Systematic Review

Rehabilitation Protocols for Superior Capsular Reconstruction Are Variable: A Systematic Review

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Purpose: To screen manuscripts that discuss rehabilitation protocols for patients who underwent superior capsular reconstruction (SCR) to elucidate whether a standard rehabilitation algorithm exists for SCR. **Methods:** A systematic review was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta Analyses (i.e., PRISMA) guidelines. PubMed (MEDLINE) and Embase were searched using pertinent Boolean operation terms "superior capsular reconstruction" and "rotator cuff repair rehabilitation," and articles that included rehabilitation protocols following superior capsular reconstruction surgery were reviewed. Two independent reviewers performed the search and quality assessment. **Results:** A total of 549 articles were yielded after our database search. Fourteen studies fulfilled our inclusion criteria and were included in the review. Study designs included 9 editorials, 3 case series, and 2 case reports. Each study included in this review used a unique rehabilitation algorithm that posed significant variability between the protocols. Four phases were identified to summarize each protocol and were used as a basis of discussion—sling versus brace time (3-6 weeks for comfort/removal vs complete immobilization), passive range of motion (immediately after surgery to initiation at 6 weeks), active range of motion (4-8 weeks), and strengthening/return to full activity (12-52 weeks). Initiation of rehabilitation, length of time spent in each phase, types of exercises, and overarching goals for return to function were significantly variable and were decided upon by the surgeon based on current massive rotator cuff repair protocols. Presently, there is no standard rehabilitation protocol for SCR. **Conclusions:** SCR is a relatively new procedure that is gaining rapid popularity with promising outcomes. Based on our review, there is no standard rehabilitation protocol in place; thus, it is not possible to recommend an evidence-based rehabilitation protocol following SCR at this time. **Level of Evidence:** Level V, systematic review of Level IV and V studies.

A subset of rotator cuff tears (RCTs) are considered irreparable due to poor tissue quality, prolonged fixed retraction, or size (tears greater than 5 cm).[1] However, patients with irreparable tears in the absence of shoulder arthritis may be amenable to surgical intervention aimed at joint preservation.[2] Historically, there have been high failure rates associated with surgical repair.[3] Several alternative treatments have been tested, such as partial repairs, patch autograft or allograft application, and latissimus dorsi tendon transfers.[4] However, these procedures have yielded mixed results with a high risk of complications.

In response, superior capsular reconstruction (SCR)[5] has been recommended as a joint-sparing treatment for irreparable RCTs.[6] SCR prevents translation of the humeral head and improves biomechanical stability and force coupling of the remaining cuff.[1] Although the procedure is fairly novel, multiple studies have demonstrated positive outcomes despite differences in surgical nuances.[1,4,6-10]

The postoperative rehabilitation protocol is an important component for a successful result. For SCR, although there is literature discussing the different variations of the procedure, there is no literature comparing postoperative rehabilitation protocols. Currently there are therapy guidelines suggested by various surgeons relatively experienced in SCR.[11] Therefore, the purpose of this systematic review is to screen manuscripts that discuss rehabilitation protocols

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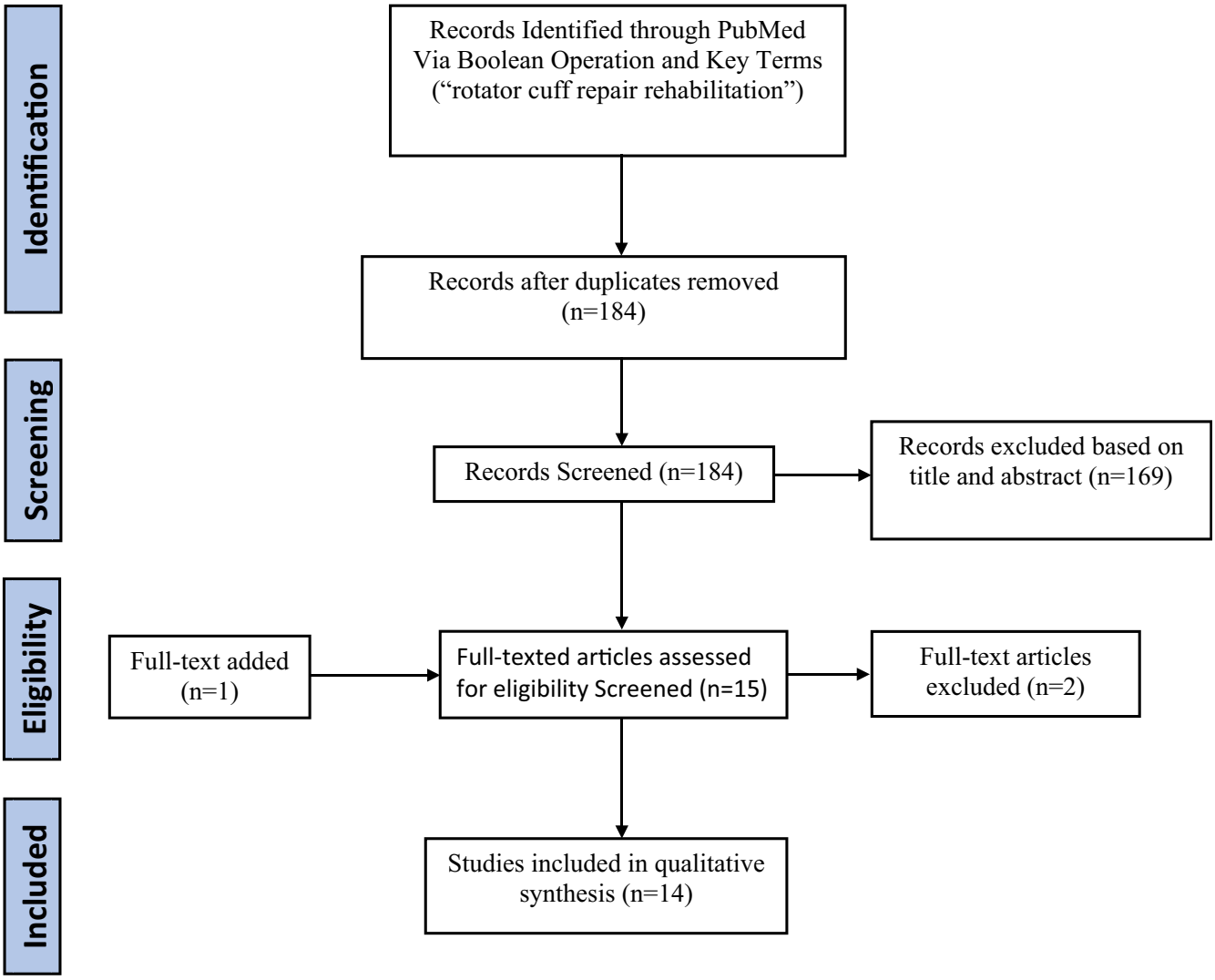

Fig 1. PRISMA flow chart.

for patients who underwent SCR to elucidate whether a standard rehabilitation algorithm exists for SCR. We hypothesized that there would be significant variability of published protocols, confirming that there is no standard rehabilitation protocol in place.

Methods

A systematic review was conducted according to Preferred Reporting Items for Systematic Reviews and Meta Analyses (i.e., PRISMA) guidelines to identify all studies that included rehabilitation protocols following SCR (Fig 1). Two reviewers (A.L., K.M.) independently conducted literature searches in September of 2019 using PubMed (MEDLINE) and Embase database. The search included the following terms: "rotator cuff repair rehabilitation" and "rotator cuff repair rehabilitation."

The main criteria for selection were articles within the aforementioned database that were written in English, published within the last 10 years, and described a rehabilitation protocol for SCR. In addition, selected studies had to include the following parameters: massive rotator cuff injury, completion of defined rehabilitation program, and patient age of 18 years or older. Review articles and meta-analyses were excluded, as we focused on reported cases or clinical studies that employed a specific rehabilitation protocol. Both reviewers independently filtered through all returned articles based on the title and abstract, identified appropriate articles, and any subsequent discrepancies were co-reviewed. Articles were then screened by the senior authors for final inclusion.

Two reviewers then assessed the quality of each of the included articles using the Case Report (CARE) guidelines.[12] The assessment was carried out independently by 2 reviewers addressing the 30 items reported by the guidelines. Possible item ratings are yes or no; any disagreement was discussed among the reviewers and

Table 1. Study Characteristics

Study	Year	Study Type	Sling	Passive ROM	Active ROM	Strengthening	Full Activity
Anderson and Trenhaile[6]	2018	Editorial	Abduction sling at all times for first 4 weeks	First 4 weeks as tolerated	Start gentle passive stretching at 4 weeks and active ROM at 6 weeks	8 weeks	Not specified
Cabarcas et al.[1]	2018	Editorial	Sling with abduction pillow for 6 weeks; Only ROM at the elbow, wrist, and hand is allowed	6-8 weeks, patients are allowed passive ROM and grip-strengthening exercises; ROM goals are 140° of forward elevation, 40° of external rotation at the side, and maximum 60° to 80° of abduction	Active assisted ROM at weeks 8-12 (ROM goals are the same as in weeks 6 to 8, but with the incorporation of light passive stretches at end ranges); from months 3 to 12, patients are advanced to full ROM with passive stretching at end ranges	Isometric strengthening exercises permitted at weeks 8-12; Eccentrically resisted exercises, plyometrics, and proprioception routines are started after week 16; from months 3 to 12, advanced strengthening exercises 3 times per week, including isometrics, resistance bands, and light weights (1-5 lb)	Should have full recovery by 12 months
de Campos Azevedo et al.[3]	2018	Case series	Wear sling for 3 weeks, but remove it several times a day to perform active assisted shoulder elevation and elbow flexion exercises			No active resistant elbow exercises until 6 weeks postoperatively; active shoulder resistant exercises not allowed until 6 months postoperatively	Return to full activity allowed at 6 months
Boutsiadis et al.[4]	2017	editorial	Abduction pillow at 60 degrees for 6 weeks; active hand, wrist, and elbow exercises are allowed from the first day	15 days postoperatively	6 weeks	No strengthening or resistance exercises before 6 months	Start working on performing daily activities at 6 weeks
Mihata et al.[13]	2013	Case series	Abduction pillow for 4 weeks with complete immobilization	Passive and active-assisted exercises initiated after 4 weeks	Passive and active-assisted exercises initiated after 4 weeks	After 8 weeks, start exercises to strengthen rotator cuff and scapula stabilizers	
Chillemi et al.[2]	2018	Editorial	Abduction pillow at 20° for 30 days	Passive shoulder mobilization and active hand, wrist, and elbow exercises started from the first day after surgery	Active-assisted shoulder exercises were allowed from the first month postoperatively	From month 2, strengthening exercises of the deltoid were allowed	

(continued)

Table 1. Continued

Study	Year	Study Type	Sling	Passive ROM	Active ROM	Strengthening	Full Activity
Frank et al.[8]	2018	Editorial	Abduction sling for 6 weeks, with pendulum exercises and elbow and wrist ROM permitted.		At week 6, active-assist ROM is permitted, progressing to active ROM	Scapular exercises allowed at week 6. Gentle isometric exercises with arm at side are allowed at week 8. Formal strengthening initiated at 3 months	Sport-specific rehabilitation started no earlier than 4-5 months
Pennington et al.[9]	2018	Case series	For comfort	Allowed during the first 4 weeks	Active assisted motion begins at 4 weeks and full active motion begins at 8 weeks		
Tajika et al.[10]	2018	Case report	Abduction brace for 3 weeks, then sling for 2 weeks after	Day after surgery	Unrestricted active ROM started 5 weeks postoperatively		
Kim et al.[14]	2018	Editorial	Abduction brace for 4-6 weeks. NO passive motion of the elbow allowed while wearing brace	Start passive ROM at 4-6 weeks after removal of brace	Active ROM starts after 8 weeks	External rotation strengthening starts at 12 weeks	
Laskovski et al.[15]	2018	Editorial	Placed with abduction pillow for 6 weeks	Allowed at 6 weeks	Allowed at 12 weeks		
Pennington et al.[16]	2018	Editorial	For comfort	Allowed during the first 4 weeks	Active assisted motion begins at 4 weeks and full active motion begins at 8 weeks		
Tokish et al.[17]	2018	Case report	Shoulder immobilizer with an abduction pillow is used, and the patient is encouraged to perform elbow, wrist, and hand exercises for 6 weeks, along with gentle passive glenohumeral motion	Gentle passive glenohumeral motion for first 6 weeks	Progressive motion started at 6 weeks	Beginning at 12 weeks	Gradually returned to activity when motion, strength, and confidence return over a 6- month period
Petri et al.[18]	2015	Editorial	Abduction sling	Focused on limited and protected passive ROM postsurgery	Both active and active assisted ROM begin at 6 weeks	Begins at 8 weeks	

ROM, range of motion.

ultimately mediated by a third reviewer. Inter-rater reliability of scoring during the assessment was tested.

For the purposes of this review, we chose 4 phases that are widely accepted in orthopaedic rehabilitation practice to make comparisons between each article: sling time, passive range of motion (ROM), active ROM, and strengthening/return to full activity.

Results

Dual review of current, relevant literature resulted in a total of 549 articles for review. Both reviewers finalized a list of 13 articles based on title and abstract for further full-text screening. One article was excluded due to it being a systematic review. One additional article that was found on review of citations was added. A total of 14 articles published from 2017 to 2019 were finally included in this review, with detailed descriptions provided in Table 1.[1-4,6,8-10,13-18]

A variety of study designs were included as follows: 9 editorials, 3 case series, and 2 case reports. All articles were assigned as Level VI evidence. The quality of each article was evaluated by 2 independent reviewers using the CARE guidelines. The CARE score was calculated by summing the number of "yes" response to each item. On average, the articles yielded a score of 26.4 of 30. The intraclass correlation coefficient for the inter-raters CARE score was excellent (0.967; 95% confidence interval 0.90-0.99; $P < .001$).

The length of time and goals for return to function was decided by the surgeon and was not based on a defined standard specific for SCR. Thus, each study included in this review employed a different rehabilitation algorithm with considerable variability between their protocols, ranging from time spent in immobilization after surgery to return to activity. In addition, 5 articles used a variation of an established protocol for massive rotator cuff repair.[1,4,7,8,16]

Phase One: Sling Time

The first phase assessed was the time spent in a sling or abduction brace with the goal of protecting the surgical repair immediately after surgery by providing support for the glenohumeral joint.[19] Overall, a sling or brace was generally employed for 4 to 6 weeks. Chillemi et al.[2] advocated for sling use for a strict time period of only 30 days. A noteable outlier was de Campos Azevedo et al.,[3] who demonstrated the use of an aduction brace for 3 weeks with removal several times per day, followed by a sling for 2 weeks. Eleven studies specified lengths of time that patients were required to wear either device, and 3 did not.[1-4,6,8-10,13-18] Two papers, Kim et al.[14] and Laskovski et al.,[15] stressed the importance of wearing the sling for 6 weeks with no motion of the shoulder.

The other 11 studies advocated for the removal of the sling periodically to perform minimal exercises. Among the articles that called for exercise during this phase, 4 articles allowed for exercises involving only the hand, wrist, and elbow to maintain accessory joint mobility.[1,4,10,20] Alternatively, 8 studies initiated passive ROM of the shoulder immediately after surgery while the patient was still using the sling.[2,3,6,8-10,16,17] de Campos Azevedo et al.[3] was the only study to advocate for active assisted shoulder motion immediately after surgery, although their rationale for such early active mobilization was not provided.

Phase Two: Passive ROM

We subsequently compared the time of initiation of passive ROM exercises. Ten studies advocated for the immediate implementation of passive ROM exercises after surgery.[2-4,6,8-10,16-18] The other 4 studies emphasized waiting 2 to 8 weeks after surgery or after sling/brace removal.[1,13-15] Boutsiadis et al.[4] were the only authors to specify a precise time point of 15 days after surgery in order to start any passive ROM of shoulder. Two articles mentioned implementation of passive ROM 6-8 weeks postoperatively to allow early time for the dermal allograft and rotator cuff healing.[1,15] Interestingly, Cabarcas et al.[1] was the only paper to define their passive ROM goals, which were 140° of forward flexion, 40° of external rotation at the side, and maximum 60 to 80° abduction.

Phase Three: Active ROM

Again, there was significant variation among all studies. Of the 14 studies in this review, 11 studies implemented active ROM sooner postoperatively.[2-4,6,8-10,13,16-18] Chillemi et al.[2] describes the earliest implementation; active-assisted shoulder exercises after the first month postoperatively. In both of their papers, Pennington et al.[9,16] encouraged the initiation of active assisted motion at 4 weeks and full active motion at 8 weeks. Mihata et al.[13] started both passive and active-assisted exercises in week 5, with the goal of promoting scapular plane elevation. Tajika et al.[10] supported initiation of unrestricted active ROM 5 weeks after surgery.

Three papers waited 8-12 weeks or longer to start active ROM.[1,14,15] Cabarcas et al.[1] advocated for active assisted ROM to begin at 8 to 12 weeks, with advancement to full ROM from months 3 to 12. Once again, this was the only paper to set specific goals for this phase of rehabilitation; the ROM goals were the same as in the passive ROM stage, but with incorporation of light passive stretches at end ranges to increase flexibility.[1,21] Kim et al.[14] began active ROS at eight weeks and Laskovski et al.[15] started at 12 weeks with explanation of their rationale.

Phase Four: Strengthening/Return to Activity

Again, we found that the majority of articles did not provide any specifics for this phase beyond basic

timelines. In 8 of 14 studies, a more aggressive approach was employed, calling for strengthening to begin as early as 6 to 12 weeks postoperatively. Only Cabarcas et al.[1] emphasized starting isometric strengthening exercises 8 to 12 weeks and eccentrically resisted exercises, plyometrics, and proprioception routines by week 16. From months 3 to 12, advanced strengthening needed to be completed 3 times per week and should incorporate isometrics, resistance bands, and light weights. Frank et al.[8] discussed initiation of scapular exercises at week 6, gentile isometric exercises with arm at side at week 8, and formal strengthening at 3 months. Mihata et al.[13] describes starting exercises to strengthen the rotator cuff and scapula stabilizers at 8 weeks. Kim et al.[14] specified that strengthening should start at week 12 and be exclusive to external rotation exercises. Two articles recommended delaying strengthening until 6 months; 4 articles did not specify a time for the introduction of strengthening.[3,4,9,10,15,16]

There was no consensus regarding the definition of return to activity of when patients would be allowed to return. De Campos Azevedo et al.[3] and Frank et al.[8] described return to full activity to be expected at 6 months. In comparison, Cabarcas et al.[1] cited that full activity by 12 months postoperatively is appropriate.

Discussion

SCR is a complicated surgery used to treat massive RCTs, yet despite the extensive rehabilitation necessary for this procedure, no formal postoperative rehabilitation protocol has been established. Among the articles reviewed here, there is substantial variation regarding the timeline and rate of progression for each phase of rehabilitation. However, there were common themes in each study, usually involving a short course of immobilization with progression to passive and active ROM, followed by strengthening exercises and ultimately return to unrestricted activity. Because we divided each protocol into 4 distinct phases, the protocols for each article in this review can be discussed further in context with one another.

The first phase saw quite a bit of variation, with some authors advocating for use of a sling for 30 days,[2,13] whereas others opted wearing a sling for up to 6 weeks with no mobility allowed whatsoever.[14,15] In particular, Kim et al.[14] reasoned that when the long head of the biceps is used for repair, it is important to avoid any passive ROM of the elbow and shoulder while wearing the sling. This stark contrast suggests some clinicians believe early removal of a sling or brace may prevent stiffness and allow for quicker restoration of ROM and return to activity, whereas others believe that preservation of the surgical repair is a priority over early mobilization,[2,3,19,22] The reasoning behind early initiation of passive ROM can be linked to a study by Li et al., which showed that passive ROM after surgery promotes tendon-bone healing by increasing type 3 collagen production at the tendon−bone interface.[23,24] Therefore, when to discontinue supportive devices as well as if initiation of passive ROM in phase 1 is appropriate remains undefined in patients undergoing SCR.

Furthermore, even when the SCR articles discuss passive ROM without the use of a supportive devices, there remains little clarity as to what joints should be involved. Three articles specified that the passive ROM should be limited to hand, wrist, and elbow,[1,4,22] whereas one article limited passive ROM to elbow and wrist only.[2] Only Tokish et al.[17] included gentle passive ROM of the glenohumeral joint, which is significant because previous literature suggests passive ROM of the glenohumeral joint as soon as possible is necessary to minimize joint stiffness and postoperative morbidity.[19] Due to the aforementioned, there is no consensus regarding initiation of passive ROM in isolation and if glenohumeral passive ROM can begin at the same time as accessory upper extremity joints.

The lack of consensus is also evident in phase 3 and 4. For phase 3, whereas previous literature suggests strength and gradual introduction of resistance training is recommended to begin by 12 weeks for patients with massive rotator cuff, others mention that patients should have 50% of normal strength by 12 weeks and full strength by 15 weeks.[25] There is no literature defining a range for strengthening in patients undergoing SCR. For the 5 articles claiming to use massive rotator cuff protocol, none reported when they initiated strength or resistance exercises. For articles defining their own protocols, phase 3 began from 6 weeks to 6 months. However, Chillemi et al.[2] were the only authors to mention that deltoid strengthening must begin by week 8 but did not provide any rationale. Greiner et al.[26] demonstrated that atrophy of the deltoid after reverse shoulder arthroplasty negatively impacted clinical outcomes because the deltoid assumes the function of the rotator cuff during the acute phases of healing after SCR surgery. Therefore, early deltoid strengthening may be important for SCR patients and warrants further exploration.

The variation in return to full activity leads to the conclusion that there is no consensus between the standard protocols followed. Typically, patients who have high expectations of their return to activity will push their rehabilitation progression.[27] In addition, the demographic cohorts for each article varied, which may alter what full activity meant for their respective patient populations. This can cause differences in rehabilitation expectations as well as variations in the type of rehabilitation endured.

Only 4 articles in this review highlighted the final outcomes of their patients, and only 2 articles touched on failure rates and complications encountered. Since

only a handful of articles reported the outcomes of their patients, and one specifically addressed failure rates, there are potentially other unreported complications within this entire cohort reviewed. Furthermore, any reported outcome of these articles cannot be solely attributed to surgical techniques as there are many varying factors, specifically rehabilitation.

Rehabilitation Protocol

As there is no standardized rehabilitation protocol for SCR, the authors of this review opted to formulate our own protocol currently being used in all patients undergoing SCR at our institution. This protocol is categorized into 5 phases based on postoperative timing. Our protocol advocates for no active movement of the shoulder joint until 6 weeks postoperatively.

Phase one is defined as postoperative day 9 to 2 weeks. During this phase, the patient is instructed to use the sling continuously. Passive and active ROM of the elbow, wrist, and neck are initiated within 0-50° as tolerated. All patients progress to phase 2 after postoperative day 14, which continues until 5 weeks postoperatively. The sling is slowly weaned off during weeks 5-6, and there is no active shoulder motion. The goals of phase 2 are to restore passive ROM, activate shoulder and scapular stabilizers in the protected position, and correct postural dysfunction.

Phase 3 begins between around 6 weeks postoperatively. Active abduction is not initiated during the first 8 weeks, and no resistance for abduction or supraspinatus strengthening for the first ten weeks. Progression to phase 4 is only allowed once the patient has achieved full active ROM and full strength for internal and external rotation at 30° abduction.

Phase 4 should be initiated at 12 to 14 weeks postoperatively. The goal of this phase is to attain full rotator cuff strength and endurance at 90° of abduction. Once these goals have been met and impingement signs are negative, the patient is cleared for phase 5.

The objective of phase 5 is to attain full rotator cuff strength at 90° abduction as well as to continue to develop strength and control for work and recreation-specific tasks. Once the physical therapist and surgeon have assessed the patient's ability to meet these goals, the patients are cleared for daily activities or return to recreational activity.

Limitations

This study has limitations, the first being the level of evidence and quality of available literature. The only studies that fit our inclusion criteria were editorials, case reports, and case series. For this reason, the authors could not perform an in-depth statistical analysis and were unable to directly compare outcomes associated with the different rehabilitation protocols. Multiple studies were excluded from this review due to the fact that they did not include a postoperative rehabilitation protocol despite evaluating SCR. Some articles were not written in English, which may have provided some guidance.

Another limitation of this review was the variability in the surgical technique and graft choice. As seen in Table 1, the studies in this review recommended different surgical techniques, such as long head of the biceps tendon transfer and supplemental partial rotator cuff repair. Studies also employed different types of grafts, including dermal acellular and fascia lata grafts.

Conclusions

SCR is a relatively new procedure that is gaining rapid popularity with promising outcomes. Based on our review, there is no standard rehabilitation protocol in place, thus it is not possible to recommend an evidence-based rehabilitation protocol following SCR at this time.

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