CONSENSUS STATEMENT

The American Society of Shoulder and Elbow Therapists' consensus statement on rehabilitation following arthroscopic rotator cuff repair

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This is a consensus statement on rehabilitation developed by the American Society of Shoulder and Elbow Therapists. The purpose of this statement is to aid clinical decision making during the rehabilitation of patients after arthroscopic rotator cuff repair. The overarching philosophy of rehabilitation is centered on the principle of the gradual application of controlled stresses to the healing rotator cuff repair with consideration of rotator cuff tear size, tissue quality, and patient variables. This statement describes a rehabilitation framework that includes a 2-week period of strict immobilization and a staged introduction of protected, passive range of motion during weeks 2-6 postoperatively, followed by restoration of active range of motion, and then progressive strengthening beginning at postoperative week 12. When appropriate, rehabilitation continues with a functional progression for return to athletic or demanding work activities. This document represents the first consensus rehabilitation statement developed by a multidisciplinary society of international rehabilitation professionals specifically for the postoperative care of patients after arthroscopic rotator cuff repair.

**Level of evidence:** Level V; Expert Opinion

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**Keywords:** Rotator cuff; tears; postoperative rehabilitation; physical therapy; therapeutic exercise; stiffness

The dilemma after rotator cuff repair: Balancing mobility and anatomic healing

Rotator cuff tears affect approximately 30% of the population aged older than 60 years, and the rate doubles to nearly

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60% of the population by age 80 years. Rotator cuff pathology results in approximately 450,000 operations per year, with the direct medical costs in the United States exceeding $7 billion per year. Although recent studies support conservative management for symptomatic full-thickness rotator cuff tears, arthroscopic rotator cuff repair (RCR) for full-thickness tears has actually become more prevalent, with the rate of arthroscopic RCR increasing by 600% over the past 10 years. Arthroscopic repair has replaced open surgery and now comprises greater than 95% of all RCRs in the United States.

Despite positive clinical results, reports of structural failure after arthroscopic RCR can range from 16%-94% per year. Although recent studies support conservative management regarding structural integrity and patient function even during these early time frames, if there are concerns regarding tissue healing. Gaining appropriate healing of the repaired rotator cuff, reduces the risks for failure after arthroscopic RCR.

In this document, we will suggest specific therapeutic interventions that we believe, on the basis of the best available evidence, are safe and effective for patients after arthroscopic RCR. For early, protected self-mobilization activities, such as the table slide or what we have termed the “forward bow,” we believe the crucial threshold is ≤15% electromyographic (EMG) activity of the supraspinatus activity.

In this document, we suggest a 2-week period of strict immobilization and a staged introduction of protected, PROM starting at 2 weeks postoperatively, followed by restoration of active range of motion (AROM) beginning at 6 weeks, with a gradual strengthening progression beginning at postoperative week 12. We acknowledge that some surgeons and scientists believe that a 6-week period of strict immobilization is preferable. We understand the attraction of this approach, but in our opinion, there is no clear human evidence to support strict immobilization versus early, protected RCR with limits of <90° of FE and <30° of ER within the first 6 weeks. In our opinion, an across-the-board recommendation of 6 weeks of strict immobilization for all sizes and types of RCRs is unnecessary and may lead to a false sense of security.

In our opinion, the decision to initiate ROM at 2-3 weeks versus 6 weeks postoperatively should be weighed among the patient, surgeon, and therapist as they select an approach that is in line with a given patient’s situation and goals. We do recommend the more conservative approach, a 6-week period of strict immobilization with delayed start of PROM activities, if there are concerns regarding tissue healing. Gaining PROM too quickly, particularly in repairs with poor tissue quality, is thought to unduly stress the suture-tendon interface. The risks for failure after arthroscopic RCR are well documented and include larger tear size, poor tissue quality, and calcific tendinitis; partial articular surface tendon avulsion-type RCR; concomitant labral repair; or acute, single-tendon cuff repair. However, a recent study has suggested that even for patients with these risk factors, stiffness can be minimized with the addition of an early, protected ER but unweighted FE ROM program, without restriction is effective in avoiding detrimental stiffness (>15° loss at 1 year).
<table>
<thead>
<tr>
<th>Author</th>
<th>Patients</th>
<th>Group 1</th>
<th>Group 2</th>
<th>Results</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Koh et al⁵¹, JBJS, 2014</td>
<td>Included: small- to medium-sized full-thickness tears Excluded: massive and concomitant stiffness or labral lesions</td>
<td>Immobilization for 4 wk; then gradual ROM return</td>
<td>Immobilization for 8 wk; then gradual ROM return</td>
<td>Rates of RC healing were similar between groups. Stiffness was more prevalent in 8-wk group (38% vs. 18%).</td>
<td>Immobilization for 1 more month did not enhance healing but was associated with more prevalent “stiffness.” Early PROM and immobilization for 6 wk are equally safe and effective after RCR.</td>
</tr>
<tr>
<td>Keener et al⁵¹, JBJS, 2014</td>
<td>Included: small- to medium-sized full-thickness tears Excluded: massive and concomitant stiffness or labral lesions</td>
<td>Immediate, therapist-guided PROM</td>
<td>Immobilization for 6 wk; then therapist-guided PROM</td>
<td>ROM, pain measures, and frequency of healed repairs were equal.</td>
<td>Early PROM and immobilization for 6 wk are equally safe and effective after RCR.</td>
</tr>
<tr>
<td>Kim et al⁵⁸, AJSM, 2012</td>
<td>Included: small- to medium-sized full-thickness tears Excluded: massive and concomitant stiffness or labral lesions</td>
<td>Immediate PROM for 4 wk (up to 120° FE)</td>
<td>Immobilization for 4 wk</td>
<td>ROM, pain measures, and frequency of healed repairs were equal.</td>
<td>Early PROM and immobilization for 4 wk are equally safe and effective after RCR.</td>
</tr>
<tr>
<td>Cuff and Pupello⁰, JSES, 2012</td>
<td>Included: full-thickness crescent-shaped supraspinatus tear repaired using transosseous-equivalent suture bridge with SAD Excluded: concomitant labral or biceps procedure; partial-thickness, L-shaped tears; reverse L-shaped tears extending into SubS or IS; glenohumeral arthritis; adhesive capsulitis; revision RTC repairs; workers’ compensation</td>
<td>Immediate PROM (up to 120° FE)</td>
<td>Immobilization with Codman pendulums only for 6 wk (up to 90° FE)</td>
<td>Patient outcomes and ROM measures were equal at 1 y. Heating occurred in 91% of patients in pendulum-only group vs. 85% in immediate PROM group.</td>
<td>Restricting postoperative exercises to pendulums only did not adversely affect ROM and was associated with a higher percentage of patients with healed repairs.</td>
</tr>
<tr>
<td>Lee et al⁶⁷, Arthroscopy, 2012</td>
<td>Included: medium-sized (1-3 cm) or large-sized (3-5 cm) tears repaired without undue tension with single-row repair Excluded: partial, small, and massive tears; SLAP; AC arthritis; DCR; glenohumeral arthritis; workers’ compensation; tenotomy or tenodesis</td>
<td>Immediate ROM (ER and FE) with no reported limits</td>
<td>Immobilization and 6 wk of protected FE ROM to 90°</td>
<td>Similar pain improvement from preoperative levels was reported. Group 2 showed slower recovery than group 1 regarding ER and IR ROM and muscle strength up to 6 mo, but there was no significant difference at 1 y. The retear rate was higher in group 1 than in group 2 (23.3% vs. 8.8%).</td>
<td>Aggressive early motion may increase anatomic failure at the repaired cuff; a gentle protocol with limited ROM would be better for tendon healing.</td>
</tr>
<tr>
<td>Arndt et al⁶, Orthopaedics &amp; Traumatology, 2012</td>
<td>Included: isolated, nonretracted supraspinatus tear, mobile shoulder; stage 2 or lower fatty infiltration; preserved acromiohumeral distance Excluded: extension of tear beyond supraspinatus</td>
<td>6 wk of preoperative therapy + immediate PROM (up to 120°)</td>
<td>6 wk of immobilization</td>
<td>Recovery of flexion and ER in group 1 that appeared to be “stabilizing over time” was reported. The mean Constant score was significantly higher in group 1. However, group 2 had a higher rate of complete healing, although this was not statistically significant.</td>
<td>The rehabilitation protocol that results in better tendon healing has not been identified; the results suggest that passive motion should be allowed because the functional results were better.</td>
</tr>
</tbody>
</table>

**Notes:**

1. **AC**: acromioclavicular; **AJSM**: American Journal of Sports Medicine; **ER**: external rotation; **FE**: forward elevation; **IR**: internal rotation; **JBJS**: Journal of Bone and Joint Surgery; **JSES**: Journal of Shoulder and Elbow Surgery; **PROM**: passive range of motion; **RC**: rotator cuff; **RCR**: rotator cuff repair; **ROM**: range of motion; **SAD**: subacromial decompression; **SLAP**: superior labrum anterior-posterior; **SubS**: subscapularis.
quality, older patient age, fatty infiltration and atrophy, smoking, hypercholesterolemia, and diabetes. These factors should be considered when modifying the proposed staged ROM goals (Table II) in consultation with the referring surgeon.

We have included our suggested rehabilitation guideline (Appendix S1) as a starting point for communication among the surgeon, physical therapist, and patient, and this should align with the surgeon’s approach, concerns he or she may have about the compliance of the patient, and any specific limitations necessitated by tissue quality and healing potential. Our document is not intended to substitute for communication between therapist and surgeon. To the contrary, we offer this document as a glossary for therapist-surgeon communication as we attempt to clarify the necessity and safety of commonly used therapeutic interventions.

**Methods of development**

This guideline evolved after representatives from the American Shoulder and Elbow Surgeons (ASES) approached ASSET about the need for clarification of guiding principles for postoperative rehabilitation after arthroscopic RCR. In response, ASSET identified a panel of members with extensive experience treating patients after arthroscopic RCR to review the literature and begin developing a rehabilitation statement. This panel included members with clinical specialty certifications and terminal research degrees from different geographic regions.

In the development of this guideline, our goal was to cite the best available evidence, relying on randomized controlled trials when available. The panel searched for English-language clinical trials and basic science evidence from multiple databases (Cochrane, PubMed, CINAHL [Cumulative Index to Nursing and Allied Health Literature], and SportDiscus). We searched the following key terms: arthroscopic rotator cuff repair, rehabilitation, exercise, shoulder, scapula, post-operative, and physical therapy. Database searches resulted in 4714 articles; then abstracts were reviewed to merit inclusion as supporting evidence related to rehabilitation after RCR. After review of the evidence, articles were divided into two groups; the first group comprises 14 randomized controlled trials, systematic reviews, and meta-analyses comparing patient outcomes after RCR. The second group of articles (103) was composed of primarily basic science and mechanistic studies, which were included to guide specific interventions (modalities, exercise selection, and progression). Given the timeline for review, assimilation, and reaching a consensus, the references were updated through June 2015 using the same search process.

After the subpanel developed the major principles and time frames guiding rehabilitation, the recommendations were sent to all members of ASSET to review, provide feedback, and develop consensus. In addition, the more contentious aspects of the statement (immobilization time frames, when to initiate AROM, time to restore normal ROM, and so on) were openly debated at subsequent annual meetings of ASSET until consensus was reached. ASSET members also completed a short survey on practice patterns regarding the dosing of exercise, frequency of visits, and management of complications. Those survey results have been incorporated into the recommendations to provide a rationale for rehabilitation decisions not commonly studied in the literature. Finally, an ASES member with extensive experience performing arthroscopic RCR reviewed the statement to provide a surgeon’s perspective. The final protocol (Appendix S1) represents an international consensus rehabilitation statement developed by a multidisciplinary society of rehabilitation professionals (physical therapists, athletic trainers, and occupational therapists) who are members of ASSET. This statement provides key recommendations that represent the best evidence and rationale for the key clinical decisions along the rehabilitation progression. This statement is intended to foster matched expectations among patient, surgeon, and therapist to provide a patient-centered rehabilitation strategy. To our knowledge, this is the first consensus statement developed for the rehabilitation of patients after arthroscopic RCR.

**Key recommendations**

The key recommendations are as follows:

- Protected PROM should be considered during the first 6 weeks after arthroscopic RCR of small to medium tears (<4 cm) to promote the best opportunity for early restoration of ROM without jeopardizing healing or long-term outcomes (evidence category [Strength of Recommendation Taxonomy (SORT)], A).
- Anatomic failure (nonhealing or retear) after arthroscopic RCR is not uncommon (25%-60%) but is not consistently associated with poorer functional outcomes. Anatomic failure is associated with increasing age, poor tissue quality, fatty infiltration, atrophy, smoking, hypercholesterolemia, and diabetes. It tends to occur in the first 3-6 months after surgery. Therefore, with each decision, the rehabilitation clinician should weigh the stresses each intervention places on the rotator cuff relative to its potential value balanced against the implications for healing (evidence category [SORT], B).
- Supervised rehabilitation should monitor ER in neutral abduction and FE ROM as indicators of progress (evidence category [SORT], A).
- Stiffness after arthroscopic RCR at 1 year is not common (3%-10%), but individuals with diabetes, thyroid disorders, acute rotator cuff tears, partial-thickness tears, and adhesive capsulitis may benefit from additional focus on their PROM during the first 6 weeks (evidence category [SORT], B).
<table>
<thead>
<tr>
<th>Initiation phase</th>
<th>Exercise goal</th>
<th>Postoperative weeks 1-6</th>
<th>Postoperative weeks 6-12</th>
<th>Postoperative weeks 8-16</th>
<th>Postoperative weeks 12-20</th>
<th>Postoperative week 20 and later</th>
</tr>
</thead>
<tbody>
<tr>
<td>EMG activity level</td>
<td>EXERCISES*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤15%</td>
<td>PROM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Phase 1</td>
<td>Phase 2</td>
<td>Phase 2-3</td>
<td>Phase 3-4</td>
<td>Phase 4</td>
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<tr>
<td>EMG activity level</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤15%</td>
<td>AAROM or AROM</td>
<td>16%-29%</td>
<td>30%-49%</td>
<td>≥50%</td>
<td>Strengthening</td>
<td></td>
</tr>
<tr>
<td>AAROM or AROM</td>
<td>Pulley FE</td>
<td>Incline FE</td>
<td>Ball roll</td>
<td>Standing dumbbell ER at 0°</td>
<td>Prone horizontal adduction, 10-rep max</td>
<td></td>
</tr>
<tr>
<td>Towel slide or horizontal dusting</td>
<td>Incline FE</td>
<td>Upright wall slide</td>
<td>Upright T-bar AAROM Elevation</td>
<td>Standing dumbbell ER in scapular plane, 10-rep max</td>
<td>Prone ER at 90°</td>
<td></td>
</tr>
<tr>
<td>AAROM supine washcloth press-up</td>
<td>Upright T-bar AAROM FE, active lowering</td>
<td>Upright active FE with no weight</td>
<td>Elastic resistance shoulder flexion</td>
<td>Elastic resistance throwing accelerate</td>
<td>Seated military press</td>
<td></td>
</tr>
<tr>
<td>AROM supine press-up</td>
<td>Upright active FE 1 lb</td>
<td>Aquatic FE fast speed</td>
<td>Side-lying dumbbell ER at 0°, resistance of 25% MVIC</td>
<td>Elastic IR at 90°</td>
<td>Elastic resistance ER at 90°</td>
<td></td>
</tr>
<tr>
<td>CPM in FE</td>
<td>Self-assisted supine FE</td>
<td>Supine elastic band FE</td>
<td>Aquatic FE fast speed</td>
<td>Prosthetic dumbbell ER at 0°, resistance of 25% MVIC</td>
<td>Elastic resistance ER, IR, and forward punch</td>
<td></td>
</tr>
<tr>
<td>ER/IR self-assisted with stick</td>
<td></td>
<td></td>
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</tbody>
</table>

AAROM, active-assistive range of motion; AROM, active range of motion; CPM, continuous passive motion; EMG, electromyographic; ER, external rotation; FE, forward elevation; IR, internal rotation; max, maximum; MVIC, maximum voluntary contraction; PROM, passive range of motion; rep, repetition.

* Exercises were grouped based on published supraspinatus EMG activity.
† Mean EMG activity levels for these exercises span from <15% to >50%, with the study by Hintermeister et al being the only study showing mean values <15%. However, the maximum EMG activity level in their study ranged from 25%-48%; thus, these exercises are best categorized in the 16% through ≥50% categories depending on the resistance level.
• Muscle performance strategies should begin with AROM exercises with the upper extremity in a short-lever or gravity-minimized position with a $\leq 15\%$ supraspinatus EMG activity level, followed by progressive stresses with a longer lever or higher loads (evidence category [SORT], C\textsuperscript{56,59,99,108,110}).

• Patient education is important to success after arthroscopic RCR and should include short-term activity modifications, compliance with home exercises, and resolution of shoulder stiffness balanced with long-term healing of the rotator cuff (evidence category [SORT], B\textsuperscript{1}).

ASSET postoperative RCR rehabilitation guideline: promoting healing of RCR through milestone-based patient progression

Appendix S1 contains the detailed rehabilitation guideline. The following information serves as the background and rationale for each phase of rehabilitation.

Typically, postoperative rehabilitation protocols describe the specific exercise or activity progression based on healing timelines after surgery. However, in addition to the passage of time from surgery, there are many other important variables that need to be considered to properly advance a patient’s rehabilitation. A protocol that offers flexibility of progression based on when patients reach specific clinical goals or criteria may be more appropriate. Most rotator cuff tears arise not from an acute injury but as a result of gradual degeneration of the tendon. Given the fact then that rotator cuff tissue is degenerative, each rehabilitation program after RCR should be approached with caution. Therapists need to understand that, from a biomechanical standpoint, the repaired tendon does not approach normal levels of elasticity or strength until at least 6 months postoperatively\textsuperscript{10,37}. Furthermore, due consideration should be given to variables that have been shown to affect healing such as age and activity level of the individual, duration of symptoms\textsuperscript{6,46}, extent of the tear\textsuperscript{52}, number of tendons involved\textsuperscript{52}, rotator cuff tissue quality, atrophy of muscles\textsuperscript{24,36,40,43,52,97,104}, associated shoulder pathology, and method of surgical repair\textsuperscript{10,11,35,37,57}. Therefore, to plan an appropriate rehabilitation program, close communication with the surgeon is vitally important to discuss associated pathology, tissue quality, surgical technique, and integrity of the repair.

Most patients after arthroscopic RCR only need to complete the first 3 phases of rehabilitation (Appendix S1). These phases comprise phase 1, in which exercises are generally considered to be passive exercises that minimize loads across the repair; phase 2, in which expanded flexibility exercises, as well as the transition from active-assistive exercises to active exercises to very light resistive exercises, begin in a way that gradually increases but maintains controlled loads to the repair; and phase 3, in which the emphasis on resistive exercise increases to focus on muscle hypertrophy and achieving the absolute force production to perform basic functional tasks. However, a patient who is a laborer or active recreational or competitive athlete will require phase 4 to restore maximal strength and power, as well as the endurance needed to participate in higher-level activities.

Although the ultimate goal of surgery and rehabilitation is a return to optimal functional improvement,\textsuperscript{12,211} clinician-rated impairments such as pain, ROM, strength, and movement quality help define the attainment of clinical milestones and are used to guide rehabilitation progression. Impairments should be quantified to the extent possible with the use of an inclinometer or goniometer to measure AROM and a handheld dynamometer to assess muscle performance. Assessing muscle activation after RCR is necessary to determine the extent of recovery, especially in the later phases of rehabilitation. There are no studies declaring when it is safe to generate maximal effort after RCR. However, numerous authors have assessed muscle performance using a handheld dynamometer beginning at 4 months, with no reports of injury\textsuperscript{2,45,65,89,96}. Thus, it is reasonable to begin assessing submaximal muscle performance beginning at 4 months, with maximal muscle testing delayed until 9-12 months postoperatively. Pain should be assessed with a patient-rated numeric pain rating scale (NPRS\textsuperscript{80}). Function of the periscapular musculature can be screened with visual observation of active elevation or rehabilitation exercises\textsuperscript{76,102,109}. Isolated testing of the periscapular muscles can be used to help make sense of an abnormality detected with visual observation.

In addition to monitoring impairment-based milestones, it is important to collect patient-rated outcome measures to comprehensively assess response to treatment. Region-specific scores such as the ASES form\textsuperscript{60} or the more robust Penn Shoulder Score\textsuperscript{66} have established measurement properties and are recommended for assessment after RCR. The disease-specific Western Ontario Rotator Cuff Index provides the most responsive tool after RCR but is cumbersome to use clinically\textsuperscript{48,60,66,79,112}.

Clinician-rated impairments are expected to improve every 1-2 weeks and will help to determine the rate of progression through this rehabilitation guideline. Patient-rated outcome measures should be assessed every 2-4 weeks to ensure symptoms and patient function are keeping pace with clinician measures.

Phase 1: 0-6 weeks

Patient education

Perhaps no component of postoperative management is more important than patient education. The first step in this process is open communication between the rehabilitation provider and the patient, family, and surgeon. Thorough and timely patient education is important to help empower patients so that they can share responsibility for rehabilitation decisions. Patients who exhibit poor compliance with postoperative restrictions in the first 6 weeks show a relative risk of retear or nonhealing that is 152 times higher than that of compli-
ant patients. Important points of emphasis in education include understanding the pathology and procedure, time frame for recovery, and associated precautions during each phase. The rehabilitation clinician should clearly communicate the expectations for patient compliance with restrictions, the identification of patient goals, the importance of a home exercise program, and the short- and long-term prognosis for the patient based on his or her pathology and situation. Specific education components for this time frame are detailed in Appendix S1.

Modalities
Although passive modalities have not been shown to alter the long-term outcome after shoulder surgery, cryotherapy and transcutaneous electrical neuromuscular stimulation have been shown to decrease opioid use in the first 72 hours and help control postoperative pain. Cryotherapy has been shown to decrease pain over the first 24 hours postoperatively, with a better potential for sleep and reduced need for pain medication. Furthermore, patients receiving cryotherapy in the first 10 days postoperatively reported diminished shoulder pain and swelling, less pain during therapy, and a more tolerable rehabilitation. Neuromuscular electrical stimulation has been shown to improve posterior cuff function after RCR. Therefore, transcutaneous electrical neuromuscular stimulation or neuromuscular electrical stimulation may be considered based on the individual patient’s needs and resources; however, the impact of these modalities on long-term outcomes is not clear.

Passive range of motion
PROM has been suggested to be beneficial after RCR and has been included as an early component of our rehabilitation program. Our analysis of recent randomized controlled trials leads us to conclude that if performed correctly, PROM exercises can be used to minimize any chance for postoperative ROM loss while simultaneously protecting the repair (Table I). To achieve these 2 competing goals, we recommend limiting the amount of ROM to the staged goals. Elevation of the arm in the scapular plane and ER with the arm in 20°-30° of abduction are the only planes of glenohumeral motion we recommend for this time frame. Even within the ranges and planes we consider “safe” for the repair, repeated cyclic loads can have potentially detrimental effects on the suture-tendon interface. Therefore, we recommend performing all exercises with only as many repetitions as necessary to achieve the staged ROM goals. In this first phase of rehabilitation, the exercises chosen for PROM should have levels of EMG muscle activity ≤15% (Table II) and should be performed only in a gentle, comfortable manner as detailed exercises that meet but do not exceed the staged ROM goals in Table III and Appendix S1.

Although the tension on the repair can only be estimated, muscle activity level, the plane of motion, the absolute degree of ROM, cyclic loading, and the weight and length of an individual’s upper extremity are likely to affect the tension on the repair. Whereas all these factors are important, exercise prescription (passive and active) for the patient with an RCR should be primarily based on known muscle activity levels, when possible, because these are the best available estimate of stress placed on the rotator cuff tendon. Yet, the correlation between EMG activity and tension in musculotendinous structures has only been established during isometric contractions, with extrapolation of these data to other types of motions. Because even passive exercises show minimal muscle activation, the treating clinician needs to recognize that stress occurs on a sliding scale rather than in discrete levels as exercises are progressed from PROM to active-assistive range of motion (AA-ROM), AROM, and resisted exercises. Yet, because stress imparted by rehabilitation exercises cannot be measured clinically, EMG evidence does offer at least some ability to match the progression of therapeutic exercises’ likely stress on the repaired rotator cuff.

Suggested exercises are divided into categories based on previous recommendations and then subdivided and modified to match the milestones and suggested phases of rehabilitation (Table III). Exercises are classified using the EMG activity level of the supraspinatus to anticipate the projected stress on the RCR. These exercises can be used to select and progress in a manner consistent with the suggested phases of rehabilitation. Table III is not meant to be an exhaustive list of EMG-supported exercises; it includes only the most commonly used rehabilitation exercises, which have documented EMG data. Specific EMG percentages are not listed for each exercise because differences in study design, instrumentation, and experimental technique, including whether mean or maximum EMG values were reported, make comparisons of specific percentages between studies inappropriate. We hope grouping exercises into broad categories of EMG activity provides clinicians with an avenue to titrate the level of exercise intensity to match the desired RCR stress.

### Table III: Immediate start to PT (postoperative day 1) staged ROM goals and approximate targets

<table>
<thead>
<tr>
<th></th>
<th>PFE</th>
<th>PER at 20° of abd</th>
<th>PER at 90° of abd</th>
<th>AFE</th>
</tr>
</thead>
<tbody>
<tr>
<td>POW 2</td>
<td>60°-90°</td>
<td>0°-20°</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>POW 6</td>
<td>90°-120°</td>
<td>20°-30°</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>POW 9</td>
<td>130°-155°</td>
<td>30°-45°</td>
<td>45°-60°</td>
<td>80°-120°</td>
</tr>
<tr>
<td>POW 12</td>
<td>140°-WNL</td>
<td>30°-WNL</td>
<td>75°-WNL</td>
<td>120°-WNL</td>
</tr>
</tbody>
</table>

The presented data are targets and should not be exceeded. They may vary based on intraoperative tissue quality findings by the surgeon. When the initiation of PT is delayed, the entire progression is delayed by the same time frame. Interventions and range of motion (ROM) should not be forceful or painful. The larger ROM value is the maximum recommended ROM at a given time frame and represents the goal at that given time frame.

**POW**, passive week; **PT**, physical therapy; **AFE**, active forward elevation; **PER**, passive external rotation; **PFE**, passive forward elevation; **POW**, postoperative week; **PT**, physical therapy; **WNL**, within normal limits.
**Phase 2: 6-12 weeks**

During the postoperative time frame of 6-12 weeks, animal studies have shown that Sharpey fibers, which bind the healing tendon to the bone, are not present in any considerable number. Therefore, repair strength is likely only 19%-30% of normal at 6 weeks and 29%-50% of normal at 12 weeks\(^\text{38}\). Although tendon-bone healing is thought to be sufficient to withstand low levels of muscle activity or passive tension, moderate to large loads or repetitive activities are not recommended. As the patient completes this phase (approximately 12 weeks), he or she typically displays near full PROM without pain; active elevation of the arm to at least 120° without compensation; and the ability to perform light, nonrepetitive activities of daily living or work tasks below shoulder level without difficulty or pain. Primary rehabilitation objectives for phase 2 include expanded PROM and stretching, introduction of AAROM or AROM exercises, and continued patient education emphasizing compliance with postoperative restrictions.

In phase 2, PROM and stretching exercises are progressed regarding both EMG activity level and planes of motion. On the basis of progressive healing of the tendon-bone interface, stretching interventions can advance to the 16%-29% level of muscle activity. Hence, exercises such as pulley and cane-assisted exercises can be included in this phase if the patient can perform them comfortably without shrugging other scapular compensation. If ROM restrictions are identified, ROM exercises can expand to planes of motion such as ER in increasing angles of abduction, internal rotation in abduction, horizontal adduction, and functional internal rotation (behind the back). Because these motions and positions are thought to place tension directly on the repair, these stretches are typically included only in the latter half of phase 2 (after week 9), should be prescribed judiciously, and should be performed only to the level of a light “stretch” sensation.

Muscle performance exercises (ie, light “strengthening”) should not begin until the patient’s pain level is well controlled (<2 of 10 on NPRS) and sufficient passive mobility is achieved, as evidenced by reaching staged PROM goals. Similar to the continuum of PROM exercises, strengthening exercises likely apply a progressive continuum of passive and active stresses on the repair based on the applied load. Thus, we recommend that muscle performance exercises should initially target AAROM exercises and then AROM exercises. We recommend beginning with exercises with documented EMG activity levels ≤15% (Table III), consistent with the PROM exercises outlined in phase 1. In general, AROM and AAROM exercises within this category (≤15% muscle activity level) use slow-speed motions in an aquatic environment\(^\text{35}\), gravity-minimized positions such as supine or side lying, and/or short lever arms to promote rotator cuff and deltoid balance\(^\text{21,22,67}\).

Once the patient tolerates the introduction of active loading, elevation can be progressed to exercises that show EMG activity levels between 16% and 29% (Table II). In the early part of this progression, the patient is generally in the upright position, moving the upper limb with assistance and then advancing to independent, unsupported elevation later in this phase of rehabilitation. Because the repair is still not biomechanically mature, we suggest avoiding excessively loading the healing tendon, as indicated by fatigue, pain, or altered patterns of movement.

The wall slide or wall walk exercise is the only AAROM exercise that has conflicting evidence regarding its EMG category (Table II). We placed the wall slide and wall walk in the category of 16%-29% EMG activity level because 2 of 3 studies documented muscle activity at this level\(^\text{36,74,113}\). Clinically, we believe the wall slide or wall walk is not appropriate to use in the early stages of phase 2 but, instead, is more appropriately used at the end of this phase, once the patient can actively elevate the arm to at least 130° without pain. In other words, the wall walk or wall slide has some utility in this phase, but this utility is more to build endurance for active elevation rather than as an assist for improving elevation ROM.

As active elevation improves, light, directed muscle activation can begin below chest level for the deltoid, rotator cuff, and scapular muscle. In our opinion, 4 key exercises are ER (infraspinatus and teres minor), internal rotation (subscapularis), row (posterior deltoid and periscapular muscles), and short lever FE or forward reaching (anterior deltoid and supraspinatus). Although we recommend pain-free isotonic, elastic resistance, or closed-chain exercises in the 16%-29% EMG activity range for phase 2 strengthening activities, caution needs to be used because muscle activation can be as high as 50% based on the level of resistance and exercise technique that are used (Table III). For example, active elevation against gravity produces 16%-29% supraspinatus activity if 0-1 lb of resistance is used but ≥50% supraspinatus activity if 3-4 lb of resistance is added to the arm\(^\text{36,73,107,110}\). Likewise, the activation level of the supraspinatus can be quite variable for the motions of ER, internal rotation, and forward punching when performed against elastic resistance\(^\text{22,47,83}\). The difficulty level of these exercises is based primarily on how the elastic resistance is applied (elasticity of band, amount of pre-tension, and percent of band elongation during exercise). Therefore, we recommend caution when prescribing these exercises during phase 2 rehabilitation. To maintain supraspinatus activity within the 16%-29% level, elastic bands should provide no more than 2-3 lb of resistance and be used through only a small ROM.

Isotonic progressions actually begin with only gravity for resistance and progress to no more than 1-2 lb for resistance in this phase of rehabilitation to maintain supraspinatus activity in the ≤16%-29% category. We advocate using the thumb-up “full can” position for assistive, active, and resisted elevation exercises because it provides better subacromial clearance\(^\text{31}\), better scapular mechanics\(^\text{103}\), and equal rotator cuff activation compared with the thumb-down “empty can” position. Closed-chain exercises at the 16%-29% EMG activity level including static quadruped and tripod positions...
may be useful in this phase to facilitate rotator cuff contraction and scapular muscle activation.

Irrespective of the type of muscle performance exercises that are chosen, the focus of these activities is trying to impart a stimulus for tendon healing by focusing on movement quality and endurance while working against relatively low loads. Unfortunately, there are no objective measures of the biomechanical effect of exercise on the rotator cuff tendon. Clinicians are reminded that overly aggressive loading can result in a retear, which—during this time frame—is most often attributed to the suture–rotator cuff interface as opposed to complete tendon failure.

Logically, it would seem that isometric exercises could be considered for restoring muscle function because there is no motion that would otherwise stress the repair. However, it is critical that patients and clinicians understand that maximal isometric exercises result in higher forces on the repair than AROM or concentric contractions. Thus, we recommend great caution when prescribing isometric rotator cuff exercises and only suggest their use if the patient understands the concept of submaximal activation. By contrast, isometric exercises for the periscapular muscles, deltoid, and trapezius are thought to be safe given the low levels of rotator cuff activity. The therapist also needs to be alert for problems such as scapular dyskinesia, poor core stability, or spinal hypomobility. Specific interventions should be added as needed to target these problems as part of a comprehensive rehabilitation program.

**Phase 3: 12-20 weeks**

In animal studies, the repair had between 29% and 50% of normal strength at 12 weeks, and by 15 weeks, the bone-to-tendon healing was nearly mature. However, it is important to remember that this information may not be directly applicable to humans and even so describes a “best-case” scenario. Patient factors such as poorer tissue quality, as well as the presence of comorbidities, slow the healing process, but in general, tendon-to-bone healing is considered sufficient to allow strengthening in this 12- to 20-week time frame as long as the addition of resistance is gradual and only commensurate with the patient’s abilities, comfort level, and long-term goals. Patients who have not yet met ROM milestones or are still having pain should not be progressed. The EMG studies we cite in this guideline represent levels of muscle activity in “normal” patients who have full ROM. Although there are no studies on the topic, trying to actively elevate a shoulder in the presence of restrictions of passive mobility likely produces levels of muscle activation well above the levels documented in normal patients. To that point, it is our experience that attempting to “strengthen” a “stiff” shoulder merely increases pain and actually results in more restricted ROM. Therefore, although strengthening is the primary activity of this phase, continued emphasis on maintaining PROM is crucial. Differentiating a shoulder with PROM restrictions (ie, “stiff”) from a painful shoulder with associated muscle guarding is difficult. Furthermore, “stiff” versus “painful” situations require different therapeutic interventions. Because this is a common but difficult situation, this scenario is covered in more detail in the “Management of complications” section, as well as Appendix S2.

Evidence suggests that strengthening exercises in phase 3 can safely progress to the 30%-49% EMG activity level for most patients (Table II). Therefore, resistance can increase as appropriate for the strengthening exercises initiated in phase 2, below–cervical level strengthening exercises, and full-can strengthening. To keep supraspinatus activity level <50%, resistance levels for elbow–extended or long-lever elevation should be limited to 0-2 lb. This level of resistance is generally complementary with many patients’ functional demands, so higher levels of resistance are often unnecessary. Similar to our recommendation that sufficient passive elevation is the milestone indicator for the initiation of muscle performance exercises, we recommend that only those patients who show adequate tolerance to resisted elevation in the scapular plane (“full can”) should attempt overhead strengthening. For most patients, phase 3 concludes their rehabilitation after arthroscopic RCR.

**Phase 4: 20-26 weeks**

Phase 4 comprises advanced strengthening exercises and is appropriate only for patients whose work or recreational demands require loads or positions not achieved during phase 3 strengthening (eg, patients who engage in heavy manual labor or routinely participate in overhead athletics). The rehabilitation clinician is reminded that very few patients recovering from arthroscopic RCR fall into this category. To help patients set realistic expectations, it is strongly recommended that time frames and ultimate recommendations for returning to demanding activities be clearly discussed early in the postoperative period and reinforced throughout the rehabilitation process.

It is generally believed that strengthening exercises that show ≥50% EMG activity levels can be safely initiated in this phase (Table II). This includes the progression of exercises begun previously but also includes new exercises that are meant to replicate the positions or forces the patients will encounter when they return to their job or sport. The rehabilitation clinician is reminded that caution should still be exercised during this phase of rehabilitation. For 2- to 4-cm tears, if a retear is going to occur, the retear happens most often during the first 6 months postoperatively. Details on functional progressions are provided in Appendices S1 and S2.

**Frequency and format of supervised rehabilitation**

The ideal form and frequency of rehabilitation after RCR are still a matter of debate. Buker et al showed that patient education and a program of home exercises resulted in similar...
Finally, when patients scheduling 1-2 visits per week in phase 1 and then 2 reported treating patients after uncomplicated RCRs for regions, or risk factors regarding healing or stiffness. Overall, frequency of 1 time a week during phase 1 (0-6 weeks) was particularly during the second 6 weeks.

The frequency of physical therapy follow-up visits will vary based on many factors including patient health status, surgery specifics, resources, patient goals, and clinician preferences. To our knowledge, there is no direct research linking the number of rehabilitation visits to patient outcomes. However, published reports suggest that physical therapy visit totals range from 12-28 visits after RCR. On the basis of a survey of usual practice among ASSET members, a visit frequency of 1 time a week during phase 1 (0-6 weeks) was most common. ASSET members then increase or decrease the frequency of follow-up visits based on patient progress balanced against factors such as pain, impairments in other regions, or risk factors regarding healing or stiffness. Overall, 90% of ASSET members who responded to the practice survey reported treating patients after uncomplicated RCRs for <25 total visits, with the vast majority (70%) of ASSET respondents scheduling 1-2 visits per week in phase 1 and then 2 visits per week for phases 2-4 as needed.

### Management of complications

Phase-to-phase progression through our rehabilitation guideline is based on achievement of milestones. If impairment and criteria-based milestones are not reached, progressing to the next phase is likely not appropriate. If milestones are not being reached, collaboration with the referring surgeon should occur to adjust the rehabilitation program and goals accordingly. Signs and symptoms suggesting the patient is not ready to advance to the next phase include excessive complaints of pain (≥3 of 10 for phase 1 and ≥2 of 10 for phases 2-4), lack of achievement of the lower range of the staged ROM goals, noncompliance with the home exercise program, and failure to adhere to healing precautions.

Complications related to postoperative pain and stiffness are not unexpected after arthroscopic RCR, especially in the first 3 months. Addressing this challenge is a critical role for the rehabilitation professional. A patient who presents with ROM that does not meet the lower end of the staged goals should be evaluated in terms of his or her comprehension of the rehabilitation program, pain levels, and passive restrictions of ROM to provide a personalized adaptation of the guidelines to that patient’s presentation. Appendix S2 provides a clinical decision-making model for managing the patient who presents with deficits in ROM. The primary clinical decision is to determine whether ROM deficits are due to excessive pain or true loss of motion. This assessment begins during the first postoperative visit and is continually re-evaluated throughout the rehabilitation process. It is not uncommon to experience a slight decrease in ROM in the late phases of rehabilitation because of increased activity levels, a new focus on strengthening activities, and less time devoted to ROM exercises. For example, if at 12 weeks postoperatively, a patient is having greater than expected pain (4 of 10 on an NPRS) with less ROM than anticipated (110° of FE and 30° of ER), the focus should remain on basic PROM activities until the expected pain and ROM milestones are reached. When surveyed and presented with a situation such as this, ASSET members ranked “increasing the aggressiveness of the stretching” last when presented with strategies to address this clinical situation. Instead, the response selected most commonly by ASSET members was to “increase the frequency of home exercises” with the rationale that a patient with higher than expected levels of pain will only have even greater levels of pain if aggressive stretching is used. By contrast, stretching more often but less aggressively should simultaneously reduce pain and improve ROM. If a situation arises in which a patient is deviating from expected ROM targets, it is important to continually communicate with the patient and referring surgeon and work together to adjust the treatment plan, goals, and timelines for progression.

Another common complication during rehabilitation after arthroscopic RCR is the presence of a lag of active elevation behind PROM values for FE. Under the best of circumstances, this is simply a matter of timing as passive restrictions are targeted before the patient is expected to build muscle performance. However, a lack of power in elevation can also signify either poor muscle coordination or, more ominously, a retear of the rotator cuff. Perhaps one of the easiest ways to differentiate these two situations is to assess the ability of the patient to actively maintain end-range elevation when passively placed there by the therapist. If the patient can maintain this position, then the lag of active motion is likely related to poor coordination and the therapist should focus on neuromuscular strategies such as manual facilitation exercises or the use of gravity-minimized positions to target positional strength at end-range elevation. Conversely, inability of the patient to maintain end-range elevation after being passively placed there can signify a retear of the rotator cuff. In this scenario, the referring surgeon should be contacted, particularly if an active lag is also present for ER.

Finally, patients who have high expectations for their return to activity tend to push their rehabilitation progression and may need longer periods of supervised rehabilitation. The al-
and loads that arise from positioning of the shoulder and active muscle contractions need to be carefully considered. Around 4-5 months postoperatively, work- and sport-specific rehabilitation activities can commence if they are in line with the patient’s goals and situation. The guideline provides a progression and summative protocol in Appendix S1. Appendix S2 includes an algorithm to assist with clinical decision making to address postoperative complications or advanced functional progressions.

Conclusion

Rehabilitation of the surgically repaired rotator cuff is a common challenge to the patient, surgeon, and rehabilitation professional. Recent randomized controlled trials have shed light on the transient nature of stiffness and the potential for nonhealing or retear of the repair with early, more aggressive mobilization. Yet, most ASSET members still work with surgeons who use passive, limited ROM within the first 6 weeks after surgery. In addition, there is no level 1 evidence for other decisions that rehabilitation clinicians must make after arthroscopic RCR. To that end, we have attempted to summarize the available scientific evidence and presented a consensus statement for postoperative rehabilitation after arthroscopic RCR from the members of ASSET.

The goals of postoperative shoulder rehabilitation are to re-establish full, symmetrical passive and active motion; to balance glenohumeral and scapulothoracic force couples; and to restore pain-free function to the shoulder. There are many factors that go into surgical and postoperative decision making that potentially influence the integrity of the repair and the ultimate outcome. Therefore, communication and coordination of care between surgeon and rehabilitation professional are essential to optimize outcomes. In addition, rehabilitation should be individualized, even beyond these guidelines, according to patient factors (age, expectations, and health status) and rotator cuff tear (size, chronicity, and tissue quality).

Within the purview of the rehabilitation clinician, the approach we put forth here focuses on controlled, protected additions of load to promote healing and remodeling of the repair. The key conflict of rehabilitation is promoting mobilization of the shoulder while avoiding excessive stress on the repair. In that vein, we favor passive, limited ROM starting within the first 6 weeks postoperatively. Once passive mobility is established and the repair begins to sufficiently heal, active motions can begin. Rehabilitation loads on the RCR progress from concentric motions with short levers and gravity-minimized positions to longer levers performed against the resistance of gravity. When the repair is sufficiently strong (approximately 12-16 weeks), progressive resistance training is the primary focus of rehabilitation. However, because most retears occur within the first 6 months postoperatively, the rehabilitation clinician is reminded that healing of the repair is paramount and loads that arise from positioning of the shoulder and active muscle contractions need to be carefully considered. Around 4-5 months postoperatively, work- and sport-specific rehabilitation activities can commence if they are in line with the patient’s goals and situation. The guideline provides a progression and summative protocol in Appendix S1. Appendix S2 includes an algorithm to assist with clinical decision making to address postoperative complications or advanced functional progressions.

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Appendix

Supplementary material

Supplementary data to this article can be found online at doi:10.1016/j.jse.2015.12.018.

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