The postoperative rehabilitation program is critical to the success of surgical treatment of rotator cuff injury. Numerous rehabilitation protocols for the management of rotator cuff disease exist and are primarily based on anecdotal clinical observation. Millett and colleagues\textsuperscript{1} described a commonly used rehabilitation protocol consisting of passive range of motion for the first 6 weeks followed by active range of motion starting in the seventh postoperative week. The rationale for the prescribed rehabilitation protocol was based on “empiric clinical experience.” Stiffness is the most common complication after rotator cuff repair, independent of repair technique.\textsuperscript{2} As a result, many surgeons start aggressive rehabilitation early to prevent postoperative stiffness. However, multiple clinical studies show that early motion may result in devastating consequences. For example, in the presence of rotator cuff muscle atrophy, a 25\% to 94\% chance of recurrent cuff tear has been reported.\textsuperscript{3,4} Results obtained after revision rotator cuff repairs are inferior to those of primary repairs.\textsuperscript{5} Therefore, it is imperative to avoid the temptation of beginning motion or strengthening too early to limit the number of re-tears that occur. In the authors’ experience, stiffness is a complication that is much easier to overcome than recurrent cuff tears. Furthermore, the literature has shown that treatment for postoperative stiffness is effective and satisfactory to the patient.\textsuperscript{6,7} Arthroscopic lysis of adhesions and capsular release are reliable in restoring the range of motion for those patients who develop clinically significant postoperative stiffness after rotator cuff repair.\textsuperscript{6,7}
CUSTOMIZED REHABILITATION

A rehabilitation program that best allows for tendon to bone healing while preventing shoulder stiffness has not definitively been established. This is a matter that requires careful judgment because an overly conservative approach tends to promote stiffness, whereas an overly aggressive tactic can result in recurrent tears. The best clinical results (restoration of strength, motion, and relief of pain) after rotator cuff repair are achieved with the use of a customized rehabilitation protocol to optimize postoperative range of motion while maintaining rotator cuff integrity.

After repair of large to massive rotator cuff tears (tears greater than 5 cm or involvement of more than 2 tendons), the authors have adopted a conservative rehabilitation protocol (Box 1). Because of the precarious nature of these repairs, with reported retear rates as high as 94%, this rehabilitation protocol avoids potentially destructive high strains at the repair site in the early postoperative period and encourages more parallel collagen orientation and improved mechanical properties in the healed rotator cuff. In addition, by delaying strengthening until postoperative 3 to 4 months, the conservative protocol allows Sharpey fibers to form before stressing the repair with resistive exercises (as previously shown in primates). Thus, the conservative rehabilitation protocol is recommended for patients with large to massive tears.

Some patients who have undergone rotator cuff surgery have a higher-than-average risk for the development of postoperative stiffness. This group includes patients with coexisting calcific tendinitis, adhesive capsulitis, partial articular supraspinatus tendon avulsion (PASTA)-type rotator cuff repair, concomitant labral repair, and single-tendon rotator cuff repair. For these patients, a modified, more accelerated rehabilitation program is used (Box 2). The patients in this group begin closed-chained overhead motion (table slides) immediately after the surgery (Fig. 1). These patients can tolerate the small additional strain at the repair site without increasing the incidence of recurrent tears. Early closed-chained overhead motion helps keep the rate of stiffness quite low in this high-risk group of patients (less than 1%). For patients who fall into the high-risk category, the authors institute the accelerated rehabilitation protocol.

UNDERSTANDING POSTOPERATIVE STIFFNESS

Much of the protocol described in this article is based on the authors’ data on postoperative stiffness after arthroscopic rotator cuff repair. A review of the literature reveals that the rate of postoperative stiffness after rotator cuff repair is from 0% to 14%. The authors used a conservative rehabilitation protocol for all their patients with arthroscopic rotator cuff repair, and their data showed a comparable overall rate (4.9%) of postoperative adhesion formation and motion restriction requiring a secondary arthroscopic release. However, certain risk factors associated with an increased prevalence of stiffness were identified among patients positive for selected risk factors. In the study, the development of clinically significant stiffness requiring arthroscopic capsular release and lysis of adhesions was more prevalent in patients with rotator cuff repair who had coexisting calcific tendonitis (16.7%), adhesive capsulitis (15%), PASTA-type rotator cuff repair (13.5%), concomitant labral repair (11%), or single-tendon rotator cuff repair (7.3%). A total of 231 of 489 patients undergoing arthroscopic rotator cuff repair were positive for at least 1 of these conditions, and 18 (7.8%) of these patients developed stiffness, whereas only 6 (2.3%) of 258 patients negative for all of these risk factors developed stiffness. As a result of this study, the authors have elected to treat all patients with rotator cuff repair who are not a part of the high-risk patient group with the conservative rehabilitation protocol.
A second study was conducted using a customized rehabilitation protocol based on risk factors for stiffness. This study showed that the prevalence of postoperative stiffness was reduced dramatically in the high-risk patient group in comparison to the earlier study. The purpose of the second study was to determine the benefits of

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**Box 1**
Rehabilitation protocol following arthroscopic repair of massive rotator cuff tears

<table>
<thead>
<tr>
<th>Preoperative period</th>
</tr>
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<tbody>
<tr>
<td>Surgeon-directed counseling on rehabilitation plan</td>
</tr>
<tr>
<td>Give patient therapy kit and instruct on initial use</td>
</tr>
<tr>
<td>Therapy kit: polyvinyl chloride (PVC) cane, rope and pulley, and graduated elastic strengthening bands</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Immediate postoperative period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient’s arm placed in sling with small pillow (Ultra-Sling; DJ Ortho, Carlsbad, CA, USA)</td>
</tr>
<tr>
<td>Surgeon gives patient and family specifics of rehabilitation plan</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Postoperative weeks 0 to 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Postoperative day 1 to 10 at initial follow-up, surgeon-directed reinforcement of home rehabilitation plan</td>
</tr>
<tr>
<td>Remove sling 3 times per day for</td>
</tr>
<tr>
<td>Active motion of hand, wrist, and elbow</td>
</tr>
<tr>
<td>Passive external rotation of shoulder with arm at side (use PVC cane)</td>
</tr>
<tr>
<td>Limited to $0^\circ$ (straight ahead) for massive tears and subscapularis tears</td>
</tr>
<tr>
<td>No active assisted motion</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Postoperative weeks 7 to 16</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discontinuation of sling and continuation of previous exercises</td>
</tr>
<tr>
<td>Advance passive external rotation with cane (limit at external rotation of opposite shoulder)</td>
</tr>
<tr>
<td>Start table slides and rope and pulley overhead stretch</td>
</tr>
<tr>
<td>Still No active assisted motion</td>
</tr>
<tr>
<td>No strengthening</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Postoperative months 4 to 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Continue previous stretching exercises</td>
</tr>
<tr>
<td>Add internal rotation stretches</td>
</tr>
<tr>
<td>Begin strengthening program with graduated elastic bands</td>
</tr>
<tr>
<td>Internal and external rotation with arm at side (deltoid and rotator cuff)</td>
</tr>
<tr>
<td>Curl and low row exercise (biceps and periscapular muscles)</td>
</tr>
<tr>
<td>No heavy overhead lifting and no acceleration of arm in sport</td>
</tr>
<tr>
<td>Patient is given option of using therapist to assist in implementation of our plan</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Postoperative months 6 to 12</th>
</tr>
</thead>
<tbody>
<tr>
<td>May progress to using light weights in gym</td>
</tr>
<tr>
<td>Massive cuff tear patients continue overhead lifting restriction and sport restriction until 1 year</td>
</tr>
</tbody>
</table>
a modified, accelerated physical therapy protocol in reducing the prevalence of post-operative stiffness after arthroscopic rotator cuff repair for patients having at least 1 of the 5 risk factors mentioned earlier. During the 17-month study period from September 2006 to January 2008, the senior author (SSB) performed 198 arthroscopic rotator cuff repair procedures.

**Box 2**

Modified rehabilitation protocol following arthroscopic rotator cuff repair for patients at high risk for stiffness

**Preoperative period**
- Surgeon-directed counseling on rehabilitation plan
- Give patient therapy kit and instruct on initial use
- Therapy kit: PVC cane, rope and pulley, and graduated elastic strengthening bands

**Immediate postoperative period**
- Patient’s arm placed in sling with small pillow
- Surgeon gives patient and family specifics of rehabilitation plan

**Postoperative weeks 0 to 6**
- Postoperative day 1 to 10 at initial follow-up, surgeon-directed reinforcement of home rehabilitation plan
- Remove sling 3 times per day for:
  - Active motion of hand, wrist, and elbow
  - Passive external rotation of shoulder with arm at side (use PVC cane)
    - Limited to $0^\circ$ (straight ahead) for subscapularis tears
  - No active assisted motion
  - Table slides for passive overhead motion

**Postoperative weeks 7 to 12**
- Discontinuation of sling and continuation of previous exercises
  - Advance passive external rotation with cane (limit at external rotation of opposite shoulder)
  - Continue with table slides and add rope and pulley overhead stretch
  - No strengthening

**Postoperative months 3 to 6**
- Continue previous stretching exercises
  - Add internal rotation stretches
- Begin strengthening program with graduated elastic bands
  - Resisted internal and external rotation with arm at side (deltoid and rotator cuff)
  - Curl and low row exercise (biceps and periscapular muscles)
  - No heavy overhead lifting and no acceleration of arm in sport
- Patient is given option of using therapist to assist in implementation of plan

**Postoperative months 6 to 12**
- May progress to using light weights in gym
- Clearance to full activity given based on examination, typically at 6 months
repairs in 192 patients. These patients were prospectively assigned to either a conservative or a modified rehabilitation program, depending on the presence of any of the 5 risk factors. The conservative program prescribed immediate passive external rotation, but patients did not begin overhead stretches or table slides until 6 weeks post-operation. The modified program prescribed immediate table slides for passive overhead motion, and, in the absence of a subscapularis tear, passive external rotation.

Among the 192 patients, 105 were assigned to the conservative rehabilitation protocol and 87, who were identified as belonging to the high-risk group, were started on the modified protocol. One of the 105 patients who underwent conservative therapy developed postoperative stiffness, a prevalence that was not significantly different from the 2.3% prevalence from the previous study ($P = .350$), and 88 ($84\%$) had complete follow-up visit data collected at a median of 8 months, with a range of 2 to 25 months. Among the 87 patients assigned to the modified protocol, the positive counts for selected risk factors were as follows: (1) 6 had adhesive capsulitis, (2) 6 had calcific tendinitis, (3) 11 had concomitant labral repair, (4) 18 had PASTA-type rotator cuff tear, (5) and 79 had single-tendon rotator cuff tear. Twenty-six patients were positive for more than one risk factor. None of these patients developed postoperative stiffness, which was a significantly lower prevalence than the 7.8% prevalence from the previous study ($P = .003$). Complete follow-up data were available for all 87 patients, with median follow-up of 9 months and a range of 2 to 23 months. Taken as a whole, the single case of postoperative stiffness out of 198 repairs defined an overall prevalence that was significantly lower than the 4.9% prevalence reported for the previous study ($P = .002$).

An equally important factor in determining the extent of rehabilitation is the potential treatment for complications that may occur after repair. Stiffness is the most common complication after rotator cuff repair but is easily treatable. All 24 patients with clinically significant stiffness requiring arthroscopic lysis of adhesions and capsular release regained their motion after the second surgery (median of 32 month follow-up). Furthermore, at the time of second-look arthroscopy, 23 of the 24 patients had

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Fig. 1. (A, B) Table slides. Seated at a table, place the hand of the affected shoulder on a sliding surface (ie, place hand on a magazine that slides against a smooth table surface). Place the opposite (unaffected) hand on the wrist of the affected side to initiate and stabilize the motion. Slowly slide the affected hand along the table and bring the head down toward the surface of the table until shoulder is in an elevated position relative to the head. Hold the stretch for 15 to 20 seconds and repeat 10 times. Patients repeat this exercise 2 to 3 times daily.
complete healing of the original pathology. One patient had a defect remaining in the rotator cuff, with healing of 60% of the repaired footprint. All patients were satisfied with the eventual outcome. Therefore, secondary surgery for postoperative stiffness is reliable. On the other hand, if a patient experiences a recurrent tear that requires a second repair, the result of the revision surgery is far less predictable.

As a direct result of these studies, the senior author (SSB) divides the postoperative rehabilitation after rotator cuff repairs into 2 categories. In the first group, patients identified as being at high risk for postoperative stiffness (rotator cuff repairs with coexisting calcific tendonitis, adhesive capsulitis, PASTA-type rotator cuff repair, concomitant labral repair, and single-tendon rotator cuff repair) are started on the accelerated modified rehabilitation protocol. The second group, which includes all other patients that do not fit into the high-risk category, are started on the conservative rehabilitation protocol.

The results obtained show that a rehabilitation program that begins closed-chained overhead stretches (table slides) early for groups at risk for developing stiffness is best to avoid stiffness without potentially increasing the risk for rerupture in the early postoperative period. Furthermore, limiting potentially destructive stresses at the repair site for patients without increased risk for postoperative stiffness helps to promote healthy healing without undesirably compromising the integrity of the rotator cuff repair.

THE REHABILITATION PHILOSOPHY

Effective communication and coordination of care by the physical therapist and shoulder surgeon are essential in optimal patient outcomes after rotator cuff repair. In the ideal situation, a well-educated therapist who has great communication with the treating surgeon can customize the therapy for each patient and mobilize the shoulder early, reestablish scapulothoracic function, and minimize the risk of stiffness and re-tear, while facilitating return to function. However, this ideal situation is often not attainable. In practice, the patient is encouraged to take responsibility for the first portion of the rehabilitation. For the most part, if the patient is agreeable, rehabilitation during the first 3 months, which consists mostly of stretching, is conducted entirely by the patient. In this way, therapy visits are reserved for the more difficult task of regaining strength, beginning in the third and fourth postoperative months. The authors have found this method to work well with their patients.

THE REHABILITATION PROTOCOL

The authors suggest using a customized rehabilitation protocol dependent on rotator cuff tear size and the presence of clinical risk factors for stiffness.

Immediate Postoperative Period to 6 Weeks

All patients who undergo arthroscopic rotator cuff repair are instructed to perform elbow range of motion exercises starting the day after surgery. In addition, if the subscapularis was not involved in the repair, patients also begin passive external rotation to an extent that can be tolerated by them. If the subscapularis has been repaired, passive external rotation beyond 0° is prohibited. Typically, patients are encouraged to remove the shoulder sling at least 3 to 4 times a day, once for each meal and again when taking a shower. A shoulder sling is worn for the first 6 weeks. All patients are given a customized therapy kit that allows them to perform the necessary exercises at home without going to a therapist.
High-risk patients
During the first 6 postoperative weeks, patients at high risk for developing shoulder stiffness are instructed to begin an accelerated shoulder rehabilitation program. This entails starting closed-chain, passive overhead range of motion exercises (ie, table slides) (see Fig. 1) and passive external rotation exercises (for those without subscapularis repairs) during the first 6 weeks. Each patient receives a therapy kit and typically manages the individual stretching program after being instructed in the clinic.

Lower-risk patients
All other patients who undergo rotator cuff repair begin only passive external rotation exercises (for those without subscapularis repairs) and not overhead table slides until 6 weeks postoperation. All patients continue with the elbow range of motion exercises.

Postoperative 7th to 12th Weeks
Beginning in the 7th and progressing to the 12th postoperative week, all patients are instructed to perform passive overhead stretches with a rope and pulley. During this period, patients continue with elbow range of motion and passive external rotation exercises. No strengthening is allowed at this time. This is the same for high-risk and non–high-risk patients.

Postoperative Third to Fourth Months
At 3 to 4 months postoperation, patients begin strengthening exercises with elastic bands. The exact time to start strengthening depends primarily on rotator cuff tear size. In patients with massive tears, defined as rotator cuff tear size greater than 5 cm or involvement of 2 or more tendons, strengthening is delayed until 4 months postoperation. Furthermore, patients with revision cuff repair do not begin strengthening until 4 months. All other patients may begin strengthening at 3 months. The strengthening consists of the “four pack,” which includes resisted external and internal rotation, biceps curls, and a low row exercise (to strengthen the scapular stabilizers).

Postoperative 4 Months to 1 Year
During the first 6 postoperative months, patients are restricted from performing heavy overhead lifting and aggressive activity that requires acceleration of the arm (golf, tennis, overhand throw). Patients are then typically allowed to return to unlimited activities at 6 months postoperation, with the exception of patients with massive 3-tendon tear and patients who underwent revision repair; these patients are allowed full activities at 1 year. Activities that accelerate the arm in space (ie, golf swing, tennis) are especially to be avoided until the full 6 months for patients with smaller cuff tears and until 1 year for patients with massive cuff tears.

ARTHROSCOPIC ROTATOR CUFF REPAIR
Given the conservative nature of the rehabilitation protocol, an increased incidence of postoperative stiffness might be expected. This is particularly true for large and massive rotator cuff tears, where passive motion is delayed until postoperative sixth week, and strengthening until postoperative fourth month. This is a reasonable expectation because these repairs typically require greater dissection and the creation of a much larger bleeding bone surface compared with smaller tears. However, a review of patients with massive rotator cuff repair reveals a very low incidence of clinically significant postoperative stiffness. This finding is particularly important, as recent studies have shown that massive rotator cuff repairs are at an increased risk for retearing and that methods to reduce strains across the repair during healing should
be used.\textsuperscript{3} Perhaps part of the explanation for the low incidence of stiffness in these patients is that arthroscopic repair is done with minimal dissection relative to open repair.

There are many benefits of using arthroscopic techniques for treatment of rotator cuff pathology. For one, the limited nature of dissection across tissue planes results in less scar tissue and adhesion formation. This tendency toward less scar formation supports the use of a conservative rehabilitation program after arthroscopic repair of large and massive rotator cuff tears to maximize the opportunity for tendon to bone healing. The same principles apply to smaller tears, as minimizing tissue plane disruptions and scar formation allow surgeons the freedom to delay the initiation of motion that may potentially disrupt the surgical repair.

**SUMMARY**

A rehabilitation program that best allows for tendon to bone healing while preventing shoulder stiffness is the goal after arthroscopic rotator cuff repairs. A customized rehabilitation program based on risk factors for developing postoperative stiffness helps to achieve these goals.

Experience with rotator cuff surgery has enabled the authors to develop differential rehabilitation guidelines in selected patient categories that are predisposed toward postoperative stiffness (ie, patients with preoperative calcific tendinitis, adhesive capsulitis, labral tear requiring repair, single-tendon supraspinatus tears, and/or PASTA lesions). In these stiffness-prone categories, a modified protocol has successfully been instituted by using more aggressive closed-chain stretching exercises in the early postoperative period for patients with any of the risk factors. The results of this postoperative regimen have been encouraging, and the authors enthusiastically recommend it. Patients who develop refractory postoperative stiffness are effectively treated with arthroscopic capsular release and lysis of adhesions. In these instances, the original pathology is reliably healed by the time of arthroscopic release. Patients regain motion, and they are satisfied after the operation. Patients who do not fall into the high-risk category are treated with the conservative rehabilitation protocol.

**REFERENCES**