Systematic Review With Video Illustrations

Prevention and Management of Stiffness After Arthroscopic Rotator Cuff Repair: Systematic Review and Implications for Rotator Cuff Healing

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Purpose: To define the incidence of stiffness after arthroscopic rotator cuff repair (ARCR) and address the prevention and management of postoperative stiffness. **Methods:** A PubMed search was performed using the combined terms "rotator cuff and stiffness," "shoulder and capsular release," and "capsular release and stiffness." Inclusion criteria were (1) primary outcome of postoperative shoulder stiffness, (2) Levels I to IV evidence, and (3) entirely arthroscopic technique for rotator cuff repair. **Results:** Seven articles met our inclusion criteria. Two articles discussed the management of preoperative stiffness and ARCR. These articles managed preoperative stiffness differently, preventing an adequate comparison to provide recommendations. Three articles described both the incidence of and risk factors for postoperative stiffness after ARCR. The incidence of transient stiffness responsive to nonoperative management was 10%. The incidence of resistant stiffness that was permanent or required capsular release was 3.3%. Several risk factors for stiffness were identified in this review. Two articles focused on postoperative rehabilitation protocols and stiffness after ARCR. Overall, resistant postoperative stiffness was reported in 1.5% of patients with an immediate passive range-of-motion protocol, 4.5% of patients in a 6-week sling-immobilization protocol, and 0% of patients with a modified protocol. Three articles, all among the above mentioned articles, reported that arthroscopic capsular release for stiffness after ARCR improved motion to a level comparable to that in patients who did not require reoperation. **Conclusions:** The studies in this systematic review indicate that with ARCR, postoperative stiffness resistant to nonoperative management is uncommon despite an initial immobilization period. In the setting of resistant postoperative stiffness, arthroscopic capsular release can successfully restore range of motion. ARCR allows a delayed mobilization protocol that may be important in achieving rotator cuff healing. The optimal management of preoperative stiffness in patients undergoing ARCR is inconclusive based on this review. **Level of Evidence:** Level IV, systematic review of Level III and IV studies.

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Rotator cuff integrity has been correlated with functional outcome after rotator cuff repair.[1,2] The primary factors implicated in the potential for rotator cuff healing have been age and tear size.[3,4] Although these factors are not modifiable, postoperative rehabilitation is determined by the surgeon and may also influence rotator cuff healing. Historically, postoperative stiffness was one of the most devastating complications for shoulder surgeons. Efforts to avoid stiffness led to the popularization of early passive range of motion after rotator cuff repair.[1,5-7] Recent basic science investigations, however, have shown that early mobilization produces strain on the rotator cuff and compromises healing.[8-11] Arthroscopic rotator cuff repair (ARCR) may allow for a more conservative approach to mobilization to maximize rotator cuff healing.

The purpose of this systematic review was to define the incidence of stiffness after ARCR and address the prevention and management of postoperative stiffness. We sought to review articles with outcomes relevant to the following 3 areas: (1) identification of preoperative or intraoperative risk factors for postoperative stiffness after ARCR, (2) the role of rehabilitation protocols in stiffness after ARCR, and (3) the postoperative management of stiffness after ARCR.

METHODS

We attempted to identify all published studies in the English language addressing ARCR and stiffness. In October 2010, 2 independent reviewers conducted a search on PubMed from 1950 to October 2010 using the combined terms "rotator cuff and stiffness," "shoulder and capsular release," and "capsular release and stiffness." We did not perform a review of all studies documenting outcomes for ARCR, but rather included only articles in which the primary outcome was postoperative shoulder stiffness. Studies were included in this systematic review if they were in the English language, provided Levels I to IV evidence relevant to the search terms, and used an entirely arthroscopic technique for rotator cuff repair. Exclusion criteria were the use of an open rotator cuff repair technique and studies describing stiffness with multiple etiologies. Because the definition of postoperative stiffness was different in all of the studies, we categorized postoperative stiffness as transient or resistant. Transient stiffness was defined as range-of-motion loss that responded to nonoperative management. Resistant stiffness was defined as range-of-motion loss that was permanent or required arthroscopic capsular release.

RESULTS

The MEDLINE search identified 227 articles. Seven articles met our inclusion criteria. We identified 2 articles that discussed the management of preoperative stiffness before ARCR (Table 1).[12,13] Three articles described both the incidence of and risk factors for postoperative stiffness after ARCR (Table 2).[14-16] Two articles were identified that focused on postoperative rehabilitation protocols and stiffness after ARCR (Table 3).[16,17] We identified several articles that reported on arthroscopic capsular release for postoperative stiffness, but only 3 articles limited the description to postoperative stiffness after ARCR.[12,14,15] All 3 of these articles were among the 7 articles described above which were identified in this systematic review.

Management of Preoperative Stiffness

Two articles focused on preoperative stiffness in patients undergoing ARCR.[12,13] The definition of preoperative stiffness and intraoperative management of stiffness varied, preventing direct comparison between the 2 studies. Postoperative rehabilitation was the same in both studies, consisting of immediate passive range of motion for all patients.

Tauro[12] retrospectively categorized 72 patients with full-thickness tears undergoing ARCR into having a mild (0° to 20°), moderate (20° to 70°), or severe (>70°) deficit in total preoperative range of motion. No capsular releases were performed at the time of ARCR. Final deficits in each plane of motion were not provided. Overall, mean total range-of-motion deficits decreased from 10° to 4° in the mild group, 36° to 12° in the moderate group, and 89° to 31° in the severe group. In patients with a total deficit of less than 70°,

TABLE 1. *Description of Studies on Management of Preoperative Stiffness*

Study	Year	No. of Patients	Design	Level of Evidence
Tauro[12]	2006	72	Retrospective cohort	IV
Cho and Rhee[13]	2008	45	Retrospective case control	III

Table 2. *Description of Studies Identifying Incidence of and Risk Factors for Postoperative Stiffness*

Study	Year	No. of Patients	Design	Level of Evidence
Brislin et al.[14]	2007	263	Retrospective cohort	IV
Huberty et al.[15]	2009	489	Retrospective cohort	IV
Parsons et al.[16]	2010	43	Retrospective cohort	IV

there was no resistant postoperative stiffness. Of the 6 patients with a preoperative deficit of more than 70°, 3 had resistant postoperative stiffness.

Cho and Rhee[13] prospectively compared 15 patients with preoperative stiffness (passive forward flexion <100° or external rotation <40°) with 30 patients without preoperative shoulder stiffness. Preoperatively, the mean passive motion was forward flexion of 118° and external rotation of 35° in the stiffness group compared with 163° and 55°, respectively, in the group without stiffness. In contrast to the study by Tauro,[12] a manipulation under anesthesia was performed in the patients with stiffness before ARCR. At final follow-up of more than 2 years, there was no significant difference in forward flexion (167° *v* 170°, $P = .157$) or external rotation (49° *v* 53°, $P = .384$) between the groups with and without preoperative stiffness. The rate of motion recovery, however, was slower in the group with preoperative stiffness. External rotation took 3 months to become equal between both groups. Recovery was slower for forward flexion, with patients with stiffness preoperatively having 13° less at 3 months, 9° less at 6 months, and 6° less at 1 year compared with the normal group ($P = .21$).

Incidence of and Risk Factors for Postoperative Stiffness

Three studies examined both the incidence of and risk factors for postoperative stiffness.[14-16] Two of the articles described both transient and resistant stiffness.[14,16] One of the articles described only resistant stiffness.[15] The combined sample between the 3 articles was 795 patients. The incidence of transient stiffness responsive to nonoperative management was 10%. The incidence of resistant stiffness that was permanent or required capsular release was 3.3%. Overall, tear size appeared to affect the development of transient or resistant stiffness. One study reported that patients with tears measuring less than 3 cm were more likely to have transient stiffness, although the difference did not reach statistical significance with the sample size of 43 patients.[16] In the 2 larger studies there was a trend ($P = .08$) toward stiffness in smaller tears[14] and significantly higher rates of stiffness in partial articular-sided tears versus 3- or 4-tendon tears (13.5% *v* 2%, $P < .05$).[15] Two studies analyzed fixation technique and did not observe a relation to stiffness.[14,15] Additional statistically significant risk factors for stiffness were described in 1 study and included Workers' Compensation (8.6%), age less than 50 years (8.6%), calcific tendinitis or adhesive capsulitis (15.6%), or concomitant labral repair (11%).[15]

Postoperative Rehabilitation Protocols

Two studies were identified that specifically focused on the postoperative rehabilitation after ARCR.[16,17] In addition, 3 of the previously discussed articles contained details on rehabilitation protocols and resistant stiffness.[12,14,15] Rehabilitation protocols were immediate passive range of motion in 2 studies, sling immobilization for 6 weeks in 2 studies, and a modified protocol based on risk factors for stiffness in 1 study (Table 4). A total of 1,019 patients were in this combined sample.

Overall, resistant postoperative stiffness was reported in 1.5% of patients with an immediate passive range-of-motion protocol,[12,14] 4.5% of patients in a 6-week sling-immobilization protocol,[15,16] and 0% of patients with a modified protocol.[17] The modified protocol described by Koo et al.[17] was based on preoperative and intraoperative risk factors for stiffness previously identified in the study by Huberty et al.[15]

Table 3. *Description of Studies Focusing on Postoperative Rehabilitation and Stiffness*

Study	Year	No. of Patients	Design	Level of Evidence
Parsons et al.[16]	2010	43	Retrospective cohort	IV
Koo et al.[17]	2011	152	Retrospective cohort	IV

TABLE 4. *Postoperative Stiffness and Rehabilitation Protocols*

Study	No. of Patients	Mean Age (yr)	Rehabilitation Protocol First 6 wk	Transient Stiffness	Resistant Stiffness	Final Forward Flexion (degrees)	Final External Rotation (degrees)
Tauro[12]	72	63	Immediate PROM	NR	4.2%	NR	NR
Brislin et al.[14]	263	61	Immediate PROM	8%	0.1%	NR	NR
Huberty et al.[15]	489	NR	Sling immobilization	NR	5%	162* 166†	58* 53†
Parsons et al.[16]	43	64	Sling immobilization	23%	0% 0%	166‡ 161§	62‡ 58§
Koo et al.[17]	152	62‖ 53¶	Sling immobilization‖ Closed-chain flexion¶	NR	0%	NR	NR

NOTE. Patients undergoing manipulation under anesthesia (n = 15) at the time of surgery are excluded.
Abbreviations: PROM, passive range of motion; NR, not reported.
*Patients in whom stiffness did not develop.
†Patients who required a capsular release.
‡Patients with transient stiffness.
§Patients without transient stiffness.
‖Patients identified as having minimal risk factors for stiffness.
¶Patients identified as having substantial risk factors for stiffness.

Of 152 patients undergoing ARCR, 79 were identified as having a risk factor for postoperative stiffness, which included calcific tendinitis, adhesive capsulitis, partial articular surface tendon avulsion, concomitant labral repair, or a single-tendon tear. Patients at risk for stiffness were enrolled in a modified rehabilitation protocol that added immediate closed-chain passive forward flexion exercises (table slides) to a standard protocol consisting of sling immobilization without overhead shoulder motion for 6 weeks. Postoperative stiffness did not develop in any of the patients undergoing this modified protocol, which was a significantly lower rate compared with the historical control rate of 7.8% for patients with 1 or more of the previously mentioned risk factors ($P = .003$).

Capsular Release for Resistant Postoperative Stiffness

Three articles were identified that described capsular release for resistant stiffness after ARCR.[12,14,15] Two of these articles had a small number of patients (3 and 1, respectively) and neither detailed the preoperative and postoperative range of motion.[12,14] Huberty et al.[15] reported the results of capsular release for 24 patients with resistant stiffness, in whom the mean forward flexion was 138° and external rotation was 32°. After capsular release, forward flexion improved to 166° and external rotation improved to 49°. Although the authors did not provide a statistical comparison, these values were comparable to the forward flexion of 162° and external rotation of 58° reported in the normal group. All patients were satisfied with the procedure, and final University of California, Los Angeles scores ranged from 28 to 35.

DISCUSSION

Prevention and management of stiffness in ARCR are important to achieving good functional outcomes. This systematic review summarized current data on the management of preoperative stiffness, incidence of postoperative stiffness, risk factors for postoperative stiffness, rehabilitation protocols, and results of arthroscopic capsular release for resistant stiffness. This information may also have implications for rotator cuff healing.

Management of Preoperative Stiffness

The optimal management of preoperative stiffness in patients undergoing ARCR is inconclusive based on this review.[12,13] In 1 study half of patients (3 of 6) with substantial preoperative stiffness required a subsequent capsular release. In the other study a manipulation under anesthesia was performed before ARCR in patients with substantial preoperative stiffness. Final range of motion in this group was decreased compared with control subjects at 1 year but equal at final follow-up of more than 2 years. On the basis of these observations, a capsular release at the time of ARCR may be indicated in patients with substantial preoperative stiffness.

Incidence of and Risk Factors for Postoperative Stiffness

Although we did not perform a systematic review of stiffness and open repair techniques, range of motion may be improved and postoperative stiffness may be lower after ARCR compared with open repairs. Forward flexion in several studies of open repair has averaged approximately 150°.[1,6,18,19] Compared with these open results, final postoperative motion was higher, 161° to 166°, in this systematic review of ARCR. Namdari and Green[20] reported on stiffness in a mixed series of 345 rotator cuff repairs, 59% of which were performed with an open or mini-open technique, and observed that 13.6% of patients were "clinically stiff" at 1 year. In this systematic review transient stiffness was common (10%) but postoperative stiffness resistant to nonoperative management was infrequent (3.3%).

Several risk factors for postoperative stiffness after ARCR were identified in this review. A small tear size was associated with a higher rate of postoperative stiffness in all studies that examined this factor. Workers' Compensation and age less than 50 years were associated with moderate rates of stiffness. The highest rate of stiffness was observed in cases of calcific tendinitis or adhesive capsulitis (15.6%) and concomitant labral repair (11%). This information may be helpful in guiding postoperative rehabilitation protocols.

Postoperative Rehabilitation

Historically, postoperative stiffness has been 1 of the most dreaded complications after open rotator cuff repair, and as a result, immediate passive range-of-motion protocols were advised. A 1985 statement by Cofield[5] reflects this philosophy: "The use of physiotherapy is no longer controversial. Early passive range of motion exercises of the shoulder both prevent adhesions and protect the repair." However, recent basic science investigations have suggested that the inflammatory response is higher after open rotator cuff repair, and in contrast to the previous statement, passive range of motion may actually increase postoperative adhesions.

In an interesting study, Shinoda et al.[21] randomized 32 patients to open repair or ARCR and showed a 3-fold increase in interleukin-6 levels postoperatively in the open repair group compared with ARCR ($P < .01$). Franceschi et al.[22] reported a 3-fold increase in levels of substance P in patients in whom postoperative stiffness developed. Thus, from a basic science perspective, surgical technique plays a role in the development of postoperative stiffness.

Several basic science studies have investigated rehabilitation protocols after rotator cuff repair. In a rat model of rotator cuff repair, Peltz et al.[23] showed that immediate passive range of motion actually led to increased stiffness compared with a continued-immobilization protocol. Similar to the clinical findings discussed in this systematic review,[16] Sarver et al.[24] reported that immobilization after rotator cuff repair led to stiffness that was transient only. In addition to the role in the development of stiffness, immobilization after rotator cuff repair may lead to increased healing potential. Gimbel et al.[8] found that immobilization led to enhanced mechanical properties of repaired rat supraspinatus tendons. In a histologic evaluation of rotator cuff healing in a primate model, Sonnabend et al.[25] reported that maturation of the repaired rotator cuff requires 12 to 15 weeks. In summary, the previously mentioned basic science investigations show that the ideal rehabilitation protocol to prevent stiffness and encourage healing after rotator cuff repair includes an initial period of immobilization.

To our knowledge, no clinical studies have compared rotator cuff healing in passive range-of-motion versus immobilization protocols. The studies in this systematic review show that a 6-week immobilization protocol slightly increases (4.5% *v* 1.5%) resistant stiffness, which can be successfully managed with arthroscopic capsular release. Furthermore, identification of risk factors for stiffness may be used to guide rehabilitation. Risk factors for stiffness identified in this review included calcific tendinitis, adhesive cap-

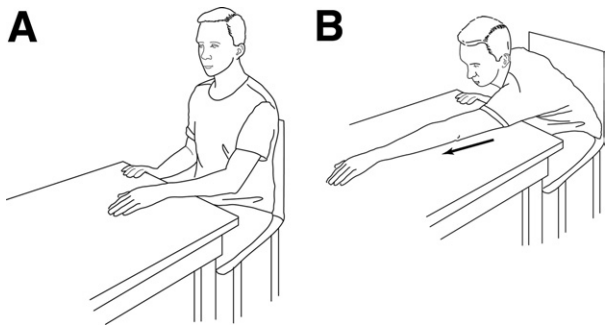

FIGURE 1. Table slide. (A) Starting position. While seated at a table, the patient places the hand of the affected shoulder on a sliding surface (e.g., a magazine that slides over a smooth table surface). (B) Ending position. The patient slides the hand forward, maintaining contact with the table, while the head and chest advance toward the table. (Reprinted with permission.[17])

sulitis, small tears, and concomitant labral repair. The lowest rate (0%) of resistant stiffness was found in the study by Koo et al.,[17] in which patients underwent 6 weeks of immobilization with only the addition of early closed-chain overhead stretches in patients with one of the previously mentioned risk factors (Fig 1).

Although stiffness in this systematic review was more common with strict immobilization, there may be a positive relationship between stiffness and rotator cuff healing. In the study by Huberty et al.,[15] 23 of the 24 patients requiring capsular release showed rotator cuff healing on repeat arthroscopy. Similarly, Parsons et al.[16] found that the rotator cuff was healed on postoperative magnetic resonance imaging in 70% of patients with transient stiffness, as compared with 36% of patients in whom stiffness did not develop ($P = .079$). Given the relation between rotator cuff integrity and function,[1,2] in our opinion, stiffness can be considered a complication, but recurrent rotator cuff tear is a failure. We believe that stiffness that can be successfully treated with a subsequent arthroscopic capsular release far outweighs the negative consequences of a recurrent rotator cuff tear.

Our Preferred Technique: Capsular Release After Rotator Cuff Repair

We perform capsular release with the patient in the lateral decubitus position with the arm in 20° to 30° of abduction and 20° of forward flexion with 5 to 10 lb of balanced suspension (Star Sleeve Traction System; Arthrex, Naples, FL). A standard diagnostic arthroscopy is performed through a posterior portal with a pump maintaining pressure of 60 mm Hg. The integrity of the rotator cuff is assessed. Assuming the rotator cuff is intact, the release begins with the rotator interval and the superior glenohumeral ligament. The procedure continues with a 3-sided release of the subscapularis (if necessary) and then proceeds with a posterior capsular release, inferior capsular release, anterior capsular release, manipulation under anesthesia, and finally, subacromial lysis of adhesions (Table 5, Videos 1-4 [available at www.arthroscopyjournal.org]).

TABLE 5. *Order of Steps for Capsular Release After Rotator Cuff Repair*

1. Release rotator interval and superior glenohumeral ligament through anterior portal with electrocautery
2. Perform 3-sided release of subscapularis if necessary
3. Move arthroscope to anterior portal and perform posterior capsular release from 11-o'clock to 7-o'clock position with pencil-tip electrocautery introduced through the posterior portal
4. Perform inferior capsular release with pencil-tip through posterior portal
5. Perform anterior capsular release with pencil-tip through posterior portal
6. Perform manipulation under anesthesia
7. Perform subacromial lysis of adhesions

An anterior portal is established. The rotator interval (including the superior glenohumeral ligament) is released with a 4-mm cautery probe. Care is taken to preserve the medial sling of the biceps. If the subscapularis had been repaired previously, there may be a component of subscapularis capture due to subcoracoid adhesions. This usually necessitates a 3-sided release of the subscapularis to re-establish lateral excursion of the tendon. This is done first to minimize extra-articular fluid extravasation before manipulation of the shoulder. The arthroscope is moved to the anterior portal, and the posterior capsule is released with a pencil-tip cautery (from the 11-o'clock position down to the 7-o'clock position in a right shoulder). Then, we release the axillary pouch, staying at least 5 mm away from the labrum to protect the axillary nerve. Next, with our pencil-tip cautery still in the posterior portal, we release the anterior capsule all the way up to the midglenoid notch. Because our posterior working portal has an angle of approach parallel to the glenoid face, it is much easier to release the anterior capsule through this portal than through an anterior portal. The superior capsule is not released, because it does not restrict the primary motions of elevation, external rotation, and internal rotation.

After capsular release, we take the arm out of traction and manipulate it through a full range of motion while manually stabilizing the scapula. Then, the arm is put back into traction, and the extent of the release is assessed.

After capsular release and manipulation of the shoulder, we perform a subacromial lysis of adhesions. The subacromial adhesions can be quite dense. We begin by exposing the bony landmarks: scapular spine, undersurface of acromion, and acromioclavicular joint. Then, we use a combination of arthroscopic shaver, electrocautery, and scissors to re-establish the posterior, lateral, and anterior gutters of the subacromial space.

The patient begins immediate unrestricted active and passive range of motion after surgery.

CONCLUSIONS

With the innovation of arthroscopy to repair the rotator cuff, a paradigm shift is taking place in the

prevention and management of postoperative stiffness. Anchored in recommendations from open techniques, passive range of motion was historically considered to be essential to preventing stiffness after rotator cuff repair. On the contrary, the studies in this systematic review indicate that with ARCR, postoperative stiffness resistant to nonoperative management is uncommon despite an initial immobilization period. On the basis of the identification of risk factors, rehabilitation protocols can be altered to prevent stiffness. In the setting of resistant postoperative stiffness, arthroscopic capsular release can achieve range of motion comparable to that in patients in whom stiffness does not develop. Finally, a period of initial immobilization likely encourages rotator cuff healing and thus functional restoration.

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