10 repeats x 1 set	10 repeats x 2 sets/day	
6-8 weeks				14-22 weeks
6 weeks	Cold pack	Once every 20 min	20 min x once/day	14-18 weeks
	Shoulder flexion with moderate Thera-band®	10 repeats x 1 set	10 repeats x 2 sets/day	
	Shoulder abduction with moderate Thera-band®	10 repeats x 1 set	10 repeats x 2 sets/day	
	Shoulder internal rotation with moderate Thera-band®	10 repeats x 1 set	10 repeats x 2 sets/day	
	Shoulder external rotation with moderate Thera-band®	10 repeats x 1 set	10 repeats x 2 sets/day	
	Posterior capsule stretching	3 repeats x 1 set, for 30 sec	3 repeats x 2 sets/day	
	Scaption thumb-up with moderate Thera-band®	10 repeats x 1 set	10 repeats x 2 sets/day	
	Prone horizontal abduction thumb-up	10 repeats x 1 set, with 1 kg	10 repeats x 2 sets/day	
	Side-lying internal rotation stretching	3 repeats x 1 set, for 30 sec	3 repeats x 2 sets/day	
	Side-lying external rotation with 2 kg	10 repeats x 1 set	10 repeats x 2 sets/day	
	Wall-ball stabilization	5 min		
	Resistive PNF patterns	10 repeats x 1 set, with 2 kg		
7 weeks				18-22 weeks
	Wall shoulder push-up	10 repeats x 1 set	10 repeats x 2 sets/day	
	On-the-table press-up	10 repeats x 1 set	10 repeats x 2 sets/day	
	On-the-table push-up	10 repeats x 1 set	10 repeats x 2 sets/day	

with the accelerated protocol, mean VAS score (±standard deviation) for pain at rest was 3.27±2.41 before surgery, but only 0.5±1.11 by the fifth week after surgery ($p<0.05$). For patients followed-up with the slow protocol, no significant preoperative vs. postoperative difference in pain at rest was identified ($p>0.05$).

Pain during activity was 2.32±2.04 in week 5 among patients subjected to the accelerated protocol and 0.32±0.86 during week 16. In the slow protocol, these values were found to be 4.67±2.2 in week 5 and 2.86±2.65 in week 16 ($p<0.05$). With the accelerated protocol, activity pain was 4.1±1.78 during week 3, but only 2.32±2.04 during week 5; values dropped further from 1.6±2.35 in week 12 to 0.32±0.86 week 16 ($p<0.05$). No significant difference between time-points was found in patients followed-up with the slow protocol ($p>0.05$). Pain during activity reduced significantly from the third week on in the accelerated group ($p<0.05$). Activity pain before surgery differed from that observed at weeks 5, 8, 16, and 24 after surgery for patients treated with the accelerated protocol ($p<0.05$).

During the fifth week, night pain was 0.98±1.57 with the accelerated protocol, but 2.83±2.56 with the slow protocol ($p<0.05$). Night pain decreased significantly from the third week on, as compared to preoperative levels, in patients treated with either the slow or accelerated protocol ($p<0.05$).

Phase of the disease was not associated with any change in activity (Table 5), rest (Table 6) or night pain (Table 7) in either group ($p>0.05$).

The functional activity level of patients followed-up with accelerated and slow protocols is shown in Fig. 2. While the DASH score for patients treated with the accelerated protocol was 31.6±21.67 in week 8, this value was 53.83±13.34 for patients treated with the slow protocol; whereas the DASH score was 15.87±15.3 in week 16 for patients treated with the accelerated protocol, the score was 31.35±20.51 for patients treated with the slow protocol ($p<0.05$). Among patients followed-up with the accelerated protocol, while DASH score in week 8 after surgery was 31.6±21.67, this value reduced to 22.66±17.82 in week 12 ($p<0.05$). For patients treated with the slow protocol, the DASH score dropped to 35.35±17.83 in week 12 from 53.83±13.34 in week 8 and to 24.9±17.75 in week 24 from 31.35±20.51 in week 16. The mean DASH score for phase 2 ruptures was 43.41±12.46 in week 8 for the slow protocol, whereas the value for phase 3 patients was 60.09±8.94 ($p<0.05$). In the accelerated protocol, no meaningful difference in DASH scores was found between phases ($p>0.05$).

Table 3. Age and physical characteristics of subjects [mean± SD (range)].

	Accelerated protocol (n=13)	Slow protocol (n=16)
Age (year)	55.85±7.8 (40-69)	56.63±10.99 (39-75)
Height (m)	1.56±0.07 (1.5-1.7)	1.59±0.08 (1.5-1.8)
Weight (kg)	71.63±21.08 (62-92)	71.88±13.32 (54-100)

Table 4. Rotator cuff tear stage and surgery technique applied (number of patients).

		Accelerated protocol (n=13)	Slow protocol (n=16)
Stage	2	6	6
	3	7	10
Anchor number	1	11	11
	2	2	5
Side-to-side technique	1	4	7
	2	1	3
	3	0	1

Discussion

Rotator cuff rupture patients treated with accelerated rehabilitation responded more rapidly to therapy, but there was no difference between patients treated with the slow and the accelerated protocols by the sixth month.

In recent years, the results of early loading after Bankart repair, anterior cruciate ligament repair, and rotator cuff repair, have been debated in the literature.[5,13-15] Although some authors are against active movement before week 6,[2,16] others maintain that early active movement has no negative impact.[5,17]

In patients followed up at 1 and 5 years, results have shown that rotator cuff repair and rehabilitation reduced pain and increased functional activity level.[17-23] The majority of these studies examine the impact of rupture size, surgery technique or physical properties.[18,19,24] Most of these studies advise that patients begin active movement in week 6, in order to allow for tendon healing.[2,16,21] However, very few studies have investigated the impact of various rehabilitation programs on responses after surgery.[4,5] Long-term studies have assessed the durability of surgical approaches; however, these have not provided any information on patients' quality of life during the first six months after the operation. These patients are rehabilitated in physical therapy departments for four months on average; results from the early postoperative period are generally encouraging. Further research will be necessary to determine when the patient can return to daily life activities with the lowest possible degree of pain and without causing harm to the repaired tissue.

In studies carried out on animals, immobilization for a given period of time has beneficial impacts on the quality and strength of the healing tissue, with no negative impact on the range of motion.[16,25] The quality of tendon-bone healing is improved by decreased loading.[26] It has been observed that in week 4 of immobilization, collagen organization has increased; by weeks 8-16, mechanical qualities have peaked.[25,27] Notably, the protection of newly formed capillaries was taken into account when determining the period of immobilization for both protocols.[3] During the first 7 days, a cold compress was used to suppress inflammation and pain; only then exercises involving a passive range of motion were initiated. In shoulders that had undergone arthroscopic and open surgery, application of a cold compress reduces night pain and speeds postoperative healing.[28] Here, we examine when movement should first be initiated after the rotator cuff operation and investigate the related effects. Strength of the tissue after long-term treatment has been investigated, but short-term effects remain to be elucidated.

In our study accelerated protocol was defined as preoperative rehabilitation in association with active exercise starting in week 3. The aims of preoperative rehabilitation were to inhibit pain, to restore normal scapular movements, to strengthen the muscles

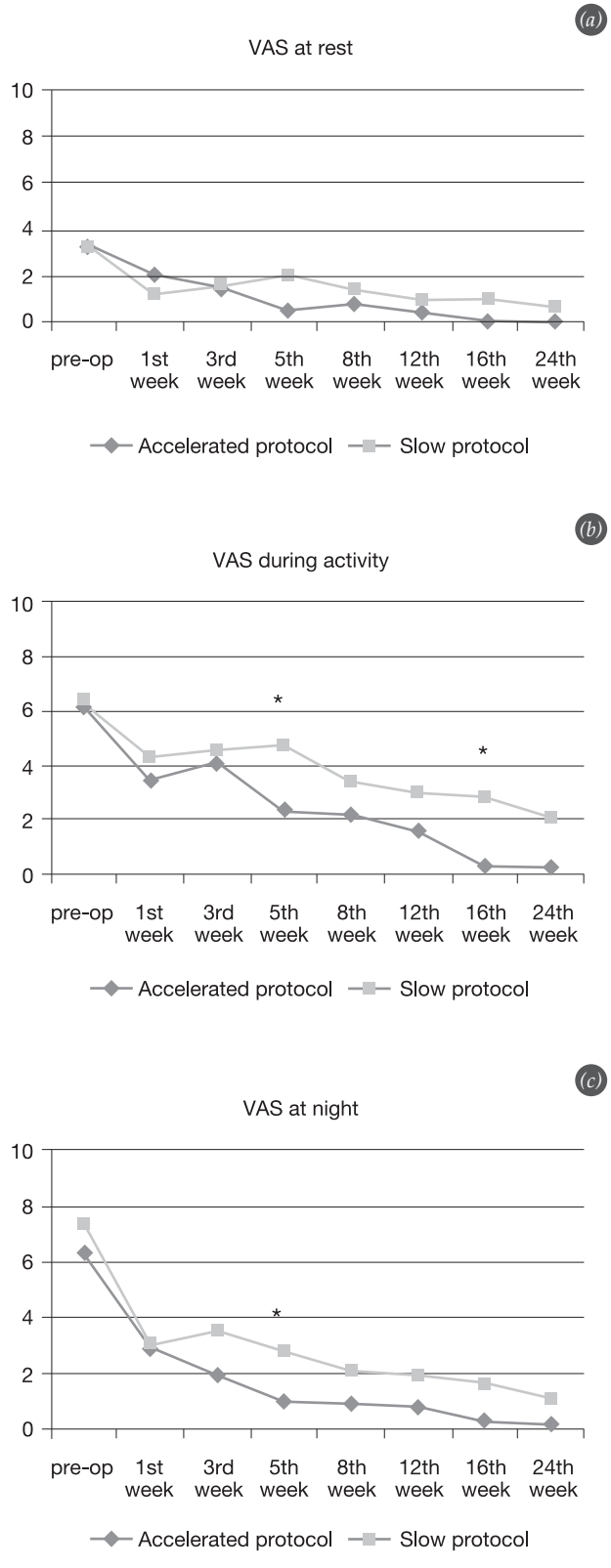

Fig. 1. The mean VAS score of accelerated and slow protocols **(a)** at rest, **(b)** during activity, and **(c)** at night. *p<0.05 for comparison of study protocols.

Table 5. Changes in rest pain according to phase of rupture (mean±SD).

	Accelerated protocol			Slow protocol		
	Phase 2	Phase 3	p value	Phase 2	Phase 3	p value
Preoperative	2.8±3.56	3.67±1.03	0.537	2.88±2.32	3.58±2.45	0.686
1st week	0.54±0.78	3.33±3.72	0.177	1.54±2.12	0.92±1.26	0.69
3rd week	0.25±0.61	2.44±1.84	0.51	1.77±1.97	1.45±1.67	1.00
5th week	0.00±0.00	0.93±1.42	0.234	3.47±2.48	1.19±1.63	0.093
8th week	0.00±0.00	1.47±1.91	0.234	2.63±3.66	0.7±1.29	0.368
12th week	0.00±0.00	0.83±1.86	0.445	1.7±2.32	0.54±1.11	0.428
16th week	0.00±0.00	0.11±0.3	0.73	1.83±3.06	0.36±0.86	0.607
24th week	0.00±0.00	1.42±1.56	1.00	0.00±0.00	0.16±0.32	0.224

around scapula and thus to provide painless shoulder movements.[29,30] Hata et al.[31] point out that the scapula-thoracic range of motion is limited in the group whose pain is ongoing at one year after the rotator cuff operation. Because adequate biomechanics of the scapula are the basis of shoulder rehabilitation, mobilization techniques have been applied to ensure a full range of scapula-thoracic motion. The physical exercise program has been designed to ensure scapula stabilization. When these parameters are ensured prior to surgery, active movement is possible sooner after surgery. Therefore the accelerated protocol has been adopted jointly with pre-op rehabilitation.

The value of preoperative pain assessment for patients treated with the accelerated protocol was 32.7% and this value dropped to 16% after the rehabilitation program was applied during the preoperative period. No change was observed in the pain remaining after preoperative rehabilitation (16%) or postoperative rest pain (0%). Pain at rest peaks during week 5 among patients treated with the slow protocol and is reduced among patients treated with the accelerated protocol. When considering that active movement begins in week 3 in the accelerated protocol, the lack of pain at rest, which is among the signs of inflammation, during the fifth week supports the therapeutic value of active movement.[32-34] Pain at rest decreased between weeks 3 and 5 in patients treated with the accelerated protocol; this decrease continued during subsequent weeks until eventually there was no difference between groups. This result supports the utility of the accelerated protocol in mobilization during rehabilitation. Follow-up during the early period would clarify whether the inflammatory response is prolonged, potentially increasing the stress load on the tissue and increasing the likelihood of rupture.

Table 6. Changes in activity pain score according to phase of rupture (mean±SD).

	Accelerated protocol			Slow protocol		
	Phase 2	Phase 3	p value	Phase 2	Phase 3	p value
Preoperative	6.2±3.42	6.17±2.99	0.931	7.0±3.56	5.75±1.71	0.486
1st week	2.14±2.5	4.52±3.34	0.247	4.24±4.23	4.48±1.45	0.841
3rd week	3.28±1.24	4.8±1.95	0.51	4.58±2.75	4.51±2.88	0.875
5th week	1.43±1.62	3.09±2.17	0.234	5.13±1.59	4.39±2.53	0.313
8th week	1.4±1.35	2.89±2.65	0.366	3.88±2.39	3.17±2.57	0.713
12th week	0.55±0.88	2.5±2.88	0.181	2.72±3.01	3.12±2.2	0.713
16th week	0.17±0.41	0.84±1.44	0.628	1.97±3.16	0.334±2.11	0.328
24th week	0.00±0.00	2.47±2.78	0.699	0.5±1.22	1.82±1.29	0.955

Table 7. Changes in night pain score according to phase of rupture (mean±SD).

	Accelerated protocol			Slow protocol		
	Phase 2	Phase 3	p value	Phase 2	Phase 3	p value
Preoperative	7.40±2.7	5.50±4.64	0.662	9.00±1.41	5.75±1.7	0.57
1st week	1.42±2.56	4.12±4.19	0.247	3.52±3.41	2.48±2.37	0.69
3rd week	0.78±1.92	2.91±2.31	0.138	4.57±3.98	2.94±2.7	0.428
5th week	0.00±0.00	1.81±1.77	0.101	4.10±2.74	2.06±2.24	0.118
8th week	0.40±0.98	1.37±2.44	0.628	3.10±3.96	1.48±2.56	0.562
12th week	0.00±0.00	1.47±3.35	0.445	1.90±2.69	1.93±3.17	0.792
16th week	0.00±0.00	0.77±1.38	0.445	1.83±3.09	1.40±2.21	0.955
24th week	0.00±0.00	2.27±3.13	0.699	0.33±0.82	0.43±0.79	0.328

Although preoperative activity pain among patients treated with the accelerated protocol diminishing starting from the third week after surgery, pain may have decreased due to the early initiation of movement. Because activity pain has a large impact on daily life activities, decreased pain during the early postoperative period suggests the importance of early initiation of movement to optimize the shoulder's range of motion.

Although there was no difference among weeks with respect to activity pain in the patients treated with the slow protocol, the pain affecting the patient's activity level continued up to week 24. This may be related to the delayed active movement program. Therefore the accelerated protocol appears to be more advantageous with regard to activity pain.

Night pain decreased starting in the third week in both groups, potentially due to more rapid tissue healing and repair. While the slow protocol induced no differences in night pain, which is a sign of inflammation, the slight drop at week 3, when active movement was introduced, emphasizes the utility of the accelerated protocol. The reduction in night pain was reduced five weeks postoperatively among patients treated with the accelerated protocol as compared to those treated with the slow protocol. This suggests that early active movement does not induce inflammation and is effective in the reduction of night pain. Among patients treated with the accelerated protocol, participation in a rehabilitation program before surgery reduced night pain.

Although Lee et al.[18] and Bishop et al.[19] assessed pain in a classical rehabilitation program using the VAS, the authors did not discriminate among rest, activity, and night pain. Notably, the protocol used was comparable to the slow protocol used in our study. The authors followed their patients for at least 12 months (mean 16.5 months, range 12-45 months) and observed a drop in pain from 5.6 to 1.6 on the VAS. Bishop et al.[19] followed patients for at least 12 months and found that for patients with ruptures smaller than 3 cm; the pain dropped from 5.3 to 1, and in ruptures larger than 3 cm, the pain dropped from 4.9 to 2.1. The follow-up time in our study was 24 weeks. Pain was measured at day 7 postoperatively among patients treated with the slow protocol; rest pain dropped to 0.7 at week 24 from a baseline value of 1.2, activity pain dropped to 2.1 from 4.3, and night pain dropped to 1.2 from 3.0. For patients treated with the accelerated protocol, rest pain fell to 0 from 2.1, activity pain dropped to 0.3 from 3.5, and night pain dropped to 0.2 from 2.9. Therefore, the size of the rupture had no impact on recovery, as reported by Lee et al.[18] and Bishop et al.[19]

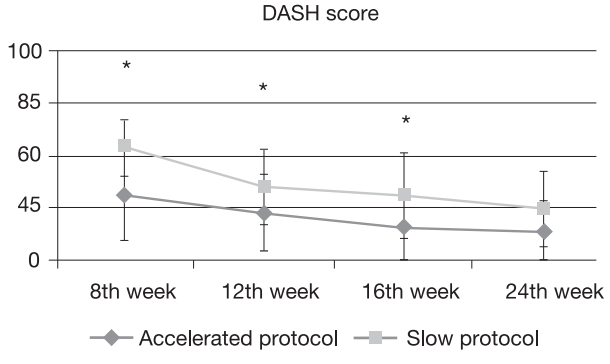

Fig. 2. The mean DASH score of accelerated and slow protocols. *p<0.05 for comparison of study protocols.

While the DASH score decreased between weeks 8 and 12 after surgery in the accelerated group, this decrease continued until week 24 in the slow group. Nevertheless, while the DASH scores between weeks 8 and 16 of patients treated with the accelerated protocol were superior to those of patients treated with the slow protocol, these between-group differences disappeared by 24 weeks postoperatively. The DASH scores also reflected between-group differences in functional activity.

Habernek et al.[17] allowed an active range of motion on the 10th day after surgery. Two-year follow-up revealed normal function, hinge movement, and force. Habernek et al.[17] observed similar results after 5-year follow-up. Klintberg et al.[5] initiated active movement in week 4, with no negative impact detectable at 2-year follow-up on pain, range of motion or functional activity level. In our study, active movement was initiated on day 21 in the accelerated protocol. Examination of the patients in week 24 revealed successful recovery in 84% of patients. Although these results are similar to those reported by Habernek et al.,[17] additional studies involving long-term follow-up will be necessary.

In this study, patients were followed up frequently until week 24 after surgery. This study is the first to examine short-term postoperative results in patients following rotator cuff rupture. However, the study has certain limitations. Future studies should involve more patients and examine long-term results. MRI and ultrasound sonography could also be used to assess the quality of repaired tissue. Furthermore, in our study, patients treated with the accelerated protocol were submitted to a preoperative rehabilitation program, while those submitted to the slower protocol were not. Therefore, the preoperative rehabilitation program may have improved postoperative recovery.

The accelerated protocol resulted in reduced pain and a more rapid return to functional activity levels. Rehabilitation after rotator cuff repair is difficult for the patient. The patient must use an abduction pad shoulder hanger for 6 weeks and cannot use his/her arm actively. Furthermore, the patient is only able to return to his/her daily life activities after 4-6 months. With use of the accelerated protocol, the patient can return to his/her daily life activities within 8-12 weeks. Therefore, the accelerated protocol is beneficial to both the patient and physiotherapist. Although the mechanism underlying this improvement in recovery remains to be determined, the accelerated protocol may positively affect collagen formation.

Therefore, the accelerated protocol is recommended to physiotherapists interested in shoulder rehabilitation after arthroscopic rotator cuff repair.

Conflicts of Interest: No conflicts declared.

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