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Do corticosteroid injections compromise rotator cuff tendon healing after arthroscopic repair?

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Background: Rotator cuff tears are associated with capsular contraction and stiffness that should be restored before surgical repair. Corticosteroid injections (CSIs) are frequently used as conservative treatments before surgical repair. This study aimed to determine the influence of preoperative and postoperative CSIs on clinical and anatomic outcomes after rotator cuff repair.

Methods: The authors analyzed the records of 257 patients who had arthroscopic rotator cuff repair, of whom 212 were evaluated at 3.1 ± 1.0 years (median, 2.9 years; range, 1.4-7.1 years) by clinical (Constant score) and ultrasound (Sugaya classification) examinations. Univariable and multivariable regressions were performed to determine associations between outcomes and administration of preoperative and postoperative CSIs, patient characteristics, and tendon characteristics.

Results: The Constant scores improved from 56.4 ± 15.1 to 80.8 ± 12.5. Multivariable regression confirmed that postoperative scores were associated with postoperative CSIs ($P < .001$), preoperative scores ($P < .001$), gender ($P < .001$), and fatty infiltration ($P < .005$). Retears (Sugaya types IV-V) were observed in 27 shoulders (13%). Multivariable regression clarified that retear rates were associated only with postoperative CSIs ($P = .007$) and stage 3 fatty infiltration ($P = .001$). Adjusting for confounders, an additional postoperative CSI would decrease scores by 4.7 points and double retear risks.

Discussion: Preoperative CSIs had no influence on clinical scores and retear rates, whereas postoperative CSIs were associated with lower scores and more retears. Although we can infer that preoperative CSIs do not affect outcomes, we cannot determine whether postoperative CSIs compromised outcomes or were administered in patients who had already poor outcomes. Our findings may resolve controversies about the administration of preoperative CSIs.

Symptomatic rotator cuff tears, characterized by pain and loss of strength, are frequently associated with capsular contraction that reduces shoulder mobility.[53] The consequent stiffness should be restored before surgical repair to optimize postoperative outcomes.[10,42,54] Therefore, combinations of physical therapy and corticosteroid injections (CSIs) are frequently used in conservative treatments[4,34] and have been shown to relieve pain and to recover passive mobility in 80% of stiff shoulders,[7,9,20,35,40,47] within 12-16 weeks.[1,14,27] Furthermore, some studies demonstrated that CSIs could be effective to relieve persistent pain and to reduce stiffness after rotator cuff repairs,[22] although their efficacy and safety remain debatable.[46]

The benefits of CSIs must be balanced against their potential harms, reported in laboratory and animal studies.[5,28,31,45,50,52] Whereas biopsy studies revealed that CSIs could reduce microvascularization at the rotator cuff footprint[8] and decrease cell proliferation,[13] other studies reported no deleterious effects.[6,17,33] The controversy led to more cautious use of CSIs in the clinical setting, for example, to improve needle positioning using radiology-assisted techniques.[15,24,32,37,41] The use of CSIs before or after rotator cuff repair therefore remains controversial in the absence of sizable comparative studies,[31] and patients are often concerned that CSIs could compromise tendon integrity.

The purpose of this study was therefore to evaluate the influence of preoperative and postoperative CSIs on clinical scores and tendon healing after arthroscopic rotator cuff repair. The hypothesis

The Institutional Review Board of Centre Osteoarticulaire des Cèdres (Grenoble, France) approved this study in advance: No. COAC 2007-03. All patients provided their written informed consent.

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was that administration of CSIs before or after surgery will be significantly associated with lower clinical scores and greater retear rates.

Materials and methods

Study design

The authors retrospectively analyzed the records of 257 patients who had arthroscopic rotator cuff repair by the senior surgeon (J.B.) between January 2007 and June 2010. The surgical technique remained unchanged during the inclusion year period as neither new equipment nor new strategies were introduced. The global clinical and radiographic outcomes of this series were recently published.[3] The inclusion criteria were full-thickness tears repaired by double-row suture technique and complete clinical and ultrasound evaluations at a minimum follow-up of 1 year. The exclusion criteria were partial-thickness tears (n = 4), revision cases (n = 9), Hamada stage >2 (n = 9), and concomitant surgery on the ipsilateral shoulder (n = 11). Of the 224 patients included, 8 (3.6%) did not have ultrasound evaluation at 12 or more months, 3 (1.3%) were excluded because they had subsequent surgery on another joint, and 1 (0.4%) died before the end of the follow-up period (Fig. 1). The remaining 212 patients were assigned to 1 of 4 groups according to whether they received at least 1 CSI preoperatively, postoperatively, or both (no-CSI, pre-CSI, post-CSI, or both-CSI).

Preoperative evaluation

Patients were evaluated clinically using the absolute Constant score and radiographically using computed tomography arthrography or magnetic resonance imaging (MRI) to assess muscle fatty infiltration (modified Goutallier classification[16,18,51]); tendon tear size and retraction were assessed following the classification of Patte.[38] In all cases, fatty infiltration of the supraspinatus muscle was considered the reference as it was the most frequently torn rotator cuff tendon (>80%). The use of different imaging modalities may represent some bias, but recent articles indicate that equivalent assessment of fatty infiltration could be archived using either computed tomography arthrography or MRI.[30,35]

Surgical technique

All operations were performed with the patient in the beach chair position, under general anesthesia and interscalene block. Intraoperative diagnosis of rotator cuff tears was confirmed after excision of the inflammatory subacromial bursa, and tear size was measured. The intraoperative torn tendon was noted as "healthy" if it appeared normal or "degenerated" if it was delaminated, thinned, or cleaved. Depending on tear size, 2-4 triple-loaded 5.5-mm bioabsorbable anchors (Bio-Corkscrew FT; Arthrex Inc., Naples, FL, USA) were used for the double-row repair. The bursa and synovitis were then cleaned in the subacromial space; the rotator cuff was reduced by tightening the lateral row, and the footprint was covered by a medial row suture.

Postoperative rehabilitation

Passive motion exercises were initiated on the first postoperative day, and the arm was supported in a 20° abduction sling during the first 6 weeks; if possible, hydrotherapy was attempted after skin healing. Active shoulder motion was allowed after 6 weeks; active passive motion was started earlier according to the preoperative tear size. Patients were not allowed to perform any strengthening or strenuous work for 6 months after the operation. Light sports and demanding activities were allowed after 6 months.

Postoperative assessment

Patients were evaluated at a minimum follow-up of 12 months. A single blinded clinician (L.B.) who did not perform the operation collected the absolute Constant score.[11,12] The integrity of the repaired rotator cuff was assessed using ultrasound, which was recently adapted from the MRI classification of Sugaya et al,[3,49] and regrouped as either intact (types I-III) or retorn (types IV and V). The ultrasound assessments were performed by a blinded radiologist (R.B.) using a linear transducer set at either 7-11 MHz for heavier morphotypes (deep penetration but lower spatial resolution) or 14-18 MHz for lighter morphotypes (shallow penetration but higher spatial resolution) and a Xario SSA-660A and SSA probe with precision 660 LG (Toshiba Medical Systems, Otawara, Japan). During the ultrasound assessment, the patients were seated with the

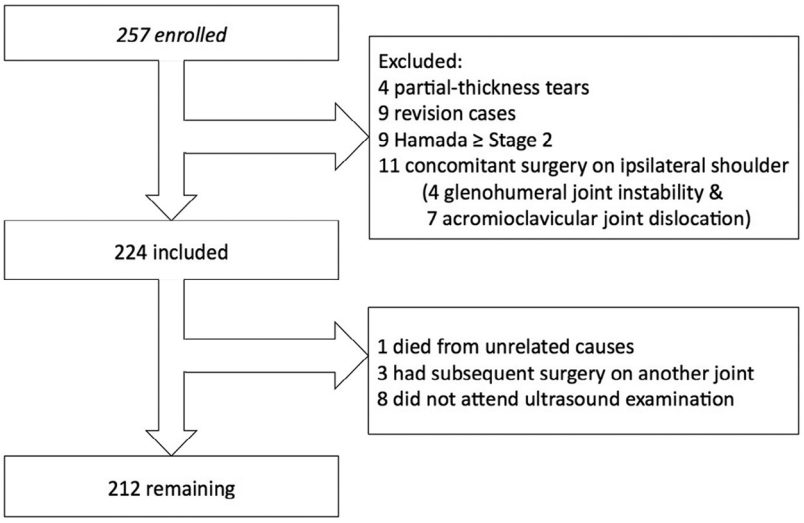

Figure 1 Flow chart of patient inclusion and enrollment with details for those who were excluded.

affected arm maintained free at the side of the trunk, and the rotator cuff repair was examined in 3 planes (axial, sagittal, and coronal).

CSIs

The CSIs consisted of 5 mg of injectable betamethasone suspension in prefilled syringes (PHI, Aïn El Aouda, Morocco) and 10 mL of lidocaine (Xylocaine 0.5%). All injections were administered into the subacromial bursa, with the patients in the supine position, after local superficial skin anesthesia using 5-cm 21-gauge needles.

Preoperatively, patients with predominant subacromial inflammation without stiffness received CSIs under ultrasound guidance, directly through a lateral approach, just below the midlateral aspect of the acromion. Patients with predominant stiffness received CSI under fluoroscopic guidance with contrast liquid (Ultravist 300 mg), by a posterior approach, through the acromioclavicular joint.[55]

Postoperatively, patients with persistent pain and subacromial bursitis, confirmed on serial ultrasound images, received CSI under ultrasound guidance, directly through a lateral approach, just below the midlateral aspect of the acromion.

Statistical analysis

The normality of distributions was tested using the Shapiro-Wilk test. Continuous variables were compared using nonparametric Spearman correlations or Mann-Whitney *U* tests with Bonferroni correction. Categorical variables were compared using χ^2 tests. Univariable and multivariable linear (postoperative Constant score) and logistic (retears, Sugaya IV-V) regressions were performed to test associations between outcomes and 10 variables: preoperative and postoperative CSIs, patient age, follow-up, preoperative Constant score, gender, tobacco use, tendon retraction, tendon delamination, and fatty infiltration of the supraspinatus. With our sample size of 212, our analysis was deemed to have sufficient power, considering the recommendations of Green[19] of a minimum of 200 subjects for any regression analysis and of Austin and Steyerberg[2] of 20 subjects per variable. Statistical analyses were performed using R version 3.3.3 (R Foundation for Statistical Computing, Vienna, Austria). The level of significance was set at $P < .05$.

Results

The 212 patients had completed clinical and ultrasound assessments at the mean follow-up of 3.1 ± 1.0 years (median, 2.9 years; range, 1.4-7.1 years). Thirty-five patients (16%) received no CSI, 68 (32%) received CSI preoperatively (mean, 1.9 injections; range, 1-10), 31 (15%) received CSI postoperatively (mean, 1.3 injections; range, 1-3), and 78 (37%) received CSI both preoperatively (mean, 2.3 injections; range, 1-10) and postoperatively (mean, 1.4 injections; range, 1-4). The preoperative CSI was administered at a mean follow-up of 5.2 ± 1.9 months (median, 5.0 months; range, 2.5-11.0 months). Patients who received CSI preoperatively were older than those in the 3 other groups ($P = .002$), whereas the group that received CSI both preoperatively and postoperatively had more female patients than the 3 other groups ($P = .009$) (Table I). There were no significant differences in follow-up, fatty infiltration, or number of torn tendons and neither tendon retraction nor degeneration among the 4 groups.

The Constant scores had improved from 56.4 ± 15.1 (median, 57.3; range, 8.0-91.0) preoperatively to 80.8 ± 12.5 (median, 83.0; range, 42.0-100) postoperatively (Table II). Pairwise comparisons revealed significant differences in postoperative Constant score (total and subcomponents) only between the group that received both preoperative and postoperative CSIs and the group that received no CSI ($P < .05$) (Table II and Fig. 2). Univariable regression revealed that the postoperative Constant score was significantly associated with preoperative CSIs ($P = .005$), postoperative CSIs ($P < .001$), preoperative Constant score ($P < .001$), gender ($P < .001$), and fatty infiltration of stage 2 ($P < .001$) or stage 3 ($P = .004$) (Table III). Multivariable regression confirmed those associations except for preoperative CSIs ($P = .082$). Adjusting for confounding variables, each additional postoperative CSI was associated with a decrease of 4.7 points in postoperative Constant score, and likewise, fatty infiltration of stage 2 or stage 3 would decrease postoperative Constant score by 6.5 and 13.9 points, respectively.

Ultrasound imaging revealed tendon retears (Sugaya types IV-V) in 27 of the 212 shoulders (13%); 2 were revised with a reverse shoulder arthroplasty, 1 had suture anchor removal, and 24 were asymptomatic or managed with medication. The retear rate was lowest for patients who had preoperative CSIs (4 of 68 [6%]) compared with patients who received no CSI (5 of 35 [14%]), postoperative CSIs (6 of 31 [19%]), or both preoperative and postoperative CSIs (12 of 78 [15%]) ($P = .16$). Univariable regression revealed that retear rate was significantly associated with age ($P < .001$), preoperative Constant score ($P = .012$), tendon retraction ($P < .001$), tendon delamination ($P = .005$), and fatty infiltration of stage 2 ($P = .011$) or stage 3 ($P < .001$) (Table IV). Multivariable regression clarified that the retear rate was directly associated only with postoperative CSIs ($P = .007$), and stage 3 fatty infiltration ($P = .001$). Adjusting for confounding variables, an additional preoperative CSI was not associated with an increased retear rate, whereas an additional postoperative CSI was associated with a 2-fold increase in retear rate.

Discussion

The goal of this study was to determine the influence of preoperative and postoperative CSIs on clinical scores and retear rates after

Table I
Preoperative epidemiologic data and characteristics of rotator cuff tears

	Entire cohort	No-CSI	Pre-CSI	Post-CSI	Both-CSI	*P* values*
	N = 212	n = 35	n = 68	n = 31	n = 78	
Patients demographics						
Age (y)	55.6 ± 9.8 (16.0-83.0)	52.3 ± 13.0	58.8 ± 7.0	52.7 ± 8.0	55.4 ± 10.1	.003
Women	47%	40%	40%	32%	62%	.009†
Follow-up (y)	3.1 ± 1.0 (1.4-7.1)	3.2 ± 0.9	3.1 ± 1.1	3.3 ± 1.2	3.0 ± 0.9	.274
Radiographic assessment						
Fatty infiltration of the supraspinatus						.545†
Stage 0-1	96 (45%)	19 (54%)	27 (40%)	15 (48%)	35 (45%)	
Stage 2	106 (50%)	13 (37%)	39 (57%)	15 (48%)	40 (51%)	
Stage 3	9 (4%)	3 (9%)	2 (3%)	1 (3%)	3 (4%)	

CSI, corticosteroid injection.
* Kruskal-Wallis tests were used to compare between-group differences unless otherwise noted.
† χ^2 test.

Table II
Evaluation of preoperative and postoperative Constant score among the CSI groups

	Entire cohort	No-CSI	Pre-CSI	Post-CSI	Both-CSI	*P* value*
	N = 212	n = 35	n = 68	n = 31	n = 78	
		(16.5%)	(32.1%)	(14.6%)	(36.8%)	
Preoperative Constant score						
Total	56.4 ± 15.1 (8.0-91.0)	58.4 ± 12.6	55.6 ± 15.0	54.7 ± 17.5	56.8 ± 15.3	.863
Pain	3.7 ± 2.7 (0.0-14.0)	4.0 ± 2.7	3.4 ± 2.4	4.5 ± 2.9	3.4 ± 2.8	.215
Function	6.4 ± 4.6 (0.0-18.0)	6.9 ± 4.0	6.4 ± 5.0	6.0 ± 4.0	6.4 ± 4.7	.715
ROM	36.0 ± 7.5 (6.0-40.0)	36.8 ± 6.9	36.4 ± 6.8	33.9 ± 9.9	36.1 ± 7.2	.643
Strength	10.3 ± 7.1 (0.0-25.0)	10.7 ± 6.6	9.5 ± 7.2	10.4 ± 7.6	10.9 ± 7.0	.543
Postoperative Constant score						
Total	80.8 ± 12.5 (42.0-100.0)	87.0 ± 10.3	84.1 ± 9.8	79.9 ± 13.4	75.4 ± 13.0	<.001†
Pain	12.4 ± 3.2 (3.0-15.0)	13.5 ± 2.7	13.4 ± 2.4	11.8 ± 3.5	11.3 ± 3.4	<.001†
Function	17.0 ± 3.3 (7.0-20.0)	18.3 ± 2.5	18.1 ± 2.5	16.5 ± 3.4	15.6 ± 3.7	<.001†
ROM	38.3 ± 3.5 (22.0-40.0)	39.5 ± 1.4	39.0 ± 2.4	38.1 ± 3.2	37.1 ± 4.5	.001†
Strength	13.2 ± 5.5 (4.0-25.0)	15.7 ± 5.8	13.7 ± 5.5	13.6 ± 5.8	11.4 ± 4.7	.002†

CSI, corticosteroid injection; *ROM*, range of motion.
* Kruskal-Wallis.
† Significant difference relative to no-CSI ($P < .05$).

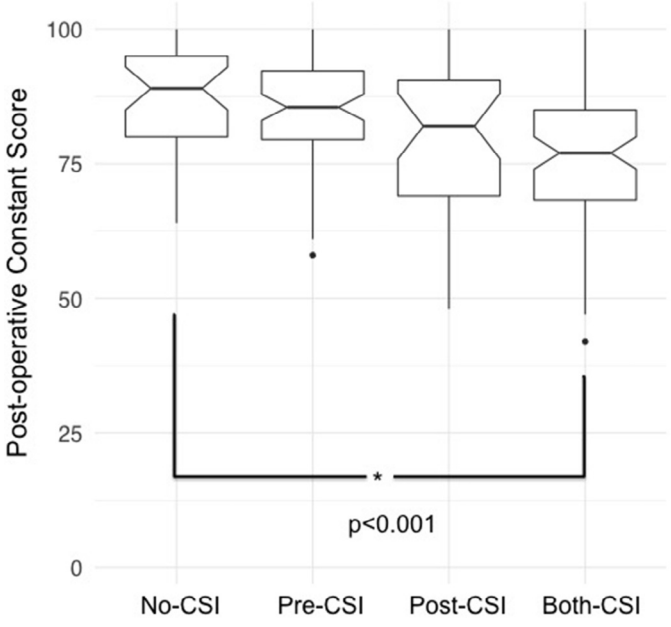

Figure 2 Box plots of postoperative Constant score by the corticosteroid injection (*CSI*) groups. Relative to no-CSI, the only significantly different group was both-CSI.

arthroscopic rotator cuff repair. The results confirmed that preoperative CSIs had little or no influence on clinical scores and retear rates, whereas postoperative CSIs were significantly associated with lower Constant scores and higher retear rates. The results also revealed postoperative Constant scores and retear rates to be most influenced by preoperative fatty infiltration.

The administration of CSIs is believed to relieve persistent pain and to reduce stiffness before or after rotator cuff repair.[22] With regard to postoperative Constant scores, our multivariable regression revealed preoperative CSIs to be a confounding variable but confirmed significant associations with postoperative CSIs as well as with lower preoperative Constant score, female gender, and fatty infiltration. Although we can infer that preoperative CSIs do not affect Constant scores, we cannot determine whether postoperative CSIs compromised scores or whether postoperative CSIs were administered in patients with poorer scores. The cause-and-effect relationship between postoperative CSIs and Constant scores cannot be determined from this study and warrants further investigation. It seems likely, however, that postoperative CSIs were not effective at resolving symptoms in patients with postoperative pain or impaired function.

The overall retear rate observed in this series (13%) compares favorably with rates reported by Park et al[36] (25%) and Gwak et al[21] (27%). The literature reports higher retear rates in delaminated rotator

Table III
Regression analysis of postoperative Constant score

Variable	Univariable			Multivariable		
	Regression	95% CI	*P* value	Regression coefficient	95% CI	*P* value
Continuous*						
Preoperative CSI	−1.4	−2.4 to −0.4	.005	−0.8	−1.7 to 0.1	.082
Pos-operative CSI	−5.3	−7.2 to −3.3	<.001	−4.7	−6.5 to −3.0	<.001
Age (y)	−0.1	−0.2 to 0.1	.553	0.1	−0.1 to 0.3	.384
Follow-up (y)	−0.2	−1.8 to 1.5	.830	0.2	−1.3 to 1.6	.839
Preoperative Constant score	0.2	0.1-0.3	<.001	0.2	0.1-0.3	.002
Categorical†						
Male vs. female	7.6	4.4-10.8	<.001	5.6	2.6-8.6	<.001
Tobacco	−0.4	−4.7 to 3.9	.858	−2.5	−6.3 to 1.3	.191
Tendon retraction	−2.2	−6.1 to 1.6	.256	−1.4	−5.4 to 2.5	.480
Tendon delamination	−0.9	−4.9 to 2.6	.621	1.4	−2.3 to 5.1	.446
Fatty infiltration of the supraspinatus, stages 0-1 vs.						
Stage 2	−6.4	−9.7 to −3.0	<.001	−6.5	−9.7 to −3.3	<.001
Stage 3	−12.2	−20.4 to −3.9	.004	−13.9	−21.4 to −6.4	<.001

CI, confidence interval; *CSI*, corticosteroid injection.
* Odds ratio of needing transfusion for an increase of the independent variable by 1 unit.
† Odds ratio of needing transfusion for the specified binary category.

Table IV
Regression analysis of retear rate (Sugaya)

Variable	Univariable			Multivariable		
	OR	95% CI	*P* value	OR	95% CI	*P* value
Continuous*						
Preoperative CSI	0.93	0.68-1.18	.646	0.85	0.58-1.18	.367
Postoperative CSI	1.47	0.93-2.29	.089	2.19	1.23-3.92	.007
Age (y)	1.09	1.03-1.14	<.001	1.06	0.99-1.13	.091
Follow-up (y)	0.97	0.64-1.43	.873	0.85	0.49-1.39	.520
Preoperative Constant score	0.97	0.94-0.99	.012	0.98	0.95-1.01	.235
Categorical†						
Male vs. female	1.11	0.49-2.54	.802	1.10	0.39-3.15	.851
Tobacco	1.22	0.42-3.10	.685	2.10	0.62-6.84	.219
Tendon retraction	3.26	1.41-7.53	.005	1.68	0.51-5.56	.388
Tendon delamination	4.95	2.11-12.60	<.001	2.20	0.69-7.19	.184
Fatty infiltration of the supraspinatus, stages 0-1 vs.						
Stage 2	4.34	1.54-15.54	.011	3.14	0.94-12.80	.080
Stage 3	46.00	9.10-298.86	<.001	28.52	4.15-245.30	.001

OR, odds ratio; *CI*, confidence interval; *CSI*, corticosteroid injection.
* Odds ratio of needing transfusion for an increase of the independent variable by 1 unit.
† Odds ratio of needing transfusion for the specified binary category.

cuff repairs[21,36]; however, our study revealed that tendon delamination was a confounding factor. Our multivariable regression for retear rate also revealed age, preoperative Constant score, and tendon retraction to be confounding factors but confirmed significant associations with postoperative CSIs and fatty infiltration. Once more, we can infer that preoperative CSIs do not increase retears; however, we cannot determine whether postoperative CSIs increased retears or whether postoperative CSIs were administered in patients who already had retears. In agreement with previous studies, we found that fatty infiltration significantly compromised repair integrity,[23,30] particularly at stage 3.

In patients with painful shoulders with rotator cuff tears, CSIs are a mainstream initial treatment, combined with rest, physical therapy, and nonsteroidal anti-inflammatory medication.[29] CSIs could prevent the need for surgical intervention, alleviating pain and facilitating rehabilitation, and could also prepare shoulders preoperatively, decreasing inflammation in the subacromial bursa. The first complication of shoulder CSIs is related to inaccurate needle position,[15,43,44,48] which is improved with use of image guidance.[24,26,41,56] In this study, the absence of adverse events could be attributed to the reliable injection technique performed by the same experienced radiologist. Therefore, perhaps some reasons for the poorer outcomes with postoperative CSIs are detailed in previous studies indicating that CSIs can cause adverse effects, such as specific cell toxicity,[13,39] alteration of the collagen composition and extracellular matrix,[25] and decreasing microvascularization of the rotator cuff footprint.[8] Conversely, Bhatia et al[6] studied the natural progression of rotator cuff tear in patients who underwent CSI for conservative treatment of impingement syndrome and found no difference in tear progression between patients who received fewer or more than 3 injections, suggesting that CSIs may not be a causative factor of rotator cuff tear.

This study has several limitations. These include the wide variability of follow-up, which could alter clinical and ultrasound evaluations; the inclusion of patients with various tear patterns, which may influence the prognosis of repair integrity; and the small subgroup sizes, which limit the statistical power. Moreover, our study design is insufficient to determine cause-and-effect relationships between CSI administration and Constant score or retear rate. Also, the statistical analyses considered tendon-to-bone healing as a binary outcome and did not account for tendon quality in greater detail. The strengths of the study are its overall sample size, the homogeneity of the surgical technique, and the collection of clinical scores by a single blinded clinician.

Conclusion

This study demonstrated that CSIs before arthroscopic rotator cuff repair did not significantly influence tendon healing. Our findings could help resolve common controversies regarding potential deleterious effects of preoperative CSIs. These observations may be valid only when CSIs are administered by experienced radiologists using image guidance. Concerns persist, however, about lower Constant scores and higher retear rates with postoperative CSIs as for preoperative fatty infiltration.

Disclaimer

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