ORIGINAL ARTICLE

CiSE
Clinics in Shoulder and Elbow

Clinics in Shoulder and Elbow Vol. 17, No. 2, June, 2014
http://dx.doi.org/10.5397/cise.2014.17.2.57

The Effect of Different Starting Periods of Passive Exercise on the Clinical Outcome of Arthroscopic Rotator Cuff Repair

Young-Woong Back, Suk-Kee Tae, Min-Kyu Kim, Oh-Jin Kwon

Department of Orthopaedic Surgery, Dongguk University Ilsan Hospital, Goyang, Korea

Background: To compare the effect of different starting periods of rehabilitative exercise (early or delayed passive exercise) on the rate of retear and other clinical outcomes after the arthroscopic repair of the rotator cuff.
Methods: In total, 103 patients who underwent arthroscopic repair of the rotator cuff were included in the study. Determined at 2 weeks post-operation, patients who were incapable of passive forward elevation greater than 90° were allotted to the early exercise group (group I: 79 patients; 42 males, 37 females), whilst those capable were allotted to the delayed exercise group (group II: 24 patients; 14 males, 10 females). The group I started passive exercise, i.e. stretching, within 2 weeks of operation, whilst group II started within 6 weeks. The results were compared on average 15.8 months (11-49 months) post-operation using the passive range of motion, the Visual Analog Scale (VAS) pain score, and the University of California at Los Angeles (UCLA) and Constant scores. Stiffness was defined as passive forward elevation or external rotation of less than 30° compared to the contralateral side. Follow-up magnetic resonance imaging (MRI) was carried out on average 1 year post-operation and the rate of retear was compared with Sugaya's criteria.
Results: There were no differences between the two groups in gender, age, smoking, presence of diabetes, arm dominance, period of tear unattended, pre-operative range of motion, shape and size of tear, degree of tendon retraction, and tendon quality. There were no significant differences in clinical outcomes. Whilst stiffness was more frequent in group II (*p*-value 0.03), retear was more frequent in group I (*p*-value 0.028) according to the MRI follow-up.
Conclusions: During rehabilitation after the arthroscopic repair of the rotator cuff, the delay of passive exercise seems to decrease the rate of retear but increase the risk of stiffness.
(Clin Shoulder Elb 2014;17(2):57-63)

Key Words: Shoulder; Rotator cuff repair; Immobilization; Rehabilitation; Stiffness

Introduction

Arthroscopic surgery is widely carried out for the repair of the rotator cuff.[1-3] However, retear after surgery is common, ranging from a rate of 25%[4] up to 94%[5] as observed by many researchers and in clinical studies.[6,7] There are several factors, biological and environmental, contributing to the retear of the rotator cuff. The biological factors include the patient's age,[6] the size of the tear,[8] period of tear unattended,[9] and the health and genetic disposition of the patient.[10,11] The environmental factors include the patient's working conditions, the rehabilitative exercise undertaken, the use of nonsteroidal anti-inflammatory drugs, smoking, etc.[12-14]

In the past, doctors have recommended the delayed passive exercise in order to lower the rate of retear. However, the consequent prolonged period of stabilization have led to a higher rate of stiffness.[15-17] To counter this, early passive exercise was pursued,[18] but the starting period of rehabilitative passive exercise that harbors the minimal risk of both retear and stiffness is still controversial. For instance, Parsons et al.[19] favors the delayed passive exercise on the grounds that a prolonged stabilization period of 6 weeks is beneficial for repair and also reduces the risk of stiffness.

Thus, our study aims to identify whether delayed passive ex-

Received October 25, 2013. **Revised** January 20, 2014. **Accepted** March 7, 2014.

Correspondence to: Suk-Kee Tae
Department of Orthopaedic Surgery, Dongguk University Ilsan Hospital, 27 Dongguk-ro, Ilsandong-gu, Goyang 410-773, Korea
Tel: +82-31-961-7310, **Fax:** +82-31-961-7312, **E-mail:** skt97@duih.org

Financial support: None. **Conflict of interests:** None.

pISSN 1226-9344
eISSN 2288-8721

ercise indeed reduces the rate of retear and increases the rate of stiffness after the arthroscopic repair of the rotator cuff.

Methods

Subject of Study

From January 2005 to May 2012, 243 patients underwent arthroscopic repair of the full-thick tear in the supraspinatus or infraspinatus. Of these, 43 patients with the following comorbidities were excluded; fracture, history of previous shoulder surgery, severe degeneration of the glenohumeral joint, inflammatory disease or infection, calcifying tendinitis (in which stiffness is common after surgery[20]), superior labral tear from anterior to posterior (SLAP) tear, and/or Bankart tear. The remaining 200 patients were followed-up 1 year after surgery, and of these, 155 patients were included in the post-operative magnetic resonance imaging (MRI). Surgery was undertaken by the same surgeon. Patients were anaesthetized and checked for the range of motion. If rotation beyond 130° was possible, manipulation was carried out before arthroscopic repair. The size of the rotator cuff tear and the length of the retraction were measured using a probe. The measurement was carried out after marginal debridement of the affected tendon. Further 52 patients were excluded; in accordance with the measurements, 41 patients with a rotator cuff tear smaller than 1.5 cm and 11 patients who underwent incomplete repair were also excluded. Data of the remaining 103 patients were analyzed for the study (Fig. 1).

Patients were visited between 1-2 weeks post-operation in order to be allotted into the two groups. Patients who were capable of passive forward elevation greater than 90° were allotted to the delayed exercise group. Here, the risk of stiffness due to prolonged stabilization was deemed low. Patients incapable of this elevation were allotted to the early exercise group. The early exercise group (group I: 79 patients; 42 males, 37 females; average age 58.5 years, range 29-77 years) started passive stretching exercise within 2 weeks post-operation, whilst the late exercise group (group II: 24 patients; 14 males, 10 females; average age 60.1 years, range 50-72 years) started at 6 weeks post-operation.

Method of Assessment

The results of the two groups were analyzed using both clinical and radiologic assessments. Clinical assessments were carried out before the surgery, and 12 months post-operation using University of California at Los Angeles (UCLA) score,[21] Constant score,[22] and Visual Analogue Scale (VAS) pain scores. Radiologic assessments were also carried out at 12 months post-operation using MRI to identify retear. The definition of stiffness in the context of the shoulder joint is based on the decreased ability of passive forward elevation and external rotation, but not on abduction internal rotation. Specifically, stiffness is defined as passive forward elevation or external rotation of less than 30° compared to the contralateral side. Retear was assessed against the Sugaya's criteria[23] during the follow-up MRI scan by the surgeon and one other orthopedic specialist. Grade 4 or 5 were classed as retear (Fig. 2), but otherwise (grade 1, 2, 3) classed as no retear (Fig. 3). Furthermore, the risk factors of retear were compared between the two groups. The risk factors include; gender, age, presence of diabetes, smoking, arm dominance,

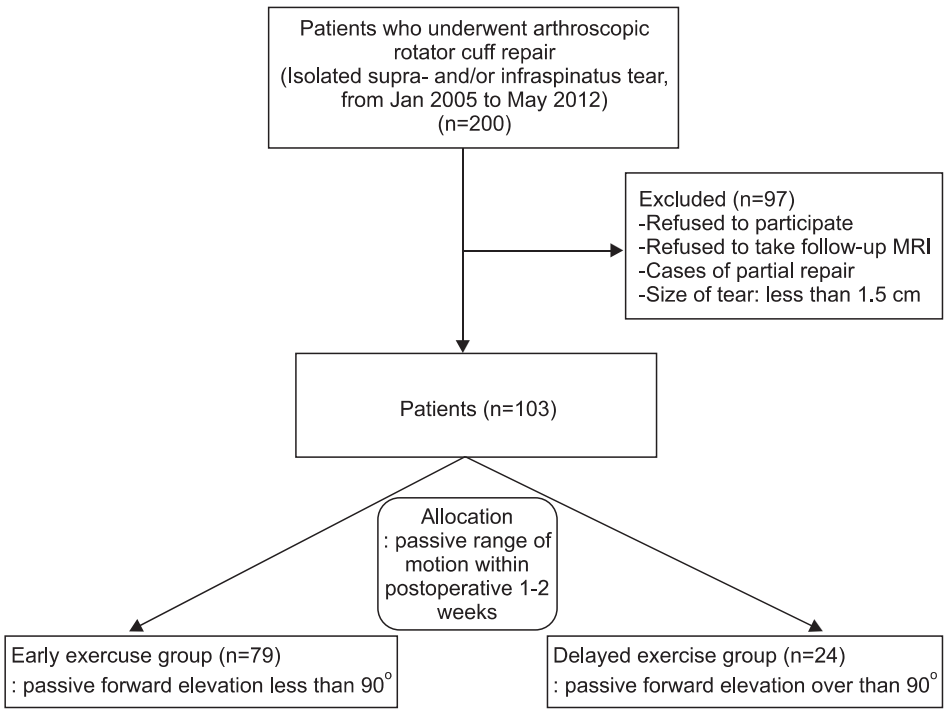

Fig. 1. Patient selection algorithm. MRI, magnetic resonance imaging.

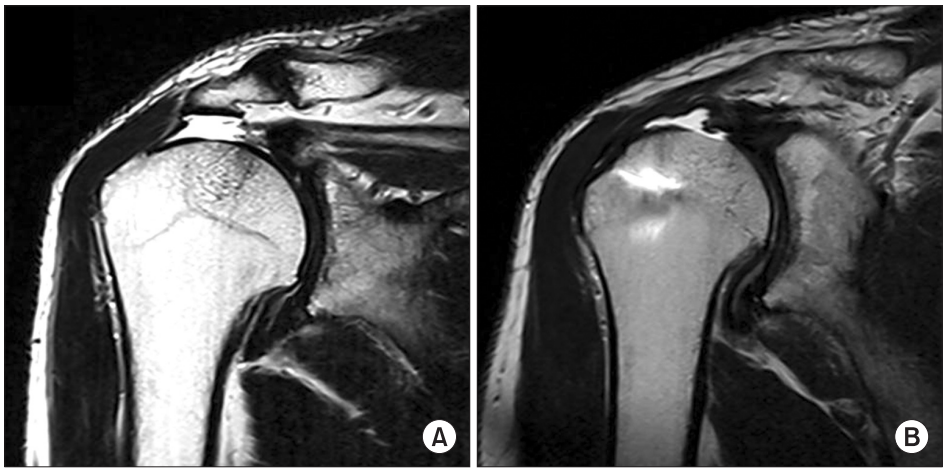

Fig. 2. (A) Preoperative T2-weighted coronal magnetic resonance image shows rotator cuff tear. (B) One-year postoperative magnetic resonance image shows retear of the supraspinatus tendon.

Fig. 3. (A) Preoperative T2-weighted coronal magnetic resonance image shows rotator cuff tear. (B) One-year postoperative magnetic resonance image shows healed rotator cuff.

period of tear unattended, pre-operative range of motion, size and shape of tear, tendon quality, degree of tendon retraction, duration of operation, start period of rehabilitative passive exercise (within 2 weeks or 6 weeks post-operation), and the degree of pre-operative fatty degeneration in rotator cuff as assessed by the global fatty degeneration index (GFDI)[24] obtained by MRI. The GFDI is the average of the degrees of fatty degeneration, obtained by Goutallier's classficiation,[24] in the 3 muscles that meet at the Scapular Y-shape. Observed in the sagittal oblique view, the Scapular Y-shape is where the spine and the scapular body meets. The size of tear was classified according to the DeOrio and Cofield criteria.[25]

Surgery Procedure and Rehabilitation Program

The following arthroscopic procedures were used; single-row repair, double-row repair, or suture-bridge technique. Eighty-six patients (78.9%) underwent acromioplasty. To control for the possible effect of the tendon quality on retear, the quality of the torn tendon was recorded by the subjective assessment of the surgeon during the operation. Using a probe, the thicknesses of the frontal, central and rear side of the torn tendon were measured. The mean values were then classed as follows; above 10 mm as good (16 patients, 14.7%), between 5-10 mm as average (83 patients, 76.1%), and below 5 mm as poor (83 patients, 76.1%). Tendons, regardless of their thickness, that were torn easily when pulled with a grasper were also classed as poor.

All patients were given a stabilization brace to support the rotator cuff after the operation. Also, they were given advice to actively move their hands, wrists and elbow joints right after the operation. At 1-2 weeks post-operation, patients were followed-up to check passive forward elevation. Patients capable of elevation greater than 90° maintained the stabilizer for 4 weeks (until 6 weeks post-operation) without passive or active exercise. Patients incapable of this degree of elevation also maintained the stabilizer for the same period but were immediately started on passive pendulum motion exercise in which the pendulum motion was increased progressively. This progressive increase in motion was within a range that did not cause pain and was carried out for one minute, 3 to 5 times a day.

At 6 weeks post-operation, stabilizers were removed regard-

less of the state of stiffness. At this point, the following exercises were started on the affected arm; pendulum motion exercise, passive elevation exercise, and passive external rotation exercise using the T-bar. The effectiveness of the passive forward elevation and external rotation exercises were maximized by repeating the following sequence 10-20 times; holding the maximal position (i.e., the greatest angle of motion) for 10 seconds followed by relaxation for 5 seconds. The exercises took 5-10 minutes to complete and were repeated 3-6 times a day. Next, at 3 months post-operation, exercises to strengthen the rotator cuff and the periscapular muscles were started. To strengthen the rotator cuff, active internal and external rotation exercises were carried out using Theraband products (Breg Inc., Carlsbad, CA, USA). Band resistance was chosen at a slight difficulty according to the patient's capability after 10 pulls. Resistance was increased if patients felt no difficulty even after 15 pulls. The exercises were carried out twice a day with 5 repeats each time. To strengthen the periscapular muscles, shoulder hunching and standing wall push-ups were carried out. Further, at 4 months post-operation, deltoid muscle strengthening exercises were started, and finally at 6 months post-operation all exercises and activities were allowed to pre-operative levels.

Statistical Analysis

Statistical data were analyzed by SPSS for windows release ver. 17.0 (SPSS Inc., Chicago, IL, USA), and statistical significance was considered as p-value <0.05. The Fisher's exact test was used to assess the correlation between the size of tear and

Table 1. Patient Demographics and Clinical Features

	Early exercise group	Delayed exercise group	p-value
Age (yr)	58.51 ± 9.72 (39-77)	60.08 ± 7.02 (50-72)	0.462*
Gender (n)			0.656†
Male	42	14	
Female	37	10	
Diabetes mellitus (n)	6	3	0.456†
Smoking (n)	11	3	0.859†
Op. side: dominant (n)	17	9	0.114†
Preop. duration of symptom (mo)	16.1 ± 5.74 (1-46)	15.4 ± 6.61 (2-57)	0.223*
Preop. PFE (°)	152.5 ± 17.05 (90-180)	149.16 ± 24.83 (50-180)	0.483*
Preop. PER (°)	52.17 ± 11.16 (20-70)	48.25 ± 8.75 (30-60)	0.252*
Postop. PFE (°)	154.3 ± 14.95 (60-170)	153.95 ± 16.21 (105-180)	0.84*
Postop. PER (°)	48.67 ± 11.37 (10-70)	49.17 ± 9.28 (30-70)	0.90*
Size of tear (cm)	2.24 ± 0.96 (1-6)	2.51 ± 0.95 (1.5-5)	0.23*
Retraction (cm)	1.93 ± 0.67 (1-4)	1.98 ± 0.52 (1-3)	0.72*
Duration of surgery (min)	137.25 ± 21.31 (89-182)	151.47 ± 17.2 (92-178)	0.562*
Quality of tendon (n)			0.715†
Good	7	2	
Fair	61	17	
Poor	11	5	
Shape of tear (n)			0.067†
Crescent	41	11	
U-shape	12	2	
L-shape	14	10	
Reverse L-shape	12	1	
GFDI	1.04 ± 0.53	1.10 ± 0.58	0.659†

Values are presented as mean ± standard deviation (range) or number only.
Op.: operative, Preop.: preoperative, Postop.: postoperative, PFE: passive forward elevation, PER: passive external rotation, GFDI: Global Fatty Degeneration Index.
*Independent t-test, †chi-square test.

subsequent retear. The paired *t*-test was used to compare functional outcome before and after operation. The chi-square test was used to compare the rate of retear and of stiffness between the two groups and an independent *t*-test was used to compare functional outcome. To assess the variables that might have an effect on the results, the chi-square and independent *t*-tests were used.

Results

Patient Demographics

Group I and II had no significant differences ($p>0.05$, Table 1) in the following variables; gender, age, presence of diabetes, smoking, arm dominance, period of tear unattended, pre-operative range of motion, size of tear, tendon quality, degree of tendon retraction, duration of operation, and GFDI as assessed by pre-operative MRI.

Clinical Outcomes

All clinical assessments, including the pain score, and UCLA and Constant scores, showed a statistically significant improvement at one year post-operation. The pain score improved from an average of 6.2 to 1.2, the UCLA score from 17.2 to 31.9 and the Constant score from 42.1 to 70.1 (Table 2).

A difference between the 2 groups in the pain scores and clinical tests exists but is statistically insignificant. For each group, the pain scores were 1.13 and 0.9 ($p=0.09$), respectively, and the Constant scores were 69.8 and 72.5 ($p=0.18$), respectively.

Table 2. Clinical Outcomes after Arthroscopic Rotator Cuff Repair Excluding Small Size Tear (103 cases)

	Preoperative	Postoperative (at 1 year)	*p*-value*
Clinical outcomes			
VAS pain score	6.2	1.2	0.028
UCLA score	17.2	31.9	0.003
Constant score	42.1	70.1	0.000

VAS: Visual Analog Scale, UCLA: University of California at Los Angeles.
*Paired *t*-test.

Table 3. Comparison Analysis of Clinical Outcomes at Postoperative One Year Follow-up Period between Early and Delayed Exercise Groups

	Early exercise group	Delayed exercise group	*p*-value*
Clinical outcomes			
VAS pain score	1.1	0.9	0.12
UCLA score	32.5	33.0	0.09
Constant score	69.8	72.5	0.18

VAS: Visual Analog Scale, UCLA: University of California at Los Angeles.
*Independent *t*-test.

All clinical and pain tests indicate an improved outcome in the delayed exercise group. However, the differences are small and statistically insignificant (Table 3).

Rate of Retear and Rate of Stiffness

Of the 38 patients with retear, most had improved pain scores and clinical outcomes compared to pre-operation. Of these, 7 retear patients expressed discomfort in daily activities and consequently, one patient underwent corrective surgery. Retear was more common in group I, whilst stiffness was more common in group II. The rate of retear is significantly greater in the group I than in group II (43%, 34 out of 79 patients vs. 16.7%, 4 out 24 patients) ($p=0.028$) (Table 4). The rate of stiffness is significantly greater in group II than in group I (20.8%, 5 out of 24 vs. 5.1%, 4 out of 79 patients) ($p=0.03$) (Table 4).

Discussion

The ultimate aim of the repair of the rotator cuff is to maintain the integrity of the repaired rotator cuff, thus relieving pain and recovering its original function. Of the various risk factors for retear, post-operative rehabilitation is the most obvious variable that can be intervened by doctors. However, rehabilitative method and starting period must be chosen appropriately since it coincides with the possibility of post-operative occurrence of stiffness. In fact, stiffness is the most common complication after the repair of the rotator cuff by open surgery.[17,18,26] Accordingly, early rehabilitative exercises were emphasized in the past,[18,27] and Raab et al.[28] argued for the positive effects of early exercises upon pain reduction and recovery of the range of motion. Conversely, the negative effects of early exercise on recovery have also been noted.[4] A number of authors have argued for a prolonged stabilization period, i.e. delayed exercise, after the arthroscopic repair of the rotator cuff,[19,29] but admitted the risk of consequent complications such as a reduced range of motion and the increased rate of stiffness. In fact, Brislin et al.[16] reports a rate of stiffness at 8.6% (23 out of 268 patients) after

Table 4. The Rate of Retear and the Incidence of Stiffness between Early and Delayed Exercise Groups

	Early exercise group	Delayed exercise group	*p*-value*
The rate of retear			
Retear	34 (43.0%)	4 (16.7%)	0.028
Intact	45	20	
The incidence of stiffness			
Stiffness	4 (5.1%)	5 (20.8%)	0.03
Intact	75	19	

*Chi-square test.

the arthroscopic repair of the rotator cuff. In a study of a similar context, Kim et al.[30] investigated the starting period of passive exercise in the repair of rotator cuffs with small- and medium-sized tears. In contrast to our study, they reported no differences between the different starting periods on the rate of retear or on the range of motion. However, it is important to note that we have excluded, unlike Kim et al.,[30] small-sized tears because the rate of retear is generally low in this category. Thus, our study of the repair of rotator cuffs with medium-size or above tears, indicates that delayed passive exercise may reduce the rate of retear. The delayed exercise group had better range of motion at right after surgery, but had significantly higher rates of stiffness at the one year follow-up than the early exercise group. Although the early and delayed exercise groups did not differ in average degree of motion range, delayed exercise seems to be correlated with the occurrence of stiffness.

In accordance with our results, we recommend the delay of passive exercise to reduce the risk of retear after the repair of the rotator cuff with tear of medium size or above. This is recommended in most cases, but in some cases, other protocol is needed, because stiffness is anticipated in particular patients. These patients, characterized by slow recovery of range of motion, should be identified through careful observation of the range of motion in numerous follow-ups and started on early passive exercise to reduce the risk of stiffness.

What is different in our study is the definition of stiffness. In previous studies, such as in the delayed exercise study by Parsons et al.,[19] stiffness was defined as forward elevation below 100° or external rotation below 30°. Our reason for newly defining stiffness is two-fold. Firstly, the range of motion fluctuates markedly between individuals and second, forward elevation greater than 100° can also negatively impact on daily activities.

The first limitation of this study is the small sample size. The risk of retear increases as the size of the tear increases. The number of large and massive tears was 15 in the early group and 6 in the delayed group, and only 1 case of retear was observed in the delayed group. The second limitation is how the presence of retear or stiffness was judged. There is risk of subjective bias depending on the observer as well as selection bias. The third limitation is the learning curve effect of the surgeon. The study includes operations that have been carried out between 2008 and 2012, and thus the skill of the surgeon may have improved across the years. A majority of the delayed exercise group has had surgery after 2010, and therefore we cannot eliminate the possible learning curve effect on the lower rate of retear in this group. Finally, various repair methods were used to repair the rotator cuff tear; single-row repair, double-row repair, or combination techniques. We did not include suture technique as a variable in our study because of numerous reports that it does not affect the post-operative range of motion or risk of retear. However, we feel that the various use of techniques poses as a possible limitation.

Conclusion

The delay of passive exercise after the arthroscopic repair of the rotator cuff may reduce the risk of retear, but increase the risk of stiffness in some patients. Thus, the appropriate starting period of passive exercise should consider the possible occurrence of joint stiffness through careful observation of the range of motion by numerous follow-ups.

References

1. Bennett WF. Arthroscopic repair of massive rotator cuff tears: a prospective cohort with 2- to 4-year follow-up. Arthroscopy. 2003;19(4):380-90.
2. Brox JI, Gjengedal E, Uppheim G, et al. Arthroscopic surgery versus supervised exercises in patients with rotator cuff disease (stage II impingement syndrome): a prospective, randomized, controlled study in 125 patients with a 2 1/2-year follow-up. J Shoulder Elbow Surg. 1999;8(2):102-11.
3. Snyder SJ, Pachelli AF, Del Pizzo W, Friedman MJ, Ferkel RD, Pattee G. Partial thickness rotator cuff tears: results of arthroscopic treatment. Arthroscopy. 1991;7(1):1-7.
4. Boileau P, Brassart N, Watkinson DJ, Carles M, Hatzidakis AM, Krishnan SG. Arthroscopic repair of full-thickness tears of the supraspinatus: does the tendon really heal? J Bone Joint Surg Am. 2005;87(6):1229-40.
5. Galatz LM, Ball CM, Teefey SA, Middleton WD, Yamaguchi K. The outcome and repair integrity of completely arthroscopically repaired large and massive rotator cuff tears. J Bone Joint Surg Am. 2004;86-A(2):219-24.
6. Gazielly DF, Gleyze P, Montagnon C. Functional and anatomical results after rotator cuff repair. Clin Orthop Relat Res. 1994;(304):43-53.
7. Gerber C, Fuchs B, Hodler J. The results of repair of massive tears of the rotator cuff. J Bone Joint Surg Am. 2000;82(4):505-15.
8. Wu XL, Briggs L, Murrell GA. Intraoperative determinants of rotator cuff repair integrity: an analysis of 500 consecutive repairs. Am J Sports Med. 2012;40(12):2771-6.
9. Chun JM, Song JS, Sohn DW. Clinical outcome and causative factor in patients of structural failure after rotator cuff repair. J Korean Shoulder Elbow Soc. 2008;11(1):29-36.
10. Gwilym SE, Watkins B, Cooper CD, et al. Genetic influences in the progression of tears of the rotator cuff. J Bone Joint Surg Br. 2009;91(7):915-7.
11. Tashjian RZ, Farnham JM, Albright FS, Teerlink CC, Cannon-Albright LA. Evidence for an inherited predisposition contributing to the risk for rotator cuff disease. J Bone Joint Surg Am. 2009;91(5):1136-42.

12. Baumgarten KM, Gerlach D, Galatz LM, et al. Cigarette smoking increases the risk for rotator cuff tears. Clin Orthop Relat Res. 2010;468(6):1534-41.
13. Cohen DB, Kawamura S, Ehteshami JR, Rodeo SA. Indomethacin and celecoxib impair rotator cuff tendon-to-bone healing. Am J Sports Med. 2006;34(3):362-9.
14. Galatz LM, Silva MJ, Rothermich SY, Zaegel MA, Havlioglu N, Thomopoulos S. Nicotine delays tendon-to-bone healing in a rat shoulder model. J Bone Joint Surg Am. 2006;88(9):2027-34.
15. Koo SS, Burkhart SS. Rehabilitation following arthroscopic rotator cuff repair. Clin Sports Med. 2010;29(2):203-11.
16. Brislin KJ, Field LD, Savoie FH 3rd. Complications after arthroscopic rotator cuff repair. Arthroscopy. 2007;23(2):124-8.
17. Tauro JC. Stiffness and rotator cuff tears: incidence, arthroscopic findings, and treatment results. Arthroscopy. 2006;22(6):581-6.
18. Mansat P, Cofield RH, Kersten TE, Rowland CM. Complications of rotator cuff repair. Orthop Clin North Am. 1997;28(2):205-13.
19. Parsons BO, Gruson KI, Chen DD, Harrison AK, Gladstone J, Flatow EL. Does slower rehabilitation after arthroscopic rotator cuff repair lead to long-term stiffness? J Shoulder Elbow Surg. 2010;19(7):1034-9.
20. Huberty DP, Schoolfield JD, Brady PC, Vadala AP, Arrigoni P, Burkhart SS. Incidence and treatment of postoperative stiffness following arthroscopic rotator cuff repair. Arthroscopy. 2009;25(8):880-90.
21. Ellman H, Hanker G, Bayer M. Repair of the rotator cuff. End-result study of factors influencing reconstruction. J Bone Joint Surg Am. 1986;68(8):1136-44.
22. Constant CR, Murley AH. A clinical method of functional assessment of the shoulder. Clin Orthop Relat Res. 1987;(214):160-4.
23. Sugaya H, Maeda K, Matsuki K, Moriishi J. Repair integrity and functional outcome after arthroscopic double-row rotator cuff repair. A prospective outcome study. J Bone Joint Surg Am. 2007;89(5):953-60.
24. Goutallier D, Postel JM, Gleyze P, Leguilloux P, Van Driessche S. Influence of cuff muscle fatty degeneration on anatomic and functional outcomes after simple suture of full-thickness tears. J Shoulder Elbow Surg. 2003;12(6):550-4.
25. DeOrio JK, Cofield RH. Results of a second attempt at surgical repair of a failed initial rotator-cuff repair. J Bone Joint Surg Am. 1984;66(4):563-7.
26. Norberg FB, Field LD, Savoie FH 3rd. Repair of the rotator cuff. Mini-open and arthroscopic repairs. Clin Sports Med. 2000;19(1):77-99.
27. Mormino MA, Gross RM, McCarthy JA. Captured shoulder: a complication of rotator cuff surgery. Arthroscopy. 1996;12(4):457-61.
28. Raab MG, Rzeszutko D, O'Connor W, Greatting MD. Early results of continuous passive motion after rotator cuff repair: a prospective, randomized, blinded, controlled study. Am J Orthop (Belle Mead NJ). 1996;25(3):214-20.
29. Trenerry K, Walton JR, Murrell GA. Prevention of shoulder stiffness after rotator cuff repair. Clin Orthop Relat Res. 2005;(430):94-9.
30. Kim YS, Chung SW, Kim JY, Ok JH, Park I, Oh JH. Is early passive motion exercise necessary after arthroscopic rotator cuff repair? Am J Sports Med. 2012;40(4):815-21.