Systematic Review

Corticosteroid Injections After Rotator Cuff Repair Improve Function, Reduce Pain, and Are Safe: A Systematic Review

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Purpose: To review the literature on postoperative corticosteroid injections (CSIs) following primary rotator cuff repair (RCR) to evaluate efficacy and adverse effects. Methods: A systematic review of the MEDLINE, EMBASE, and Cochrane databases were performed to identify all studies published within the last 15 years, which reported on outcomes of postoperative CSIs following RCR. Studies including patients who received only preoperative CSIs and revision RCRs were excluded. Included studies were evaluated for study methodology, patient demographics, outcome measures, physical examination parameters, results of imaging studies, and adverse effects or clinical complications. Results: Seven studies comprising 5,528 patients satisfied inclusion criteria. Among included patients, 54.8% were female and mean age range from 52.3 ± 13.0 to 62.7 ± 6.6 years. Only 1 included investigation was a Level I study. Overall, 4 of 5 studies reported significant improvements in pain and outcome scores (Constant score, American Shoulder and Elbow Surgeons score) compared with controls. Across all studies, the majority of these effects were statistically significant at 3 months postoperatively but not beyond this time point. Five of the 6 included investigations reported no increased rate of retears after postoperative CSIs. One study did find an increase in retear in patients receiving postoperative CSIs but was unable to determine whether these retears were present before the patient received the CSI. Another investigation reported an increased rate of infection only if the CSI was administered in the first postoperative month. Conclusions: Postoperative CSIs may improve pain and function for up to 3 months following primary RCR but not at later follow-up time points. CSIs should be administered only after the first postoperative month to minimize the potential risk for adverse events. Level of Evidence: Systematic review of level I-IV studies.

Corticosteroid injections (CSIs) have become commonplace in the realm of orthopaedic surgery and are now used in the treatment of several prevalent conditions, including osteoarthritis, adhesive capsulitis of the shoulder, and various tendon pathologies. A number of options for injections exist, including hydrocortisone, betamethasone, methylprednisolone, triamcinolone, and dexamethasone. These drugs exert a complex anti-inflammatory effect on injected tissues by counteracting proinflammatory cytokines, down-regulating immune function, and dampening vascular responses. The net result is often a reduction in pain and stiffness, with substantial relief conferred to the patient in the short- to intermediate-term.

One application of CSIs that has garnered considerable interest in recent years is their use in rotator cuff pathology. In 2 recent meta-analyses, Lin et al. and Mohamadi et al. found that corticosteroids had limited by counteracting...
and transient utility in reducing pain and increasing function for patients with rotator cuff tendinopathy. Moreover, several studies have recently established significant relationships between preoperative CSIs and postoperative complications following rotator cuff repair (RCR) including retear, the need for revision surgery, and infection.9-14 These complications associated with preoperative CSIs also may apply to postoperative CSIs after RCR. Basic science investigations have additionally reported that local administration of glucocorticoids can be deleterious to tendon health and physiology, inducing changes such as reduced cellular viability/proliferation, diminished mechanical strength, increased necrosis, and disorganization of the extracellular matrix.15 Given this growing body of evidence challenging the role of CSIs in rotator cuff pathology, this topic remains actively debated within the orthopaedic community.

In the midst of this discussion, several groups also have investigated the use of CSIs in the postoperative setting.9,16-21 Pain and stiffness are among the most common complications following RCR,22,23 and there may be a meaningful role for steroid injections in management. However, this application of CSIs is poorly understood, and neither the efficacy nor safety of CSI for this indication is well-established. As the rate of RCR continues to rise,24 it is imperative to better comprehend the implications of postoperative CSI administration to guide clinical decision-making and optimize patient outcomes. The purpose of this study was to review the literature on postoperative CSIs following primary RCR to evaluate efficacy and adverse effects. We hypothesized that postoperative CSIs following primary RCR would be efficacious in improving function and reducing pain, with a low rate of adverse effects.

Methods
Systematic Review and Study Inclusion
In November 2019, a systematic review of the MEDLINE, EMBASE, and Cochrane databases was performed according to the Preferred Reporting Item for Systematic Reviews and Meta-Analyses (PRISMA) guidelines25 (Fig 1). The following search term was entered into the respective interface, with no date restriction applied: (rotator cuff OR supraspinatus OR infraspinatus OR subscapularis) AND (injection OR steroid OR corticosteroid OR cortisone OR glucocorticoid OR methylprednisolone OR triamcinolone OR dexamethasone OR betamethasone). The titles and abstracts of articles identified by this query were then screened by 2 independent reviewers (R.P., B.P.) according to the following inclusion criteria: (1) publication in the English language; (2) publication within the past 15 years; (3) studies reporting on outcomes or adverse effects of CSIs following RCR. Following screening, full-text assessments of all identified articles were performed to confirm inclusion. If there was any ambiguity regarding the potential inclusion of a study based on the title or abstract, a full-text review was conducted. Studies were excluded if they (1) were case reports with 3 or fewer patients, (2) were systematic review articles, (3) reported on revision RCR or concomitant major procedures in addition to RCR, such as fracture fixation, and (4) reported only on preoperative CSIs. Papers listed in the references section of all studies that met the aforementioned inclusion criteria were also screened and evaluated for potential inclusion.

Evaluation of Literature Quality
Evaluation of all included studies was performed by 2 independent reviewers (B.P. and R.P.), using the Methodological Index for Non-Randomized Studies (MINORS) criteria26 or the Cochrane Risk of Bias (C-ROB) tool27 in the case of randomized controlled trials (RCTs). MINORS criteria assess 8 critical aspects of study design for noncomparative clinical studies and an additional 4 aspects of study design for comparative clinical studies. Each item is scored from zero to two—“zero” reflects that the information in question was not reported, whereas “one” reflects that information was reported but was inadequate, and “two” reflects that information was reported and was adequate. Therefore, the maximum possible score is 16 for noncomparative studies and 24 for comparative studies.

The C-ROB tool evaluates RCTs in 5 domains that may predispose to bias: randomization, deviations from intended interventions, missing outcomes data, measurement of the outcome, and selection of the reported result. By answering signaling questions with regard to study methodology, raters grade each domain as having high, moderate, or low ROB. An overall assessment is then made based on the assumption that a given level of ROB for an individual domain implies that the study as a whole has ROB at least this severe. In the event of any discrepancy of MINORS score or C-ROB between the 2 reviewers, the item in question was discussed with the senior author who made the final determination.

Data Collection and Presentation
For all included papers, information regarding study publication, design, and methodology was extracted. In addition, patient demographics and outcomes data were recorded, including patient-reported outcome measures (PROMs), range of motion (ROM), strength testing, and imaging studies. Finally, all instances of adverse effects or clinical complications were tabulated.

Statistical Analysis
Upon initial review of the included investigations, we found that only one study was a Level of Evidence
LOE I RCT, with the remaining studies ranging between LOE IV and LOE II. Therefore, pooling of data was deemed to be inappropriate; instead, data are presented qualitatively by use of tables. Data were tabulated using Excel 365 (Microsoft, Redmond, WA) and evaluated using RStudio software, version 1.0.143 (R Foundation for Statistical Computing, Vienna, Austria).

**Results**

**Study Characteristics and Patient Demographics**

Our systematic review included 7 unique studies pertaining to corticosteroid injections following RCR following RCR. Methodologic characteristics of the included papers are summarized in Table 1. In total, 5,528 patients were included, 54.8% of whom were female, with a mean age range 52.3 ± 13.0 to 62.7 ± 6.6 years (Table 2). None of the included studies reported financial industry support. There was a single Level I prospective RCT, which was determined to have low ROB, whereas the remaining 6 studies were retrospective investigations. None of the included studies reported financial industry support. Among these, the average MINORS score was 20.6 ± 1.3 and 13 ± 1.4 for comparative (n = 4) and noncomparative (n = 2) studies, respectively. In general, studies lost points on MINORS criteria for lack of a priori study size calculations, lack of prospective data collection, and bias related to assessments of endpoints, although the overall scores were high. In total, our review comprised 5,528 patients, of whom 2,501 were male (45.2%). Among the included cohorts, mean age ranged from 52.3 ± 13.0 to 62.7 ± 6.6 years (Table 2).

**Efficacy**

Overall, 5 studies reported on the effectiveness of postoperative CSIs. Of these, 4 reported significant improvements in outcome scores among patients who received postoperative CSIs compared with a control group of patients who did not receive postoperative CSIs. These relative improvements were found at 3 months postoperatively, but not at later time points (Table 2). The most commonly reported outcome scores among the included studies were the Constant score and the American Shoulder and Elbow Surgeons (ASES) score. Three studies reported on the Constant score—at 3-year follow-up, Baverel et al. found significantly lower Constant scores in those who received pre- and postoperative CSIs versus those who received neither pre- nor postoperative injections (Table 3). However, the authors acknowledged that these poorer outcomes in CSI patients were likely the result of pre-existing tears and more reflective of the pathology indicating the CSI rather than a result of the CSIs themselves. Shin et al. found no difference in Constant score between CSI and
| First Author  | Journal, Year | Region of Origin | Study Design (LOE) | MINORS or C-ROB | Confounder Adjustment or Bias Minimization | Patient Source | Inclusion Criteria | Notable Exclusion Criteria |
|---------------|---------------|------------------|-------------------|----------------|------------------------------------------|----------------|-------------------|--------------------------|
| Baverel et al.9 | JSES OA, 2018 | Europe           | Retrospective case series (IV) | 14/16          | Multivariable regression                 | Single institution | Full thickness RC tear repaired by double-row suture technique | Partial thickness tear |
| Kew et al.16   | AJSM, 2019    | North America    | Retrospective cohort study (III) | 20/24          | Use of 10:1 matched controls; multivariable regression | PearlDiver Database | Arthroscopic subacromial decompression, RC debridement, or RC repair | Previous or concomitant septic arthritis |
| Kim et al.17   | AJSM, 2018    | Asia             | Retrospective cohort study (III) | 19/24          | Demographically similar groups           | Single institution | Repair of full thickness supraspinatus tear | Partial-thickness supraspinatus tear |
|                 |               |                  |                   |                |                                          | Single institution | Repair of small- to medium-sized RC tear | Concomitant biceps procedure or distal clavicle excision |
| Kim et al.18   | AJSM, 2019    | Asia             | Prospective randomized controlled trial (I) | Low risk of bias | Double blinded; block randomization; a prior sample size calculation | Single institution | Repair of partial RC tear or small- to medium-sized full-thickness RC tear | Preoperative stiffness |
| Lee et al.28   | KSSTA, 2019   | Asia             | Retrospective case series (III) | 22/24          | Demographically similar groups           | Single institution | Repair of partial RC tear or small- to medium-sized full-thickness RC tear | Athletes and heavy workers |
| Shin et al.20  | AJSM, 2016    | Asia             | Retrospective cohort study (III) | 20/24          | Single blinded; multivariable regression | Single institution | Repair of partial-thickness RC tear >50%, or full-thickness tear | Partial repair |
| Skedros et al.31| Pain and Therapy, 2017 | North America | Retrospective case series (IV) | 12/16          | None                                      | Single institution | Repair of partial-thickness RC tear >50%, or full-thickness tear | Worker’s compensation status |
|               |               |                  |                   |                |                                          | Single institution | Nonarthroplasty shoulder surgery | Stiffness 2/2 glenohumeral osteoarthritis |

AJSM, American Journal of Sports Medicine; C-ROB, Cochrane Risk of Bias tool; JSES OA, Journal of Shoulder and Elbow Surgery Open Access; KSSTA, Knee Surgery, Sports Traumatology, and Arthroscopy; LOE, Level of Evidence; MINORS, Methodological Index for Non-Randomized Studies; RC, rotator cuff.

*All included studies excluded revision surgery or RC repairs with concomitant major procedures (arthroplasty, fracture fixation, etc.).

Skedros et al. reported a single surgeon case series of nonarthroplasty shoulder surgeries; of these, only the patients who underwent rotator cuff repair were included in our investigation.
| First Author, Cohort | N (M:F)     | Mean Age, y | Follow-up | Postoperative CSI Schedule | Method and Location of CSI | Steroid, Dose                  | Significant Efficacy? | Significant Adverse Effects? |
|----------------------|-------------|-------------|-----------|---------------------------|---------------------------|-------------------------------|---------------------|-----------------------------|
| Baverel et al.       | 31 (21:10)  | 52.7 ± 8.0  | 3.3 ± 1.2 y | Mean 1.4 CSIs (range 1-4), timing NR | Betamethasone, 5 mg        | No                            | Yes                 |
| Postoperative CSI    |             |             |           |                           |                           |                               |                     |
| only                 |             |             |           |                           |                           |                               |                     |
| No CSI               | 35 (21:14)  | 52.3 ± 13.0 | 3.2 ± 0.9 y |                           | US-guided, subacromial     |                               |                     |
| Preoperative CSI     | 68 (41:27)  | 58.8 ± 7.0  | 3.1 ± 1.1 y |                           |                           |                               |                     |
| only                 |             |             |           |                           |                           |                               |                     |
| Preoperative and     | 78 (30:48)  | 55.4 ± 10.1 | 3.0 ± 0.9 y |                           |                           |                               |                     |
| postoperative CSI    |             |             |           |                           |                           |                               |                     |
| Kew et al.           | 1,648 (730:918) | NR         | Up to 4 mo | 1 CSI within 4 months    | NR                        | NR                            | NR                  | Yes¹ |
| Humana insured       |             |             |           |                           |                           |                               |                     |
| Medicare insured     | 2,298 (964:1334) | NR         |           |                           |                           |                               |                     |
| Kim et al.           | 35 (12:23)  | 58.1 ± 7.2  | Min. 2 y   | 1 CSI every 2 wk for 6 wk total, starting at 6 wk vs 12 wk postop | US-guided, glenohumeral    | Triamcinolone, 20 mg         | Yes                | No             |
| Postoperative        |             |             |           |                           |                           |                               |                     |
| CSIs starting at     |             |             |           |                           |                           |                               |                     |
| 6 wk                 |             |             |           |                           |                           |                               |                     |
| No CSI               | 135 (63:72) | 60.0 ± 7.3  |           |                           |                           |                               |                     |
| Kim et al.           | 40 (17:23)  | 59.8 ± 8.4  | 23.1 ± 1.8 mo | 1 CSI at 8 weeks          | US-guided, glenohumeral    | Triamcinolone, 40 mg         | Yes                | No             |
| Postoperative        |             |             |           |                           |                           |                               |                     |
| SI                   |             |             |           |                           |                           |                               |                     |
| No CSI               | 40 (21:19)  | 60.4 ± 8.6  | 27.0 ± 2.3 mo |                           |                           |                               |                     |
| Lee et al.           | 56 (24:32)  | 60.9 ± 7.3  | Min. 2 y   | 1 CSI at 3 months         | US-guided, glenohumeral    | Triamcinolone, 20mg          | Yes                | No             |
| Postoperative        |             |             |           |                           |                           |                               |                     |
| SI                   |             |             |           |                           |                           |                               |                     |
| No CSI               | 262 (106:156)| 61.3 ± 7.8  |           |                           |                           |                               |                     |
| Shin et al.          | 72 (38:34)  | 57.3 ± 8.6  | Min. 2 y   | 1 CSI at mean 34 ± 5 days | US-guided, subacromial     | Triamcinolone, 40mg          | Yes                | No             |
| Postoperative        |             |             |           |                           |                           |                               |                     |
| SI                   | 386 (203:183)| 57.3 ± 8.5  |           |                           |                           |                               |                     |
| Skedros et al.       | 58 (32:26)  | 53 ± 13     | Min. 12 wk | 1 CSI at mean 88 ± 38 days | No imaging guidance, subacromial or glenohumeral | Methylprednisolone, 80 mg or 160 mg at provider discretion | NR                  | No             |
| Postoperative        | 247 (157:90)| 58 ± 12     |           |                           |                           |                               |                     |
| CSI, corticosteroid injection; F, female; M, male; NR, not reported; SI, steroid injection; US, ultrasound.

*Results for these parameters are based on the authors’ primary findings and their resultant recommendations for postoperative CSI use.

¹Kew et al. found a significant increase in infection risk only if CSI was administered within 1 month following surgery; CSIs administered at later intervals did not confer increased risk.
Table 3. Summary of Patient-Reported Outcome Measures (PROMs)

| First Author Cohort, n | Measure, Preoperative Score | Interval Change in Score (Time Frame, P Value) | P Value Between Groups |
|------------------------|-----------------------------|-----------------------------------------------|-----------------------|
| Baverel et al.9         |                             |                                               |                       |
| A. CSI postoperative only, n = 31 | Constant: 54.7 ± 17.5 | +25.2 (preoperative to 3 y, NR) | B vs D Constant at 3 y: <.05 |
| B. No CSI n = 35       | Constant: 58.4 ± 12.6      | +28.6 (preoperative to 3 y, NR)              | Other groups not significantly different from each other in Constant score at 3 y. |
| C. CSI preoperative only, n = 68 | Constant: 55.6 ± 15.0      | +28.5 (preoperative to 3 y, NR)              |                       |
| D. CSI pre- and postoperative, n = 78 | Constant: 56.8 ± 15.3      | +18.6 (preoperative to 3 y, NR)              |                       |
| Kim et al.17           |                             |                                               |                       |
| A. CSIs starting at 6 wk, n = 35 | Constant: 54.7 ± 17.5 | +25.2 (preoperative to 3 y, NR) | B vs D Constant at 3 y: <.05 |
| B. CSIs starting at 12 wk, n = 39 | Constant: 58.4 ± 12.6 | +28.6 (preoperative to 3 y, NR)              | Other groups not significantly different from each other in Constant score at 3 y. |
| C. No CSI n = 135      | Constant: 55.6 ± 15.0      | +28.5 (preoperative to 3 y, NR)              |                       |
| D. CSI pre- and postoperative, n = 78 | Constant: 56.8 ± 15.3      | +18.6 (preoperative to 3 y, NR)              |                       |
| Kim et al.18           |                             |                                               |                       |
| A. CSI, n = 40         | ASES: 66.4 ± 17.2          | +24.7 (preoperative to 6 mo, P = .01)        | A vs B ASES preoperative: 0.27 |
|                        | Constant: 60.3             | +17.5 (preoperative to 6 mo, P = .02)        | ASES at 3 mo: .02     |
|                        | VAS: 4                     | -2.9 (preoperative to 6 mo, P = .03)         | ASES at 6 mo: .02     |
|                        | VAS: 4.7                   | +27.7 (preoperative to 6 mo, P = .03)        | ASES at 6 mo: P > .05 |
|                        | Constant: 62.8             | -3.5 (preoperative to 6 mo, P = .02)         | VAS preoperative: NR  |
|                        |                             | +15.4 (preoperative to 6 mo, P = .02)        | VAS at 3 mo: .02      |
| B. No CSI n = 40       | ASES: 62.1 ± 18.5          | +27.7 (preoperative to 6 mo, P = .03)        | VAS at 6 mo: >.05     |
|                        | Constant: 60.3             | +17.5 (preoperative to 6 mo, P = .02)        |                       |
|                        | VAS: 4.7                   | -3.5 (preoperative to 6 mo, P = .02)         |                       |
|                        | Constant: 62.8             | +15.4 (preoperative to 6 mo, P = .02)        |                       |

(continued)
Table 3. Continued

| First Author Cohort, n | Measure, Preoperative Score | Interval Change in Score (Time Frame, \(P\) Value) | \(P\) Value Between Groups |
|------------------------|-----------------------------|--------------------------------------------------|-----------------------------|
| **A. CSI, n = 56**     | VAS: 6.5 ± 1.3              | −1.9 (preoperative to 3 mo, NR)                  | VAS at preoperative, 6 mo, 1 y, 2 y: >.05 |
|                        |                             | −2.9 (3 mo to 6 mo, NR)                         | VAS at 3 mo: <.001          |
|                        |                             | −0.5 (6 mo to 1 y, NR)                         | SSV at preoperative, 6 mo, 1 y, 2 y: >.05 |
|                        |                             | −0.1 (1 y to 2 y, NR)                          | SSV at 3 mo: .026          |
|                        |                             | −5.4 (preoperative to 2 yr, \(P < .001\))       |                             |
|                        | SSV: 37.0 ± 5.3             | +9.5 (preoperative to 3 mo, NR)                 | ASES at preoperative, 6 mo, 1 y, 2 y: >.05 |
|                        |                             | +36.7 (3 mo to 6 mo, NR)                        | ASES at 3 mo: <.001        |
|                        |                             | +36.5 (6 mo to 1 y, NR)                         | UCLA at preoperative, 6 mo, 1 y, 2 y: >.05 |
|                        |                             | +5.0 (1 y to 2 y, NR)                          | UCLA at 3 mo: <.001        |
|                        |                             | +51.5 (preoperative to 2 yr, \(P < .001\))      |                             |
|                        | ASES: 37.0 ± 5.3            | +15.2 (preoperative to 3 mo, NR)                |                             |
|                        |                             | +34.3 (3 mo to 6 mo, NR)                        |                             |
|                        |                             | +3.0 (6 mo to 1 y, NR)                         |                             |
|                        |                             | +1.2 (1 y to 2 y, NR)                          |                             |
|                        |                             | +53.8 (preoperative to 2 yr, \(P < .001\))      |                             |
|                        | UCLA: 15.1 ± 3.7            | +2.1 (preoperative to 3 mo, NR)                 |                             |
|                        |                             | +10.7 (3 mo to 6 mo, NR)                        |                             |
|                        |                             | +1.4 (6 mo to 1 y, NR)                         |                             |
|                        |                             | +0.9 (1 y to 2 y, NR)                          |                             |
|                        |                             | +15.1 (preoperative to 2 yr, \(P < .001\))      |                             |
| **B. No CSI, n = 262** | VAS: 6.7 ± 1.3              | −4.7 (preoperative to 3 mo, NR)                 |                             |
|                        |                             | −0.4 (3 mo to 6 mo, NR)                         |                             |
|                        |                             | −0.5 (6 mo to 1 y, NR)                         |                             |
|                        |                             | −0.0 (1 y to 2 y, NR)                          |                             |
|                        |                             | −5.6 (preoperative to 2 yr, \(P < .001\))       |                             |
|                        | SSV: 37.4 ± 19.2            | +17.8 (preoperative to 3 mo, NR)                |                             |
|                        |                             | +29.0 (3 mo to 6 mo, NR)                        |                             |
|                        |                             | +1.1 (6 mo to 1 y, NR)                         |                             |
|                        |                             | +3.0 (1 y to 2 y, NR)                          |                             |
|                        |                             | +50.9 (preoperative to 2 yr, \(P < .001\))      |                             |
|                        | ASES: 37.1 ± 5.7            | +32.3 (preoperative to 3 mo, NR)                |                             |
|                        |                             | +17.5 (3 mo to 6 mo, NR)                        |                             |
|                        |                             | +3.0 (6 mo to 1 y, NR)                         |                             |
|                        |                             | +0.5 (1 y to 2 y, NR)                          |                             |
|                        |                             | +53.3 (preoperative to 2 yr, \(P < .001\))      |                             |
|                        | UCLA: 15.6 ± 4.6            | +7.7 (preoperative to 3 mo, NR)                 |                             |
|                        |                             | +5.8 (3 mo to 6 mo, NR)                         |                             |
|                        |                             | +0.8 (6 mo to 1 y, NR)                         |                             |
|                        |                             | +0.9 (1 y to 2 y, NR)                          |                             |
|                        |                             | +15.1 (preoperative to 2 yr, \(P < .001\))      |                             |

Shin et al.20
non-CSI patients at 2-year follow-up, whereas Kim et al.29 found similar Constant scores between CSI and non-CSI patients at 6-month follow-up, though comparative statistics were not reported. Three studies reported on ASES scores, 2 of which reported significantly greater improvements among CSI patients versus non-CSI patients at 3 months postoperatively. However, in both cases, these improvements were not statistically greater than the non-CSI group at later follow-up time points18,28 (Table 3). In addition, the studies by Shin et al.,20 Kim et al.,18 and Lee et al.28 reported significant reductions in pain at 1 month, 3 months, and 3 months post-CSI, respectively. Other PROMs were reported by fewer than 3 studies, and complete reporting of PROMs from all included investigations are displayed in Table 3.

ROM data were reported by 3 included investigations. Kim et al.17 found that ROM was improved in patients who received CSIs starting at 6 weeks postoperatively when compared with those starting injections at 12 weeks postoperatively. Lee et al.28 found significantly better ROM in forward flexion in those who received CSIs versus those who did not at 3 months postoperatively. There were no significant differences between groups in forward flexion at 6-, 12-, or 24-month follow-up, nor were there any significant differences in external rotation or internal rotation at any time point. Finally, Baverel et al.9 reported significantly better ROM in patients who received no CSIs, when compared with those who received only preoperative injections, those who received only postoperative injections, and those who received both pre- and postoperative injections (P = .001).

Adverse Effects

Several included investigations reported on adverse effects of postoperative CSIs. Kew et al.16 found that among 3,946 patients, 264 received a CSI within 1 month following arthroscopic shoulder surgery, and these patients had a significantly increased risk of infection (privately insured; odds ratio [OR] 2.63; 95% confidence interval [CI] 1.32-5.22, P = .014) (Medicare insurance; OR 11.2; 95% CI 2.33-53.57, P < .0001). Conversely, injections from 2 to 4 months postoperatively were not significantly associated with a greater risk for infection in either cohort. However, the authors included multiple types of arthroscopic shoulder surgery in their investigation, including subacromial Decompression, rotator cuff debridement, lysis of adhesions, synovectomy, and RCR, and did not stratify their results by procedure. The study by Kim et al.17 reported that retear rates were 5.7%, 10.8%, and 14.1% at minimum 2-year follow-up for patients who started CSIs at 6 weeks postoperatively, 12 weeks postoperatively, and those who did not receive CSIs, respectively (P = .374). All patients included in this
study had received a postoperative magnetic resonance imaging (MRI) scan at 6 months, with retears defined as Sugaya type IV or V. Lee et al. reported no significant difference in retear rate between CSI and non-CSI patients, as evaluated by magnetic resonance arthrography at 6 months postoperatively (CSI: 17.9% vs no CSI: 17.2%, \( P > .05 \)). All patients included in this study received the postoperative imaging, and retear was defined as a stage 3 or 4 tear according to the French Society of Arthroscopy. Shin et al. reported similar results, also at 6 months postoperatively, based on MRI studies (CSI: 6.8% vs no CSI: 18.4%, \( P = .06 \)). In this study, 71.2% of patients received a postoperative MRI at 6 months (61% who had received a CSI, 73% without an injection), and the criteria for retear was not defined. In contrast to these findings, however, Baverel et al. found a 2-fold increase in retear rate, as defined by a Sugaya type IV or V tear on ultrasound evaluation performed on all patients, per each postoperative CSI (OR 2.19; 95% CI 1.23-2.92, \( P = .007 \)). However, the authors of this study were unable to determine whether these retears were present before receiving the postoperative CSI. Finally, Skedros et al. reviewed 754 patients who underwent nonarthroplasty shoulder surgery, including 305 who underwent RCR. Of these, 58 patients (19%) received a postoperative CSI for indications of pain, stiffness, or inflammation/bursitis within the first 3 postoperative months. There were no minor or major complications in any patients, including no instances of tendon rupture. However, only instances of infections, poor wound healing, dermatitis, and apparent structural compromise on examination, were recorded as complications. A summary of the reported adverse effects is displayed in Table 4.

**Discussion**

Studies included in this review reported statistically significant improvements in at least one outcome measure at 3 months postoperatively (Constant, ASES, and visual analog scale score for pain) in patients who received postoperative CSIs when compared with those who did not. However, this significant relative improvement did not persist at 6 months, 1 year, or 2 years, postoperatively. The only study not to find some level of efficacy of postoperative CSIs was conducted by Baverel et al., and the authors concede that the poor results in CSI patients was more likely a consequence of the degree of rotator cuff retears in this cohort, rather than the CSI itself. In addition, this study was 1 of only 2 investigations to describe a significantly increased risk of adverse effects in the CSI group. In the other case, Kew et al. found an increased risk of infection only if the CSI was administered within 1 month postoperatively (OR 2.6 and 11.2, for privately insured and Medicare patients, respectively). On the basis of these cumulative results, this systematic review suggests that, if administered at least 1 month after surgery, postoperative CSIs may provide patients with meaningful improvements in function and pain control in the first few months following primary RCR, with a low risk of adverse effects.

The molecular effects of corticosteroids on the inflammatory cascade, healing, and matrix remodeling of tendon continues to be a topic of interest in the orthopaedic literature. Surgical intervention for rotator cuff−related pain should ideally strike a delicate balance between achieving tensile strength for early motion to prevent adhesive scars and catalyze a local inflammatory cascade to promote healing and regeneration of tissue. Rotator cuff pathology is associated with an abundance of molecular markers, including matrix proteins, growth factors, enzymes, and local inflammatory cells. Steroids have been shown to decrease collagen matrix remodeling, halt the initial proliferative healing response, prevent tenocyte differentiation, and reduce tendon biomechanical strength. Still, other basic science studies report that corticosteroids both dampen the initial inflammatory response by increasing nuclear translocation of inhibitory transcription factors and prolong it by decreasing the number of local cytotoxic cells needed to halt inflammation. Although current data remain ambiguous, CSIs appear to decrease local inflammation at best and at worst have the potential to interfere with the course of crucial postoperative healing.

The timing of postoperative CSIs appears to be the critical factor in efficacy and safety. Notably, an investigation by Lee et al. has reported that the detrimental molecular effects of CSIs on collagen composition, extracellular matrix organization, and early healing likely normalize within 6 weeks of administration. This is in line with the aforementioned results of Kew et al., which indicate that CSIs increase rates of retear if administered within one month post-operatively but not if administered after that time point. In addition, the study by Kim et al. included in the present review reported persistently improved UCLA Shoulder Scores and Korean Shoulder Scores for up to 2 years postoperatively in patients receiving CSIs starting at 12 weeks post-operatively, as compared to those receiving CSIs starting at 6 weeks postoperatively. This finding further supports the concept of the detrimental effect of CSIs only in the very early postoperative period. The remainder of the data accumulated in the present review suggest that at long-term follow-up, patients who receive CSIs outside of this early postoperative window of 4 to 6 weeks achieve a similar level of function as their counterparts who do not receive injections. Taken together, these findings may suggest that any adverse molecular effects of postoperative CSIs on the biomechanical integrity are transient.
The effect of CSIs in the preoperative setting has also been a focal point of the literature in the past several years. In a recent review, Puzzitiello et al. considered 8 investigations on this topic and found that a single CSI for rotator cuff tendinosis was associated with an increased risk of revision RCR (OR range 1.3 [1.1-1.7] to 2.8 [2.2-3.4]), and postoperative infections (OR 2.1 [1.5-2.7]) when administered within a month before RCR. The authors ultimately concluded that a temporal and dose-dependent relationship exists between administration of preoperative CSIs and adverse postoperative effects. Risk mitigation of modifiable

| Table 4. Summary of Reported Adverse Effects and Complications of Postoperative CSIs |
|-----------------------------------------------|
| First Author; Cohort, n | Retears, n (%) | Other Complications | Statistical Significance and Additional Information |
| Baverel et al.7 | | |
| A. CSI postop only, n=31 | 6 (19) | Reverse shoulder, n (%) | Retear rate between all groups: P = .016 |
| B. No CSI, n=35 | 5 (14) | Arthroplasty: 2 (0.9) |
| C. CSI preoperative only, n=68 | 4 (6) | Suture anchor |
| D. CSI pre & postop, n=78 | 12 (15) | Removal: 1 (0.5) |
| Kew et al.16 | | |
| A1. CSI by 1mo (Medicare), n = 120 | NR | Infections, n (%) | OR of suffering postoperative infection: |
| A2. CSI by 1 mo (Humana), n = 144 | NR | A2. 8 (6.7) |
| B1. CSI by 2mo (Medicare), n = 421 | NR | B1. 2 (0.5) |
| B2. CSI by 2 mo (Humana), n = 350 | NR | B2. 1 (0.3) |
| C1. CSI by 3mo (Medicare), n = 632 | NR | C1. 2 (0.3) |
| C2. CSI by 3mo (Humana), n = 405 | NR | C2. 2 (0.5) |
| D1. CSI by 4mo (Medicare), n = 1125 | NR | D1. 3 (0.3) |
| D2. CSI by 4mo (Humana), n = 749 | NR | D2. 2 (0.3) |
| E1. Matched controls (Medicare), n = 1200 | NR | E1. 4 (0.3) |
| E2. Matched controls (Humana), n = 1440 | NR | E2. 7 (0.5) |
| Kim et al.17 | | |
| A. CSI starting at 6w | 2 (5.7) | NR | Retear rate between all groups: P = .677 |
| B. CSI starting at 12w | 4 (10.8) | NR | Number of Involved Tendons in Retear: |
| C. No CSI | 19 (14.1) | NR | 2 patients in group B and 9 patients in group C had ≥2 tendon tears, P value NR. |
| Kew et al.18 | | |
| A. CSI | 3 (7.5) | NR | Retear rate between groups: P = .690 |
| B. No CSI | 4 (10.0) | NR |
| Lee et al.20 | | |
| A. CSI | 10 (17.9) | NR | Retear rate between groups: P > .05 |
| B. No CSI | 45 (17.2) | NR |
| Shin et al.20 | | |
| A. CSI | 3 (6.8) | NR | Retear rate between groups: P = .060 |
| B. No CSI | 52 (18.4) | NR |
| Skedros et al.21 | | |
| A. CSI | 0 (0.0) | 0 (0.0) | NR |
| B. No CSI | 0 (0.0) | 0 (0.0) |

NOTE. P values in bold indicate statistical significance. 
CSI, corticosteroid injection; NR, not reported; OR, odds ratio. 
*Reteared defined as Sugaya Grade IV or V on ultrasound.
perioperative factors, including potential postponement of surgery for patients with recent or frequent shoulder injections, have been proposed as a possible approach to minimize CSI complication risk. However, mitigation of complications is but one factor in the clinical context of CSI after rotator cuff surgery, and CSI’s potential for interference with postsurgical healing is critical to thoughtfully consider in clinical decision-making.

If deemed necessary in the very early postoperative period, it may be prudent to offer patients struggling with pain and stiffness an aggressive regimen of physical therapy and medical pain control before considering CSIs. The most recent review of the literature on CSI analgesic effects in rotator cuff repair CSIs. The most recent review of the literature on CSI analgesic effects in rotator cuff repair 12 weeks postoperatively. Further studies investigating combination therapy addressing both pain and function, such as one currently enrolling multicenter RCT in the United Kingdom investigating physiotherapy in addition to CSI, are promising. At present, CSIs appear to be a safe and efficacious management option for improving function and reducing pain if administered after the first postoperative month.

Limitations
The results of this review should be considered in the context of several limitations. Although selection criteria of the included studies were strict, there was only one investigation with Level I evidence, whereas the others were lesser in quality. This limitation precluded the pooling of data for more involved statistical analysis. Moreover, many of the included non-randomized studies administered CSIs to patients with persistent postoperative pain or stiffness, whereas the control groups had lesser degree of symptoms and thus were not indicated for a postoperative CSI. However, the efficacy of the postoperative CSI was measured in terms of improvement in outcomes. In addition, the inclusion of several retrospective cohort studies from single institutions may limit the applicability of our results to a broader patient population. Moreover, the included studies were heterogeneous with regard the particular steroid used in the CSI, as well as with regard to dosage and the location of the injection (subacromial injection vs intra-articular injection). Finally, methods of evaluating patients varied among the included investigations, limiting our ability to make comparisons across studies.

Conclusions
Postoperative CSIs may improve pain and function for up to 3 months following primary RCR but not at later follow-up time points. CSIs should be administered only after the first postoperative month to minimize the potential risk for adverse events.

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