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Management of shoulder stiffness following rotator cuff repair: a systematic review and meta-analysis

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The purpose was to systematically review and synthesize the literature on treatment modalities for shoulder stiffness following rotator cuff repair (RCR) and investigate which modality provides the greatest postoperative range of motion (ROM). A search was performed on PubMed, Embase, and Cochrane. Clinical case series and comparative studies that report pre- and posttreatment ROM of shoulder stiffness following RCR were included. Studies that exclusively assess idiopathic frozen shoulder or primary shoulder stiffness were excluded. Five eligible studies that reported on a total of 177 patients who underwent treatment for shoulder stiffness following RCR were included. The ranges of postoperative ROM following arthroscopic capsular release were 158°-166° for active forward elevation (AFE) and 53°-59° for external rotation (ER). The ranges of postoperative ROM following infiltration were 146°-163° for AFE and 34°-35° for ER. The ranges of postoperative ROM following rehabilitation were 166° for AFE and 62° for ER. For AFE, 4 studies (5 data sets) were eligible for meta-analysis, which indicated better AFE when treated with a mean difference (MD) of 5.10° with no heterogeneity ($I^2 = 0\%$, CI, 0.83-9.38). For ER, 3 studies (4 data sets) were eligible for meta-analysis, which indicated better ER without treatment with an MD of 4.59° with no heterogeneity ($I^2 = 0\%$, CI, −7.04 to −2.13). For the treatment of shoulder stiffness following RCR, all included treatments improved the ROM, resulting in comparable AFE and ER compared to the comparative group. Among the treatment modalities, arthroscopic capsular release granted the greatest posttreatment AFE, while rehabilitation granted the greatest posttreatment ER.

Rotator cuff pathology is one of the most common causes of shoulder pain, with an overall incidence of 3.7 patients per 100,000.[4,7] Results of both open and arthroscopic rotator cuff repairs (RCRs) have proven adequate pain relief, increased shoulder function, and improved patient satisfaction.[1,3,6,26]

Postoperative shoulder stiffness is a known complication of both open and arthroscopic surgery and is believed to result from an intra-articular inflammatory process that leads to thickening and fibrosis of the joint capsule.[5,25] The prevalence of postoperative resistant stiffness (defined as permanent range of motion [ROM] loss) or transient stiffness (defined as [ROM] loss which responds to nonoperative treatment) following arthroscopic surgery is considerable and ranges from 3% to 23%,[8,21] and may cause patients to be dissatisfied with surgery even though their rotator cuff tear is successfully repaired. Furthermore, it is important to identify risk factors which are associated with shoulder stiffness, a recent study found a greater prevalence in women, in shoulders with partial tears, low-baseline passive abduction, nondegenerative tears, and in those treated without acromioplasty.[2]

Treatments of postoperative shoulder stiffness include conservative and operative modalities, both of which can be challenging. To the authors knowledge there is no consensus regarding the best treatment for postoperative shoulder stiffness following RCR. Over 10 years ago, Denard et al[8] performed a systematic review, including 2 studies,[15,21] on treatment of postoperative shoulder stiffness and found that the best improvement was achieved by a capsular release. However, since then, several new clinical studies were published,[4,14,20] and their findings are yet to be integrated within an updated systematic review. Therefore, the purpose of the present systematic review was to synthesize the literature on

Institutional review board approval was not required for this systematic review study.

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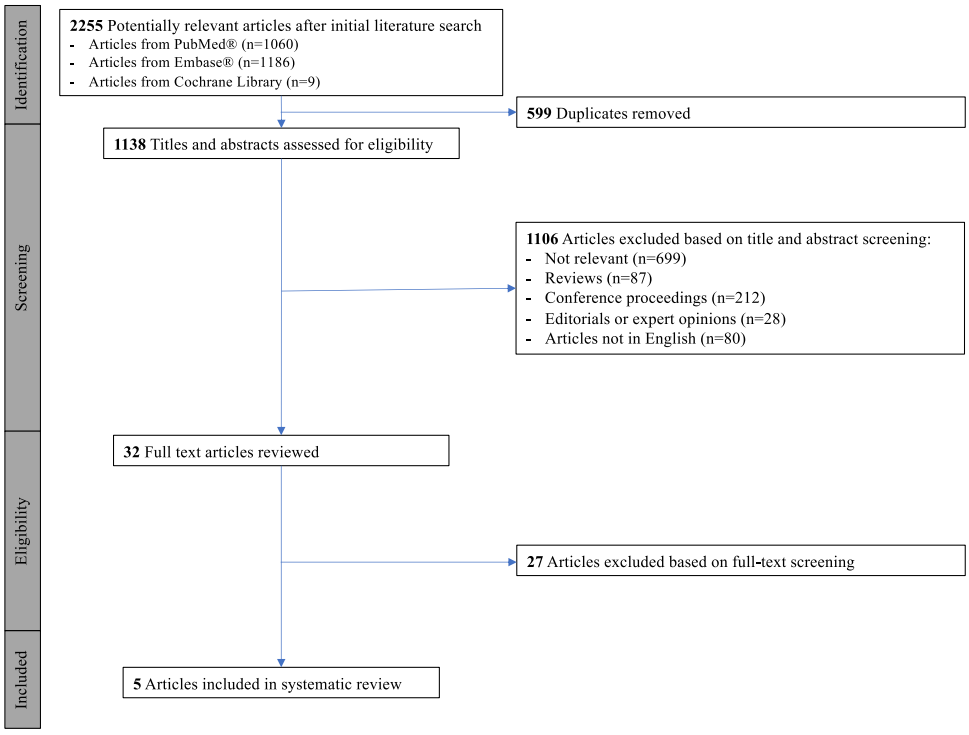


Figure 1 Flowchart.

Table I
Study characteristics and declaration.

Author, year, Country	Journal	Study type	Treatment for shoulder stiffness	Groups	Declarations		
					Cohort	Funding	COI
Bhatia et al, 2013, USA[4]	Indian J Orthop	R	Arthroscopic capsular release	No comparative group	29	No	Yes
Parsons et al, 2010, USA[21]	JSES	R	Rehabilitation (Conservative treatment)	Stiffness with rehabilitation	10	No	Yes
				No stiffness, without rehabilitation	33		
Oh et al, 2011, South Korea[20]	Clinics in Orthop	R	Subacromial injection of HA/carboxymethylated cellulose (CMC)	Injection	40	Yes	Yes
			None	Control group	40		
Kim et al, 2018, South Korea[14]	AJSM	R	Intra-articular steroid injection 6 weeks after RCR	6-week group	35	NA	No
			Intra-articular steroid injection 12 weeks after RCR None	12-week group	39		
				No stiffness, without injection	135		
Huberty et al, 2009, USA[13]	Arthroscopy	R	Arthroscopic capsular release	Stiffness, with release	25	NA	NA
			None	No stiffness, without release	465		

R, retrospective; *RCR*, rotator cuff repair; *COI*, conflict of interest; *JSES*, Jounal of Shoulder and Elbow Surgery; *AJSM*, American Journal of Sports Medicine; *HA*, hyaluronic acid; *NA*, not available.

treatment modalities for shoulder stiffness following RCR and investigate which modality provides the greatest postoperative ROM.

Material and methods

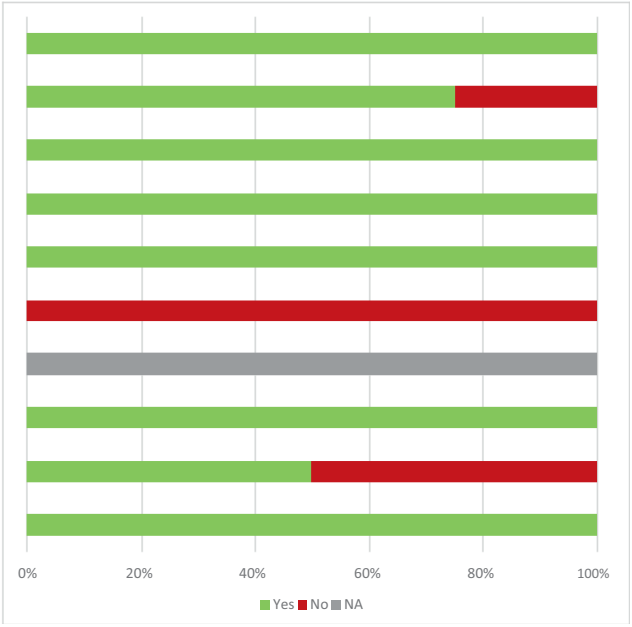
The protocol for this systematic review was submitted to PROSPERO prior to commencement (registration number CRD42021275390) and conforms to the principles outlined in the handbook of the Cochrane Collaboration,[11] along with the guidelines established by the Preferred Reporting Items for Systematic Reviews and Meta-analysis.[18]

Search strategy

The authors conducted a structured electronic literature search on 1 September 2021 using the PubMed, Embase, and Cochrane Central Register of Controlled Trials databases, applying the keywords presented in Supplementary Appendix S1. The search was limited to articles published between January 2001 and September 2021, to ensure a contemporary systematic review, in consideration of modernization of surgical techniques. After removal of duplicate records, each of two researchers (F.S. & F.V.R.) screened the titles and abstracts to determine the suitability for the review using the following predefined eligibility criteria:

Table II
JBI checklist for case control studies.

		Parsons et al. (2010)	Oh et al. (2011)	Kim et al. (2018)	Huberty et al. (2009)
1	Were the groups comparable other than the presence of disease in cases or the absence of disease in controls?	Y	Y	Y	Y
2	Were cases and controls matched appropriately?	Y	Y	Y	N
3	Were the same criteria used for identification of cases and controls?	Y	Y	Y	Y
4	Was exposure measured in a standard, valid and reliable way?	Y	Y	Y	Y
5	Was exposure measured in the same way for cases and controls?	Y	Y	Y	Y
6	Were confounding factors identified?	N	N	N	N
7	Were strategies to deal with confounding factors stated?	NA	NA	NA	NA
8	Were outcomes assessed in a standard, valid and reliable way for cases and controls?	Y	Y	Y	Y
9	Was the exposure period of interest long enough to be meaningful?	Y	N	N	Y
10	Was appropriate statistical analysis used?	Y	Y	Y	Y



JBI, Joanna Briggs Institute; *Y*, yes; *N*, no.

Table III
JBI checklist for case series.

		Bhatia et al. (2013)
1	Were there clear criteria for inclusion in the case series?	Y
2	Was the condition measured in a standard, reliable way for all participants included in the case series?	N
3	Were valid methods used for identification of the condition for all participants included in the case series?	Y
4	Did the case series have consecutive inclusion of participants?	Y
5	Did the case series have complete inclusion of participants?	Y
6	Was there clear reporting of the demographics of the participants in the study?	Y
7	Was there clear reporting of clinical information of the participants?	Y
8	Were the outcomes or follow up results of cases clearly reported?	Y
9	Was there clear reporting of the presenting site(s)/clinic(s) demographic information?	Y
10	Was statistical analysis appropriate?	Y

JBI, Joanna Briggs Institute; *Y*, yes; *N*, no.

Inclusion criteria

- Clinical case series and comparative studies on outcomes of treatments for shoulder stiffness following RCR
- Studies that report pre and post-treatment ROM
- In cases of duplicate patient population between two studies, the most complete dataset was used

Exclusion criteria

- Exclude: studies that exclusively assess idiopathic frozen shoulder or primary shoulder stiffness.
- Studies that do not report pre and post-treatment ROM
- Narrative or systematic reviews, noncomparative case series, case reports, expert opinions, editorials, or letters to editors
- Articles published in other languages than English, French, German, Italian, or Spanish

Study selection

Full-text review of studies meeting the eligibility criteria in the initial screening was performed by two researchers (F.S. & F.V.R.) and any disagreement was first discussed between the researchers and, when required, a third researcher (A.G.) was consulted. The reference lists of studies for full-text review were searched, and an expert on the topic was consulted to identify further relevant studies that may not have been captured by the database searches.

Table IV
Cohort demographics.

Author, year Country	Groups	Shoulders	Sex			Age (y)	
			M/F	M (%)	F (%)	Mean ± SD (range)	Diabetics
Bhatia et al, 2013, USA[4]	No comparative group	29	18/11	62%	38%	50 ± 11 (24-70)	17%
Parsons et al, 2010, USA[21]	Stiffness with rehabilitation	10	4/6	40%	60%	60 ± 12	
	No stiffness, without rehabilitatio	33	15/18	45%	55%	65 ± 10	
Oh et al, 2011, South Korea[20]	Injection	40	20/20	50%	50%	59 ± 8	
	Control group	40	19/21	48%	53%	60 ± 8	
Kim et al, 2018, South Korea[14]	6-week group	35	12/23	34%	66%	58 ± 7	8%
	12-week group	39	21/18	54%	46%	63 ± 7	18%
	No stiffness, without injection	135	63/72	47%	53%	60 ± 7	
Huberty et al, 2009, USA[13]	Stiffness, with release	24	17/7	71%	29%	[49]	11%
	No stiffness, without release	465	311/154	67%	33%	[55]	

M, male; *F*, female; *SD*, standard deviation.
[i] Values in square brackets [] are medians.

Data extraction and quality assessment

Data extraction was performed by two researchers (F.S. & F.V.R.) independently and their results were compared to ensure accuracy. Where there was disagreement in the documented value, the true value was ascertained by simultaneous review of the data in question by both researchers. The following data were extracted from the included studies; author(s), journal, year of publication, level of evidence, country where study was performed, conflicts of interest, and funding declaration. Patient characteristics were retrieved, including number of patients in each group, sex, and age. Furthermore, clinical outcomes collected were: American Shoulder and Elbow Surgeons (ASES) score, the Constant Score, pain on visual analogue scale (pVAS), and ROM (active forward elevation [AFE] and external rotation [ER]). Methodological quality of the eligible studies was assessed by two researchers (F.S. & F.V.R.) according to the Joanna Briggs Institute checklist, to appraise the reporting quality (10-13 items). Where there was disagreement between the researchers, consensus was achieved by discussion and review.

Statistical analysis

Where the domains of studies were not sufficiently comparable to pool, results were displayed in a forest plot and the summary estimate withheld.[9] Heterogeneity was evaluated by visual inspection of the forest plots and quantified using the I^2 statistic to provide a measure of the degree of inconsistency across the studies.[12] Where possible, summary pooled estimates of proportions with 95% confidence intervals were calculated via logit transformation using inverse-variance weighting within a random effects model framework. Statistical analyses were performed using R version 3.5.0 (R Foundation for Statistical Computing, Vienna, Austria) using the meta package.

Results

The systematic search returned 2255 records, of which 599 were duplicates, leaving 1138 for screening (Fig. 1). A total of 1106 studies were excluded by examining their titles and/or abstracts, and a further 27 studies were excluded after full-text review. This left 5 eligible studies[4,13,14,20,21] which reported on a total of 177 patients that underwent treatment for shoulder stiffness following RCR (without accounting for patients in control groups) (Table I). Of the 5 studies, 4 studies were eligible for meta-analysis: Oh et al[20] administered injection and physiotherapy in the treatment group and compared to a control group, while 3 other studies[13,14,21] considered shoulders treated for stiffness as treatment groups vs. shoulders that had no stiffness as control groups.

Quality assessment

Of the 5 included studies, 3 were performed in the United Stated (60%)[4,13,21] and 2 were performed in South Korea (40%).[14,20] Two studies compared to a control group that underwent no treatment (60%),[13,14] 1 study compared to another treatment (20%),[20] and 1 was a case series (20%).[4] The case control studies did not identify any confounding factors,[13,14,20,21] and 1 study did not clearly match cases and controls[13] (Table II). Furthermore, the only case series did not measure the condition in a reliable way[4] (Table III).

Range of motion

All 5 studies reported the ROM before and after treatment for shoulder stiffness; 2 used arthroscopic capsular release,[4,13] 2 used intra-articular or subacromial injections,[14,20] and 1 used rehabilitation[21] (Table IV). The ranges of ROM following arthroscopic capsular release were 158°-166° for AFE and 53°-59° for ER[4,13] (Table V). The ranges of ROM following infiltration were 146°-163° for AFE and 34°-35° for ER.[14,20] The ROM following rehabilitation were 166° for AFE and 62° for ER.[21] For AFE, 4 studies (5 datasets) were eligible for meta-analysis, which indicated better AFE in the treatment groups (compared to control groups), with a mean difference (MD) of 5.1° and no heterogeneity ($I^2 = 0\%$, CI, 0.83-9.38) (Fig. 2). For ER, 3 studies (4 datasets) were eligible for meta-analysis, which indicated better ER in control groups (compared to treatment groups), with a MD of 4.6° and no heterogeneity ($I^2 = 0\%$, CI, −7.04 to −2.13) (Fig. 3).

Clinical scores

Three studies reported the ASES, Constant Score, and pVAS after treatment for shoulder stiffness[4,14,20] (Table VI). The postoperative scores following arthroscopic capsular release were 76 for ASES, 69 for Constant Score, and 2.5 for pVAS.[4] The postoperative scores following infiltration were 83-85 for ASES and 67-69 for Constant Score.[14,20] The postoperative scores following rehabilitation were 83 for ASES, 77 for Constant Score, and 2.0 for pVAS.[21] Meta-analysis was not performed on the clinical scores, due to heterogeneity in reported outcomes among studies.

Table V
ROM.

Author, year, Country	Groups	Shoulders	Follow-up (mo)	Active forward elevation			External rotation		
			Mean ± SD	Preop mean ± SD	Pretreatment ± SD	Post-treatment ± SD	Preop mean ± SD	Pretreatment ± SD	Post-treatment ± SD
Bhatia et al, 2013, USA[4]	No comparative group	29	18 ± 13 (4-44)	104 ± 26		158 ± 22	25 ± 15		59 ± 19
Parsons et al, 2010, USA[21]	Stiffness with rehabilitation	10	12		129 ± 52	166 ± 10	61 ± 29		62 ± 16
	No stiffness, without rehabilitation	33			150 ± 32	161 ± 10	52 ± 20		58 ± 10
Oh et al, 2011, South Korea[20]	Injection	40	12		ND	146 ± 17	ND		ND
	Control group	40		ND		138 ± 25	ND		ND
Kim et al, 2018, South Korea[14]	Injection at 6 weeks postop	35	3			132 ± 29			29.0 ± 12.1
	Injection at 12 weeks postop	39				104 ± 25			21.2 ± 9.4
	No stiffness, without injection	135				139 ± 26			39.3 ± 13.3
Huberty et al, 2009, USA[13]	Stiffness, with release	24	[32]	150.2 ± 37.9	138 ± 26	166 ± 13	32 ± 21		53 ± 15
	No stiffness, without release	465	(14-41)	151.9 ± 45.1	152 ± 2	162 ± 31	56 ± 19		58 ± 15

ND, no difference; *AFE*, anterior forward elevation; *ER*, external rotation; *IR*, internal rotation; *ROM*, range of motion; *SD*, standard deviation.
[i] Values in square brackets [] refer to the entire cohort as opposed to comparative and control groups.

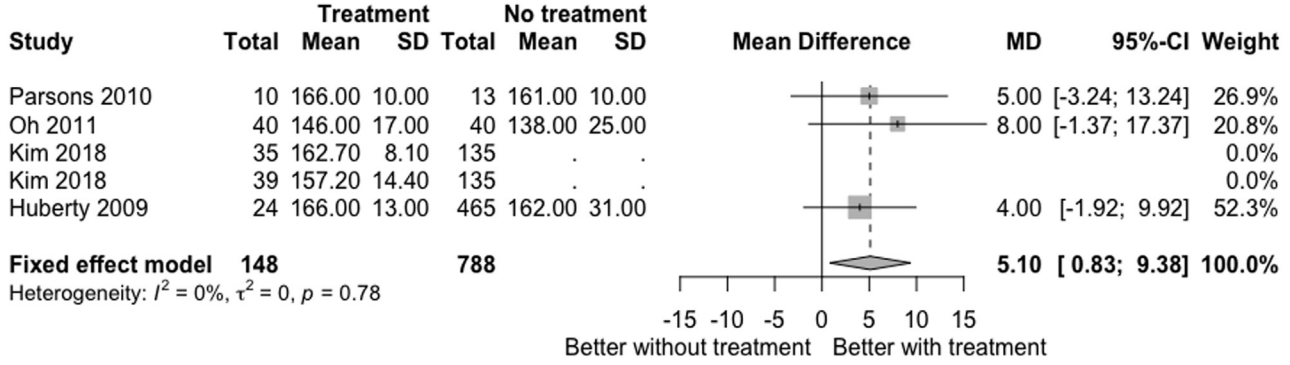


Figure 2 Forest plot of active forward elevation. *SD*, standard deviation; *MD*, mean difference; *CI*, confidence interval.

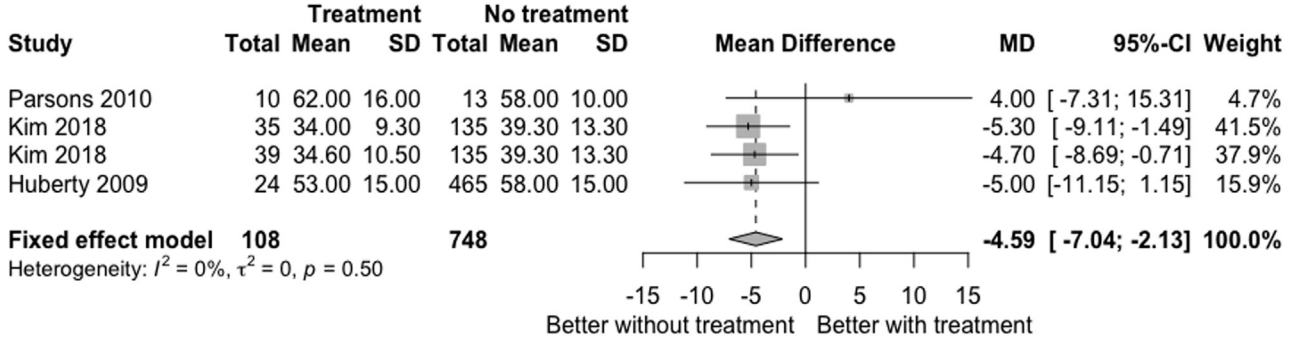


Figure 3 Forest plot of external rotation. *SD*, standard deviation; *MD*, mean difference; *CI*, confidence interval.

Discussion

The most important findings of this systematic review are that, for the treatment of shoulder stiffness following RCR, all included treatments improved the ROM, resulting in similar AFE and ER compared to the control groups. Among the treatment modalities, arthroscopic capsular release granted the greatest post-treatment AFE, while rehabilitation granted the greatest post-treatment ER.

Table VI
Clinical outcomes.

Author, year Country	Groups	Shoulders	Follow-up	Timepoint	ASES		Pain on VAS		Constant Score		Other scores #1		
			Mean ± SD		Pretreatment mean ± SD	Post-treatment mean ± SD	Pretreatment mean ± SD	Post-treatment mean ± SD	Pretreatment mean ± SD	Post-treatment mean ± SD	name	Pretreatment mean ± SD	Post-treatment mean ± SD
Bhatia et al, 2013, USA[4]	No comparative group	29	18 ± 13 (4-44)			75.5 ± 24		2.5 ± 2.9		68.9 ± 16	SANE		80.3 ± 19
Parsons et al, 2010, USA[21]	Stiffness with rehabilitation	10	12		45.0 ± 21	83.0	5.8 ± 3.1	2.0	46.0 ± 21.0	77.0			
	No stiffness, without rehabilitation	33			47.0 ± 23	79.0	5.1 ± 2.7	1.7	54.0 ± 22.0	74.0			
Oh et al, 2011, South Korea[20]	Injection	40	12	6 mo		82.5	ND	ND		68.4			
	Control group	40		6 mo		84.4	ND	ND		67.9			
Kim et al, 2018, South Korea[14]	Injection at 6 weeks postop	35	12								KSS	61.2 ± 12	81.3 ± 12
	Injection at 12 weeks postop	39										58.5 ± 17	83.4 ± 9
	No stiffness, without injection	135										66.3 ± 15	90.4 ± 14
Huberty et al, 2009, USA[13]	Stiffness, with release	24	[32] (14-41)					[1] (0–3)					
	No stiffness, without release	465											

ND, no difference; *ASES*, American Shoulder and Elbow Surgeons; *VAS*, visual analog scale; *SD*, standard deviation; *SANE*, single assessment numeric evaluation; *KSS*, Knee Society Score.
[i] Values in square brackets [] refer to the entire cohort as opposed to comparative and control groups.

There was considerable heterogeneity among the studies, in terms of timepoints at which outcomes were collected, rendering it difficult to conclude on the best treatment for shoulder stiffness following RCR. Further clinical studies are required to provide better evidence on the best treatment for postoperative shoulder stiffness, which could provide clearer information to surgeons and patients.

Shoulder stiffness is a common and important complication after arthroscopic RCR,[5,13] and even though postoperative pain and limitation of ROM due to shoulder stiffness may resolve over time without treatment,[20,23] early postoperative shoulder stiffness may cause uncomfortable pain that can hinder rehabilitation. Furthermore, shoulder stiffness following RCR may not improve with medication and physical therapy, possibly due to extra-articular or capsular adhesions.[24] In severe cases, nonoperative treatment for stiffness following RCR may be a long agonizing wait for enhanced results, in which surgical interventions may be needed.

In the present systematic review, 2 of the included studies evaluated the efficacy of arthroscopic capsular release. Bhatia et al[4] found arthroscopic capsular release (with lysis of adhesions, manipulation under anesthesia, and aggressive physical therapy) to be safe and reliable for restoring shoulder motion in cases with post-traumatic stiffness and demonstrated that AFE and ER considerably improved in recalcitrant cases. Huberty et al[13] found that, in a series of 489 consecutive arthroscopic RCRs, 24 (4.9%) developed postoperative stiffness, but that arthroscopic capsular release restored normal ROM in all patients. Huberty et al[13] found that risk factors for postoperative stiffness following RCR were calcific tendinitis, adhesive capsulitis, single-tendon cuff repair, younger than 50 years, and having workers compensation.

Intra-articular corticosteroid injection is a common treatment for primary frozen shoulder, with satisfactory long-term results by improvement of ROM and reduction of pain,[16] and the use of intra-articular steroid injections for adhesive capsulitis can results in an increase in AFE before postoperative rehabilitation. Among the studies included in the present systematic review, Kim et al[14] found that early injection of intra-articular corticosteroids could relieve pain and improve ROM. Conversely, Oh et al[20] used subacromial injections of sodium hyaluronate as an antiadhesive agent and found a tendency for faster improvement in forward flexion at 2 weeks postoperatively. The efficacy and safety of hyaluronate has been widely reported in abdominal and gynecologic surgery.[10,17] The use of sodium hyaluronate as a conservative treatment of rotator cuff tears and shoulder pain has been reported,[19,22] but considering that stiffness is one of the important complications after shoulder surgery, there is little to no data available on the antiadhesive effects of hyaluronate in the shoulder joint, particularly after RCR.

The results of the present systematic review should be interpreted with the following limitations in mind. The comparative studies found had different definitions of control groups, with 1 comparing injection and physiotherapy (treatment group) vs. physiotherapy (control group) and the 3 other studies comparing shoulders treated for stiffness (treatment groups) vs. shoulders that had no stiffness (control groups). There was also considerable heterogeneity among the studies, in terms of timepoints at which outcomes were collected, rendering it difficult to conclude on the best treatment for shoulder stiffness following RCR. Although the overall level of quality was good to fair for the majority of studies, 4 were comparative studies, while 1 was a case series. Furthermore, we only included studies which reported outcomes of treatments, even though other options, such as simple observation of the patient are available. Finally, it is worth noting that since the last systematic review, few additional studies have been published in recent years, highlighting a need for new studies and trials on this topic.

Conclusion

For the treatment of shoulder stiffness following RCR, all included treatments improved the ROM, resulting in similar AFE and ER compared to the control groups. Among the treatment modalities, the 2 studies that investigated post-treatment AFE favored arthroscopic capsular release, while the 1 study that investigated ER favored rehabilitation.

Disclaimers:

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Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.xrrt.2023.02.004.

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