Systematic Review

Corticosteroid Injections May Increase Retear and Revision Rates of Rotator Cuff Repair: A Systematic Review

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Purpose: To synthesize the clinical outcome data of preoperative and postoperative corticosteroid injections (CIs) and their effect on rotator cuff repairs (RCRs). **Methods:** A systematic review was performed to identify studies that reported the results or clinical outcomes of RCRs in patients receiving either preoperative or postoperative CIs. The searches were performed using MEDLINE, Google Scholar, and Embase, and studies were chosen following PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-analyses) guidelines. **Results:** A total of 11 studies were included with data for 176,352 shoulders: 6 studies involving 175,256 shoulders with data regarding preoperative CIs, 4 studies involving 1,096 shoulders with data regarding postoperative CIs, and 1 study with 212 shoulders containing preoperative and postoperative data. Preoperative CIs were found in 3 studies to increase the risk of revision surgery when administered within 6 months (odds ratio [OR], 1.38-1.82) and up to 1 year (OR, 1.12-1.52) prior to RCR, with revision rates in 2 studies being highest when patients received 2 or more injections (OR, 2.12-3.26) in the prior year. Postoperative CIs reduced pain and improved functional outcomes in 5 studies without increasing the retear rates (5.7%-19% for CI and 14%-18.4% for control) in most studies. **Conclusions:** CIs provide benefit by relieving pain and improving functional outcome scores. However, repeated preoperative CIs may increase retear rates and the likelihood of revision surgery. A lower frequency of CI and longer preoperative waiting period after CI should be considered to decrease such risks. Postoperative CIs several weeks after RCR do not appear to increase retear rates. **Level of Evidence:** Level IV, systematic review of Level I through IV studies.

Shoulder pain is among the most common complaints at orthopaedic clinics, ranking third among musculoskeletal complaints.[1] Rotator cuff–related pathologies account for 65% of shoulder-related visits.[1] First-line conservative treatment of rotator cuff tears often entails anti-inflammatories in the form of a corticosteroid injection (CI). The current American Academy of Orthopaedic Surgeons guidelines support the use of a single CI to improve pain and function in patients with rotator cuff tears while maintaining that CIs may be detrimental to subsequent repair.[2] In addition, the American Academy of Orthopaedic Surgeons lists a consensus recommendation against multiple CIs for rotator cuff tears because they may affect repair. CIs can also be used postoperatively after rotator cuff repair (RCR) for pain relief and shoulder stiffness. CIs reduce the production of numerous proinflammatory cytokines, thus decreasing inflammation and pain,[1,3] but such effects may be short-lived.[1] Moreover, there is increasing concern about the effect of CIs on tendon-to-bone healing in the setting of RCR.[1,3] This is of interest to orthopaedic surgeons because inadequate tissue healing is the primary cause of retear, which has been reported to occur at a rate of 12% to 94% depending on the repair technique performed and a variety of patient-specific factors.[4-8] Although revision RCR is associated

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with improved patient outcomes from baseline, these improvements are limited compared with those in patients undergoing primary RCR.[9]

Additional studies have highlighted the transient effects of a CI in the setting of a rotator cuff tear. Contreras et al.[10] reported that 40% of patients who received a subacromial CI for rotator cuff pathology elected to undergo surgical intervention within 1 year. There is also evidence of a potential link between repeated CIs and tendon degeneration or rupture.[11,12] Maman et al.[12] reported that rat tendons exposed to multiple CIs had significantly decreased maximal load and stiffness compared with a control group. Their study also revealed decreased humeral greater tuberosity density after repeated CIs.

The purpose of this study was to synthesize the clinical outcome data of preoperative and postoperative CIs and their effects on RCRs. We hypothesized that CIs administered in the setting of RCR might have deleterious effects on tendon-to-bone healing evidenced by poor functional outcomes, increased retear rates, and increased revision surgery rates.

Methods

This systematic review was performed using the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-analyses) 27-item checklist.[13]

Eligibility Criteria

Included were studies that reported either patient-reported functional outcomes, retear rates identified by either magnetic resonance imaging or ultrasound, or reoperation rates after RCR. Results must have included RCR and the use of a CI before or after surgical repair. We excluded case reports, reviews, and studies published in languages other than English.

Data Sources and Searches

The PROSPERO database was searched for previous systematic reviews on this topic. MEDLINE (accessed through PubMed), Google Scholar, and Embase were searched for qualifying publications. Searches for qualifying literature in these databases were performed in May 2019. PROSPERO was searched for the search term "rotator cuff." The search-term algorithm used to search PubMed, Google Scholar, and Embase was "rotator cuff" AND (anti-inflammatory OR steroid OR corticosteroid OR injection OR methylprednisolone).

Study Selection

Titles and abstracts were reviewed to determine relevance and the potential of the study to meet the inclusion criteria. Studies that did not meet the inclusion criteria were excluded. After exclusion of nonrelevant studies, the full text of each article was reviewed for inclusion. In addition to review of the article, the references listed in each article were reviewed to search for additional relevant studies. The search was performed independently by 2 investigators (G.C.V. and A.M.C.). Any discrepancies were settled by consensus. Pooled means and ranges were calculated, and individual study evaluation and comparisons (qualitative analysis) were performed for systematic review.

Results

The PROSPERO search resulted in no previous systematic reviews analyzing outcomes after RCR with associated CI. The literature search produced 732 nonduplicate publications. After review of full articles, 11 studies published between 2016 and 2019 met the inclusion criteria: 6 evaluated only patients with preoperative CIs, 4 evaluated only patients with postoperative CIs, and 1 evaluated patients with both preoperative and postoperative CIs. Figure 1 summarizes the search algorithm.

Preoperative CIs

Of the 7 studies including preoperative CIs, 5 were Level III studies,[14-18] 1 was Level IIb,[19] and 1 was Level IV.[20] All 7 studies administered CIs less than 12 months before RCR. Of these studies, 6 had a follow-up period ranging from 1 to 7 years postoperatively and 1 had a follow-up period ranging from 2 to 13 years.[16] Outcome measures reported by these studies included the visual analog scale (VAS) score,[19] American Shoulder and Elbow Surgeons (ASES) score,[14,19] Constant-Murley score,[20] revision RCR rates,[16,18]

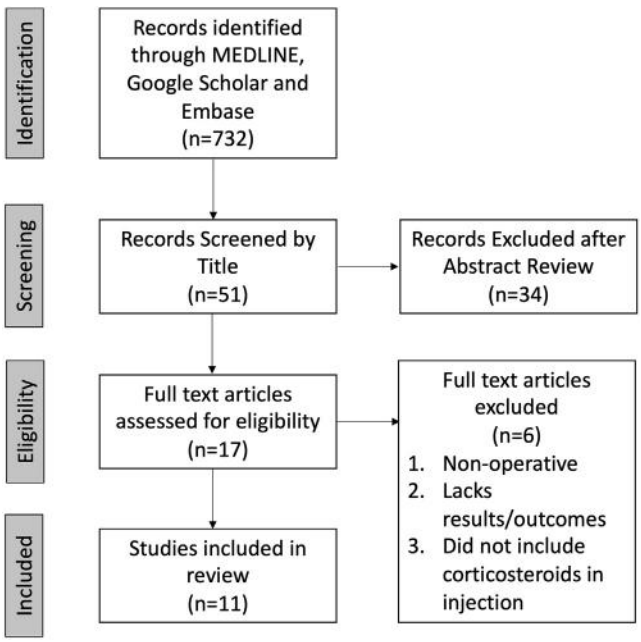

Figure 1. Literature selection algorithm.

reoperation rates,[15,17] frequency effects,[16,18] and temporal effects.[16] Table 1 includes a summary of the preoperative studies.

Revision Rates. Four studies reported the rates of revision to evaluate the potential effects of preoperative CI on healing after RCR (Table 2).[15-17,20] The study by Traven et al.[15] included 4,959 patients and found that patients who received CI within 0 to 3 months (odds ratio [OR], 1.38 [95% confidence interval, 1.03-1.84]) and 3 to 6 months (OR, 1.822 [95% confidence interval, 1.290-2.537]) of surgery had significantly higher odds of requiring revision RCR within 3 years. Weber et al.,[16] conducting a study with 22,156 patients, showed that those who received a CI 0 to 12 months prior to RCR had significantly higher odds of future revision RCR (OR, 1.52 [95% confidence interval, 1.38-1.58]) when matched with controls. The study by Agarwalla et al.[17] included 24,108 patients and indicated that patients who received CI within 1 year prior to RCR had significantly higher odds of revision RCR (1.6% vs 1.1%; OR, 1.3 [95% confidence interval, 1.1-1.8]) and subsequent subacromial decompression (1.5% vs 1.1%; OR, 1.3 [95% confidence interval, 1.1-1.7]) than patients who did not receive CI. Baverel et al.,[20] in a study of 103 patients, calculated through multivariable analysis that retear rates at final follow-up were not significantly associated with preoperative CIs (regression coefficient, 0.85 [95% confidence interval, 0.58-1.18]; $P = .367$).

Two studies reported the effects of receiving greater than 1 CI during the year prior to RCR (Table 2).[16,18] Weber et al.[16] showed that both patients who received 1 injection (OR, 1.25 [95% confidence interval, 1.10-1.43]) and those who received 2 or more injections (OR, 2.12 [95% confidence interval, 1.82-2.47]) within 12 months prior to RCR had significantly higher odds of revision. The study by Desai et al.[18] included 123,459 patients and found no significant increase in the odds of revision in groups receiving 1 injection within the year prior to RCR. However, they found that those receiving 2 or more injections prior to RCR had significantly higher odds of revision surgery.

Functional Outcomes. The study by Donohue et al.[19] included 132 patients and reported that both patients who received a preoperative CI and those who did not showed significant improvements in VAS, ASES, and Constant scores at final follow-up. The patients who required a preoperative CI showed the greatest change in all functional scores. In a study of 374 patients, Tonotsuka et al.[14] reported that patients who received multiple preoperative CIs showed significant improvements in ASES scores postoperatively, but their preoperative and postoperative ASES scores were significantly lower than those of patients who did not receive CIs at final follow-up. Baverel et al.[20] found that both patients who received preoperative CIs and those who did not showed significant improvements in postoperative Constant scores, but there was no statistically significant difference between the groups at final follow-up.

Temporal Effects. Weber et al.[16] reported the temporal effects of administering a CI before RCR. They concluded that a CI given at any time point within 1 year before RCR significantly increases the risk of revision surgery. Receiving a CI within 2 months of RCR was shown to be associated with the highest odds of requiring revision surgery.

Postoperative CIs

Of the 4 solely postoperative CI studies, 3 were Level III studies[21-23] and 1 was Level I.[24] The study by Baverel et al.[20] was a Level IV study that included postoperative data as well. CIs were administered at periods ranging from 1.1 to 11 months postoperatively. The follow-up period for these studies ranged from less than 1 month to 25.7 months. Outcome measures reported included the VAS score,[21,22,24] ASES score,[21,22,24] Constant-Murley score,[20,21,24] Subjective Shoulder Value,[22] University of California, Los Angeles (UCLA) shoulder score,[22,23] Korean Shoulder Score,[23] and retear rates.[20-22,24]

Retear Rates. All 5 studies examining postoperative CIs evaluated retear rates as outcomes (Table 3). Retears were identified through magnetic resonance imaging in 4 postoperative studies at an average of 7.5 months postoperatively.[21-24] Baverel et al.[20] used ultrasound to assess retear at an average of 3.1 years after RCR. Their study was the only study to find a significant increase in retear rates in patients receiving CI after RCR (OR, 2.19 [95% confidence interval, 1.23-3.92]); the remaining 4 studies found no significant increase in retear rates.

Functional Outcomes. Five studies reported functional outcomes in patients who received postoperative CIs. Shin et al.[21] reported VAS, ASES, and Constant scores in 458 patients receiving postoperative CIs; all significantly improved, but the study failed to establish a significant difference between the injection and control groups at final follow-up. Kim et al.[24] conducted a randomized trial of 80 patients, and those who received a CI at 8 weeks postoperatively had significantly lower VAS scores and increased ASES scores at 3 months postoperatively compared with the control group, but at 6 months postoperatively, there were no significant differences

Table 1. Demographic Characteristics of Included Studies (Publications Reporting Outcomes After RCR With Either Preoperative or Postoperative CIs)

Authors	Year	Journal	LOE	Drugs Used	Time of Injection	Follow-up Time after Surgery	No. of Shoulders	Outcome Measures
Preoperative injection								
Donohue et al.[19]	2017	*Muscle, Ligaments and Tendons Journal*	IIb	Betamethasone with 1% lidocaine	0-3 mo, 3-6 mo, and >6 mo prior to RCR	1 yr postop	132	VAS score, ASES score, Constant score
Tonotsuka et al.[14]	2019	*Clinics in Orthopaedic Surgery*	III	Dexamethasone and mepivacaine	M ± SD, 4.4 ± 1.2 mo before RCR	M ± SD, 29.6 ± 9.7 mo postop	374	Postoperative refractory pain, ASES score
Traven et al.[15]	2019	*Arthroscopy*	III	Unspecified CI	<12 mo before RCR	3 yr postop	4,959	Adjusted OR of reoperation
Weber et al.[16]	2019	*Arthroscopy*	III	Unspecified CI	<12 mo before RCR	Unlimited	22,156	Revision RCR rates, temporal effects, frequency effects
Agarwalla et al.[17]	2019	*Arthroscopy*	III	Unspecified CI	<12 mo before RCR	12 mo postop	24,108	Reoperation rates
Desai et al.[18]	2019	*Arthroscopy*	III	Unspecified CI	<12 mo before RCR	1-7 yr postop	123,459	Revision RCR rates, frequency effects
Baverel et al.[20]	2017	*JSES Open Access*	IV	Betamethasone	M ± SD, 5.2 ± 1.9 mo prior to RCR	M ± SD, 3.1 ± 1.1 yr	103	Constant score, retear rates
Postoperative injection								
Shin et al.[21]	2016	*AJSM*	III	Triamcinolone and lidocaine	M ± SD, 34 ± 5 d after RCR	0, 1, 3, 6, and 12 mo and final follow-up	458	VAS score, ASES score, Constant score, retear rates
Kim et al.[24]	2019	*AJSM*	I	Triamcinolone and lidocaine	8 wk postop	3, 6, and 12 mo and final follow-up (25.7 mo)	80	VAS score, ASES score, Constant score, ROM, retear rates
Lee et al.[22]	2019	*Knee Surgery, Sports Traumatology, Arthroscopy*	III	Unspecified CI	<3 mo postop	3, 6, 12, and 24 mo postop	318	VAS score, ASES score, SSV, UCLA score, ROM, retear rates
Kim and Jung[23]	2018	*AJSM*	III	Triamcinolone and bupivacaine	2 groups: 12, 16, and 20 wk (12-wk group) and 6, 10, and 14 wk (6-wk group)	2 yr postop	209	KSS, UCLA score, ROM, retear rates
Baverel et al.[20]	2017	*JSES Open Access*	IV	Betamethasone	NR	M ± SD, 3.1 ± 1.1 yr	66	Constant score, retear rates

AJSM, *American Journal of Sports Medicine*; ASES, American Shoulder and Elbow Surgeons; CI, corticosteroid injection; KSS, Korean Shoulder Score; LOE, level of evidence; OR, odds ratio; postop, postoperatively; RCR, rotator cuff repair; ROM, range of motion; SD, standard deviation; SSV, Subjective Shoulder Value; UCLA, University of California, Los Angeles; VAS, visual analog scale.

Table 2. Long-Term Outcomes of Preoperative Corticosteroid Injections

Authors	N	Outcome Measures	Units	Results (95% CI)
Traven et al.[15]	4,959	Adjusted odds of reoperation and 95% CI	Adjusted OR, 95% CI	0-3 mo before RCR: 1.375 (1.027-1.840)* 3-6 mo before RCR: 1.822 (1.290-2.573)* 6-12 mo before RCR: 1.237 (0.787-1.943)
Weber et al.[16]	22,156	Revision RCR rates, CI frequency effects	OR, 95% CI	0-12 mo before RCR Unmatched analysis: 1.52 (1.32-1.68)* Matched analysis: 1.52 (1.38-1.68)*
			Revision rates, OR, 95% CI	0 injections 0-12 mo before RCR: 3.2% 1 injection 0-12 mo before RCR: 4.7%; OR, 1.25 (1.10-1.43)* 2 or more injections 0-12 mo before RCR: OR, 2.12 (1.82-2.47)*
Agarwalla et al.[17]	12,054	Revision RCR rates	Revision rates, OR, 95% CI	Revision RCR Reoperation within 3 mo: 2.9% for control and 2.6% for injection; OR, 0.9 (0.8-1.1) Reoperation at 3-6 mo: 0.9% for control and 1.1% for injection; OR, 1.0 (0.8-1.4) Reoperation at 6-12 mo: 1.1% for control and 1.6% for injection; OR, 1.3 (1.1-1.8)* Reoperation within 12 mo: 4.8% for control and 5.1% for injection; OR, 1.1 (0.9-1.3) Total reoperations 3.7% for control and 3.1% for injection; OR, 0.8 (0.7-1.0)* 1.4% for control and 1.8% for injection; OR, 1.3 (1.0-1.6)* 2.0% for control and 2.5% for injection; OR, 1.2 (1.0-1.5)* 6.9% for control and 7.1% for injection; OR, 1.1 (0.9-1.3)
Desai et al.[18]	123,459	Revision RCR rates, CI frequency effects	Revision rates, OR, 95% CI	Medicare patients 3.4% for control 3.8% for 1 injection; OR, 1.12 (0.93-1.34) 9.0% for 2 injections; OR, 2.76 (2.25-3.38)* 9.4% for ≥3 injections; OR, 3.26 (2.68-3.97)* Humana patients 3.4% for control 3.7% for 1 injection; OR, 1.16 (1.01-1.33) 7.0% for 2 injections; OR, 2.53 (2.15-2.99)* 8.6% for ≥3 injections; OR, 2.87 (2.44-3.38)*

CI, confidence interval; OR, odds ratio; RCR, rotator cuff repair.
*Statistical significance ($P \leq .05$).

Table 3. Retear Rates for Postoperative Corticosteroid Injections

Authors	Injection, %	No Injection, %
Shin et al.[21]	6.8*	18.4
Kim and Jung[23]	5.7 in 6-wk group and 10.3 in 12-wk group	14.1
Lee et al.[22]	17.9	17.2
Kim et al.[24†]	Type I: 77.5	Type I: 67.5
	Type II: 12.5	Type II: 17.5
	Type III: 2.5	Type III: 5
	Type IV: 7.5	Type IV: 4
Baverel et al.[20†]	Preoperative CI: 6	14
	Postoperative CI: 19‡	
	Both preoperative and postoperative CI: 15	

CI, corticosteroid injection.
*$P = .06$.
†Sugaya classification.
‡Statistical significance ($P < .05$).

between the injection and control groups. Lee et al.,[22] in a study with 318 total patients, administered CIs at 3 months postoperatively, and this group was found to have a significantly higher VAS score and lower Subjective Shoulder Value, ASES score, and UCLA shoulder score at the time of injection. These patients progressed to have no significant differences in functional scores compared with the control group at subsequent follow-up. In a study of 209 patients, Kim and Jung[23] administered CIs in one group starting at 6 weeks and another group starting at 12 weeks postoperatively. The 6-week group showed significant improvement in the Korean Shoulder Score and UCLA score compared with the 12-week group at 3 months postoperatively, but both groups showed no significant difference compared with the control group at final follow-up. Baverel et al.[20] found that the 35 patients who received postoperative CIs showed a significant improvement in the Constant score, but there was no significant difference compared with the control group. Postoperative Constant scores were significantly associated with preoperative CIs, preoperative Constant scores, and postoperative CIs.

Discussion

CIs prior to RCR may increase retear rates and subsequent revision rates when multiple injections are given or when injections are given too close to surgery, whereas postoperative CIs do not appear to increase revision rates after a sufficient period of healing. Preoperative CIs were shown in 3 included studies to be associated with an increased risk of revision surgery. Weber et al.[16] found patients receiving a CI within 1 year prior to RCR were 25% more likely to require revision surgery whereas those who received a CI within 2 months prior to RCR were 50% to 70% more likely to require revision surgery. Agarwalla et al.[17] found that patients receiving a CI within 1 year prior to RCR were 40% more likely to require revision surgery. Finally, Traven et al.[15] found that patients receiving a CI within 6 months of RCR were 80% more likely to undergo revision RCR whereas those receiving an injection more than 6 months prior to RCR did not show a significant increase in the likelihood of revision RCR. The temporal relation between a CI and RCR needs further evaluation to better understand the optimal time surgeons should wait after a CI before proceeding with RCR to minimize the risk of revision surgery, presumably owing to a retear. Additionally, a preoperative CI within 1 month prior to RCR has been associated with an increased risk of surgical-site infection.[25,26]

The number of CIs prior to RCR may also increase the risk of revision surgery. Patients who received 2 or more injections within the year prior to RCR were over 2 times more likely to require revision surgery.[16] Desai et al.[18] found that patients receiving a single injection in the year prior to RCR had no significant increase in the likelihood of revision RCR. However, patients receiving 2 or more injections in the prior year were 3 times more likely to require revision RCR in the same study. Thus, it appears that multiple CIs should be avoided within a year prior to RCR.

The included studies in this review found that patients receiving a CI before RCR showed improvement in functional outcomes at final follow-up similar to the control groups. Baverel et al.[20] found that preoperative CIs had no significant influence on functional outcome scores or retear rates after RCR. In contrast, Donohue et al.[19] and Tonotsuka et al.[14] reported a significant improvement in functional outcomes in patients receiving CI prior to RCR. It is unclear why a preoperative CI may help long-term outcomes, but perhaps there is a continued effect of the CI in the immediate postoperative period that ultimately allows for improved and earlier rehabilitation.

Studies indicated that patients receiving a postoperative CI after RCR had reduced postoperative pain, improved functional outcome scores, and increased range of motion (ROM). Most of the included studies showed that postoperative CIs did not increase retear rates[21-24]; these 4 studies indicated that postoperative CIs ranging from 6 weeks to 3 months after RCR for symptomatic patients reduced pain, increased functional outcome scores, and increased ROM. Kim et al.[24] noted that they delayed injections until 8 weeks after RCR to avoid adverse effects on tendon healing. In contrast, Baverel at al[20] showed that patients who received a postoperative CI had lower Constant scores and higher revision rates. It should be noted that the postoperative timing of CI administration was not recorded in this study and that the authors pointed out

that they could not determine whether postoperative CIs were causative of worse outcomes or whether they were administered in patients who already had poor outcomes. Postoperative CIs appear to improve postoperative pain, function, and ROM while having a minimal effect on the risk of revision surgery. The effect of postoperative CIs will need to be further evaluated to determine the appropriate time to administer a CI postoperatively. It is likely that the patients who fare the best with a postoperative CI have had adequate time for tendon healing to occur.

The increased risks of retears and revision surgery can be explained by basic science animal studies. CIs have been shown to have deleterious effects on tendon healing. Studies have been conducted evaluating the biomechanical effects of CIs on rat tendons.[12,27] CIs significantly decrease bone microvascularization at the tendon insertion site, which is imperative for healing after RCR.[28] CIs also increase apoptosis of tendon tenocytes and fibroblasts[27,29] and decrease the density of the tendon insertion site of the greater tuberosity in rats.[12] Repeated CIs have been shown to decrease the biomechanical strength of the tendon at the insertion site.[12,27] Although a decrease in biomechanical strength occurs in the early phase, numerous studies have shown that this effect is transient and a waiting period of 4 to 8 weeks at a minimum is required to regain normal structural integrity.[27,30,31] However, a large-scale randomized trial is warranted to measure these effects in humans. These studies suggest that CIs negatively affect tendon integrity, therefore lending possible explanations as to why there is an association between increased retear rates and patients receiving preoperative CIs.

Tear size or shape was cited in 6 of the 11 included studies.[14,20-24] All patients were treated with suture anchors according to the size of the tear. Only 1 study found a significant difference in tear size between the groups receiving CIs and the control group.[23] L-shaped rotator cuff tears had a significantly higher incidence of CI use after RCR owing to persistent pain compared with flap tears, crescent-shaped tears, and U-shaped tears.[21]

Limitations

Our study is limited by the quality of the studies included in this review, which are mostly retrospective analyses, with the exception of a single randomized controlled trial.[24] Additionally, there exists a large disparity in the number of patients included in each study; the studies, therefore, cannot be given equal weight. Another limitation of this study is the lack of homology of the included studies regarding tear size, fatty infiltration, and tear chronicity. Furthermore, bias is introduced by the idea that patients receiving CI prior to surgery will ultimately have rotator cuff tears that are larger, have greater retraction, and have increased fatty infiltration simply because of increased chronicity. It is difficult to establish a causal relation between CI and the risk of revision after RCR. The included studies' use of insurance databases limits the ability to clinically correlate outcomes and adverse effects, which speaks to the need for randomized controlled studies to account for possible confounders. These confounders could include but are not limited to tear size, patient age, tear chronicity, presence of muscle atrophy, additional surgical procedures such as subacromial decompression, diabetes management, and other factors that may affect tendon-to-bone healing such as smoking status. Multivariate analyses would be necessary to tease out confounders and elucidate the unbiased effect of corticosteroids on RCR failure. In addition, only 1 study identified other causes of pain that were addressed at the time of surgery, including biceps tenodesis or tenotomy, SLAP lesions, subscapularis tears, and acromioplasty.[22] These concomitant procedures can contribute to postoperative pain and influence outcomes.

Conclusions

CIs provide benefit by relieving pain and improving functional outcome scores. However, repeated preoperative CIs may increase retear rates and the likelihood of revision surgery. A lower frequency of CI and longer preoperative waiting period after CI should be considered to decrease such risks. Postoperative CIs several weeks after RCR do not appear to increase retear rates.

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