

Factors associated with treatment success following shoulder intra-articular steroid injections

Omuz intraartiküler steroid enjeksiyonları tedavi başarısı ile ilişkili faktörler

Merve Sekizkardes Tutuncu¹, Yusuf Oguzhan Yuruk², Medine Yılmaz³, Zehra Nur Yüce³, Binnur Ercan³,
Buse Nur Aksoy³, Abdelrhman Sallam³, Savas Sencan¹

¹Department of Physical Medicine and Rehabilitation, Division of Pain Medicine, Marmara University Faculty of Medicine, İstanbul, Türkiye

²Department of Physical Medicine and Rehabilitation, Marmara University Faculty of Medicine, İstanbul, Türkiye

³Marmara University Faculty of Medicine, İstanbul, Türkiye

ABSTRACT

Background: This study aims to investigate the factors which influence the treatment efficacy of intra-articular corticosteroid injections in patients with adhesive capsulitis.

Patients and Methods: Between January 2020 and January 2024, a total of 126 patients who received intra-articular steroid injections for adhesive capsulitis were retrospectively analyzed. Pain severity was measured using the Numerical Rating Scale (NRS-11) at four time points: pre-procedure, 1 h post-procedure, three weeks, and three months. Treatment success was defined as a $\geq 50\%$ reduction in the NRS-11 pain scores at three months compared to baseline. Based on this criterion, the patients were categorized into two groups: responders and non-responders. The Central Sensitization Inventory (CSI) was used to evaluate central sensitization and Charlson Comorbidity Index (CCI) was used to assess comorbidity scores. Both groups were compared in terms of demographics, baseline pain scores, range of motion, and magnetic resonance imaging findings.

Results: Of the patients, 40 were male and 86 were female with a mean age of 60.8 ± 11.02 (range, 32 to 83) years. A reduction of $\geq 50\%$ in NRS-11 pain scores was observed in 95.2%, 69.8%, and 67.5% of patients at 1 h, three weeks, and three months post-injection, respectively. There were no significant differences between responders and non-responders in terms of demographic characteristics, baseline pain scores and range of motion, CSI scores, or CCI scores. However, on both univariate and multivariate logistic regression, the presence of acromioclavicular joint degeneration was independently associated with lower odds of treatment success (adjusted odds ratio [OR] = 0.34, 95% confidence interval [CI]: 0.13-0.90, $p = 0.030$).

Conclusion: Intra-articular corticosteroid injections do not consistently yield favorable outcomes in patients with adhesive capsulitis. Neither central sensitization nor composite comorbidity scores appear to be reliable predictors of treatment failure. However, the presence of additional degenerative changes, such as acromioclavicular joint degeneration, may be associated with poorer outcomes.

Keywords: Adhesive capsulitis, injection, shoulder, steroid, treatment success.

ÖZ

Amaç: Bu çalışmada, adeziv kapsülitli hastalarda intraartiküler kortikosteroid enjeksiyonlarının tedavi etkinliğini etkileyen faktörler araştırıldı.

Hastalar ve Yöntemler: Ocak 2020 ile Ocak 2024 tarihleri arasında adeziv kapsülit nedeniyle intraartiküler steroid enjeksiyonu uygulanan toplam 126 hasta retrospektif olarak incelendi. Ağrı şiddeti, işlem öncesinde, işlemden 1 saat sonra, üç hafta ve üç ay sonra olmak üzere dört zaman noktasında Sayısal Derecelendirme Ölçeği (NRS-11) kullanılarak değerlendirildi. Tedavi başarısı, başlangıç değerine kıyasla üçüncü ayda NRS-11 ağrı skorlarında $\geq 50\%$ azalma olarak tanımlandı. Bu kriter gereği hastalar yanıt verenler ve yanıt vermeyenler olmak üzere iki gruba ayrıldı. Santral duyarılabilirliği değerlendirmek için Santral Duyarılabilirlik Envanteri (CSI), komorbidite skorlarını değerlendirmek için ise Charlson Komorbidite İndeksi (CCI) kullanıldı. Her iki grup demografik özellikler, başlangıç ağrı skorları, eklem hareket açıklığı ve manyetik rezonans görüntüleme bulguları açısından karşılaştırıldı.

Bulgular: Hastaların 40'ı erkek ve 86'sı kadın olup, ortalama yaş 60.8 ± 11.02 (dağılım, 32-83 yıl) idi. Enjeksiyon sonrası 1. saatte, üçüncü haftada ve üçüncü ayda hastaların sırasıyla %95.2'sinde, %69.8'inde ve %67.5'inde NRS-11 ağrı skorlarında $\geq 50\%$ azalma gözlemlendi. Yanıt verenler ile yanıt vermeyenler arasında demografik özellikler, başlangıç ağrı skorları ve eklem hareket açıklığı, CSI skorları veya CCI skorları açısından anlamlı fark saptanmadı. Bununla birlikte, hem tek değişkenli hem de çok değişkenli lojistik regresyon analizlerinde, akromiyoklaviküler eklem dejenerasyonunun tedavi başarısı olasılığının daha düşük olması ile bağımsız olarak ilişkili olduğu bulundu (düzeltilmiş olasılık oranı [OR] = 0.34; %95 güven aralığı [GA]: 0.13-0.90; $p = 0.030$).

Sonuç: İntraartiküler kortikosteroid enjeksiyonları, adeziv kapsülitli hastalarda her zaman olumlu sonuçlar sağlamamaktadır. Ne merkezi duyarılabilirlik ne de bileşik komorbidite skorları, tedavi başarısızlığının güvenilir yordayıcıları gibi görünmektedir. Bununla birlikte, akromiyoklaviküler eklem dejenerasyonu gibi ek dejeneratif değişikliklerin varlığı, daha kötü tedavi sonuçlarıyla ilişkili olabilir.

Anahtar sözcükler: Adeziv kapsülit, enjeksiyon, omuz, steroid, tedavi başarısı.

Corresponding author: Merve Sekizkardes Tutuncu, MD.

E-mail: merve.sekizkardes@gmail.com

Doi: 10.5606/agri.2026.105

Received: September 26, 2025 | **Accepted:** September 06, 2026 | **Published online:** September 27, 2026

Cite this article as: Sekizkardes Tutuncu M, Yuruk YO, Yılmaz M, Yüce ZN, Ercan B, Aksoy BN, et al. Factors associated with treatment success following shoulder intra-articular steroid injections. Agri 2026;38(4):247-256. doi: 10.5606/agri.2026.105.

© 2026 The Author(s). This is an open access article published under the terms of the Creative Commons Attribution 4.0 International License (CC BY 4.0), which permits unrestricted use, distribution, reproduction, and adaptation in any medium, provided the original work is properly cited. <https://creativecommons.org/licenses/by/4.0/>

Adhesive capsulitis, commonly referred to as frozen shoulder, is a frequent clinical condition characterized by contracture of the glenohumeral capsule. Its prevalence in the general population is estimated at 2 to 5%.^[1] The disorder typically occurs after the age of 40 and is often associated with comorbidities such as diabetes mellitus, thyroid dysfunction, and dyslipidemia.^[2]

The diagnosis of adhesive capsulitis is primarily clinical, typically presenting with shoulder pain and restricted range of motion (ROM). Although often considered a self-limiting condition, it can be refractory to treatment. Initial management generally involves physical therapy, an exercise regimen, and non-steroidal anti-inflammatory drugs (NSAIDs). However, in cases unresponsive to conservative therapy, minimally invasive interventions such as intra-articular corticosteroid injections may be necessary.^[3-5]

Intra-articular corticosteroid injections have been reported to offer significant pain relief and functional improvement in adhesive capsulitis.^[6,7] However, not all patients respond favorably to these interventions.^[8,9] To illustrate, the presence of diabetes has been associated with reduced treatment efficacy, potentially due to connective tissue proliferation and thickening, which may lead to decreased ROM.^[8] Additionally, higher pre-injection pain scores and limited improvement in ROM following injection have been identified as predictors of treatment failure.^[9] Shoulder pain that is unresponsive to injections or surgical interventions is attributed not only to structural abnormalities, but also to psychological factors such as depression and anxiety, social and emotional factors.^[10] Moreover, central sensitization (CS), defined as increased responsiveness of nociceptive neurons in the central nervous system, has been implicated in chronic, treatment-resistant shoulder pain.^[11,12] Altered pain perception due to changes in pain threshold has been shown to reduce the therapeutic effectiveness of subacromial corticosteroid injections in chronic shoulder impingement syndrome; however, its impact on adhesive capsulitis has not been investigated yet.^[13] A Cochrane review suggested that intra-articular injections could provide benefit for patients with adhesive capsulitis; however, the available evidence is insufficient to draw firm conclusions.^[14] Another Cochrane review reported that intra-articular corticosteroid injections were more effective than a combination of manual therapy and exercise in the short term.^[15] Both reviews emphasize the need for more comprehensive

research to identify factors that influence treatment success or failure across different modalities.

In the present study, we hypothesized that higher levels of CS and a greater comorbidity burden could be associated with poorer responses. We, therefore, aimed to identify variables influencing the efficacy of intra-articular corticosteroid injections in adhesive capsulitis and to investigate the potential relationship between specific magnetic resonance imaging (MRI) findings and treatment success.

PATIENTS AND METHODS

This single-center, retrospective clinical study was conducted at Marmara University Faculty of Medicine, Department of Physical Medicine and Rehabilitation, Division of Pain Medicine between January 2020 and January 2024. Initially, medical records of patients who were diagnosed with adhesive capsulitis and underwent intra-articular corticosteroid injection under either fluoroscopic or ultrasonographic guidance were screened. Adhesive capsulitis was diagnosed based on limitation in both active and passive shoulder ROM involving abduction, flexion, extension, or internal/external rotation, accompanied by pain that interferes with activities of daily living.^[16,17] Structural causes, including dislocations, subluxations, prior surgery, and fractures in the shoulder region, were excluded. Inclusion criteria were as follows: having a diagnosis of adhesive capsulitis according to the aforementioned criteria, age ≥ 18 years, and pre-procedural pain score ≥ 4 on the 11-point Numerical Rating Scale (NRS-11). Exclusion criteria were as follows: structural abnormalities of the shoulder, recent dislocations or subluxations, prior shoulder surgery or fractures, active infection, active inflammatory disease, or malignancy, missing or incomplete clinical/radiographic records, and lack of access to relevant imaging data. A total of 401 patients initially met the eligibility criteria. The patients were further excluded if they received more than one injection, had incomplete datasets, or could not be contacted for follow-up questionnaires. Finally, a total of 126 patients were included in the final analysis (Figure 1). The study protocol was approved by the Marmara University Faculty of Medicine Clinical Research Ethics Committee (Date: 12.01.2024, No: 09.2024.84). The study was conducted in accordance with the principles of the Declaration of Helsinki.

All patients had a prior clinical diagnosis of adhesive capsulitis and underwent a standardized intra-articular injection protocol consisting of 6 mg

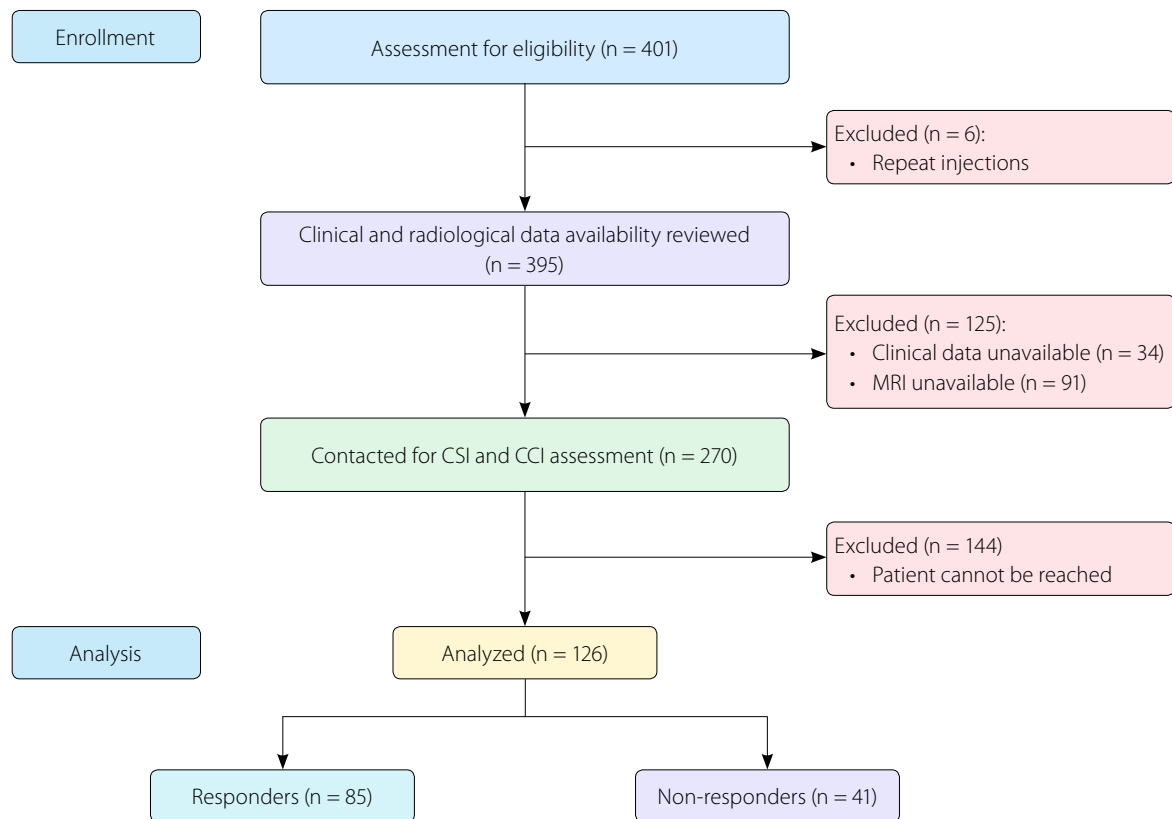


Figure 1. Study flowchart.

CSI, central sensitization inventory; CCI, Charlson Comorbidity Index; MRI, magnetic resonance imaging.

betamethasone, 10 mg bupivacaine hydrochloride, and 1 mL saline.

Demographic data such as age, sex, and body mass index (BMI) were retrieved from hospital records. Relevant clinical data, including symptom duration, physical examination findings, and MRI results, were also obtained from electronic hospital records. Comorbidities, such as diabetes, thyroid dysfunction, and cardiovascular diseases, were identified through outpatient and primary care physician notes.

Range of motion was assessed in abduction, flexion, and external rotation using a goniometer. The ROM limitations were categorized based on criteria similar to those proposed by Hanish et al.,^[9] but adapted to reflect the system routinely used in our clinical practice. Specifically, for abduction and external rotation, a range of $\geq 45^\circ$ was considered mild limitation, whereas $< 45^\circ$ was considered severe limitation. For flexion, a range of $\geq 120^\circ$ was classified as mild, and $< 120^\circ$ as severe limitation. The type of procedural guidance, fluoroscopy or ultrasonography, was also documented.

Central sensitization was evaluated using the Central Sensitization Inventory (CSI), a tool for screening patients with chronic pain, including a validated Turkish language version.^[18] The CSI comprises two parts: Part A includes 25 somatic and psychosocial symptoms commonly associated with CS, scored from 0 to 100. Part B, which is not scored, assesses the presence of comorbid conditions strongly linked to CS. A score of ≥ 40 was considered indicative of CS. Following retrospective record review, eligible patients were contacted via telephone, and CSI assessment was completed after obtaining informed consent.

Comorbidity burden was assessed using the Charlson Comorbidity Index (CCI), which accounts for 19 medical conditions, each assigned a weight (1-6) based on severity. The total CCI score was calculated by summing the individual condition scores and adding one point for each decade of life beyond age 40.^[19] This score reflects overall comorbidity risk. Patients were contacted via telephone for CCI assessment following informed consent.

Pain severity was measured using the NRS-11 at four time points: Pre-procedure, 1 h post-procedure, three weeks, and three months. A reduction of $\geq 50\%$ in the NRS-11 score at three months compared to baseline was defined as a successful treatment outcome.^[20] Patients were accordingly categorized as responders or non-responders, and the two groups were compared across all recorded variables.

Statistical analysis

Statistical analysis was performed using the IBM SPSS version 20.0 software (IBM Corp., Armonk, NY, USA). The Shapiro-Wilk test assessed normality for continuous data. Continuous data were presented in mean $\pm$ standard deviation (SD) or median (min-max), while categorical data were presented in number and frequency. The chi-square test was used to compare categorical variables. The Mann-Whitney U test was used for non-normally distributed variables, whereas the independent samples t-test was used for normally distributed variables. Temporal changes were analyzed using repeated measures analysis of variance (ANOVA). To evaluate associations between individual variables and MRI findings and three-month treatment outcome, univariate binary logistic regression was performed for each variable, with treatment success as the dependent variable; the results are reported as odds ratios (ORs) with 95% confidence intervals (CIs). A multivariate logistic regression model was additionally constructed including all MRI findings with an adequate number of events to identify findings independently associated with treatment success while accounting

for the coexistence of multiple imaging findings within the same patient; findings present in fewer than 10 patients were excluded from the multivariate model due to an insufficient events-per-variable ratio. A two-tailed p value of < 0.05 was considered statistically significant.

RESULTS

Of a total of 126 patients included in the study, 40 were male and 86 were female with a mean age of 60.8 ± 11.02 (range, 32 to 83) years. The majority of patients (62.6%) had CS. Intra-articular steroid injections were administered under fluoroscopic guidance in 39.7% of patients and under ultrasonographic guidance in 60.3% of patients. Demographic and clinical characteristics of the patients are presented in Table 1.

A reduction of 50% or more in the NRS-11 pain score following intra-articular shoulder injection was considered a clinically significant improvement. This improvement was observed in 95.2%, 69.8%, and 67.5% of patients at 1 h, three weeks, and three months post-procedure, respectively (Table 1).

Pairwise comparisons of NRS-11 scores across the four assessed time points, using repeated-measures ANOVA with Bonferroni post-hoc correction, are presented in Table 2. Compared to pre-procedural NRS-11 scores, the NRS-11 scores at 1 h, three weeks, and three months after intra-articular shoulder injection were significantly lower ($p < 0.001$ for all). Except for the comparison between the three-week and three-month follow-ups ($p = 1.000$), all other

Table 1. Demographic and clinical characteristics of the patients

Variables	n	%	Mean $\pm$ SD	Median	IQR
Age (year)			60.8 $\pm$ 11.0		
Sex					
Female	86	68.3			
Male	40	31.7			
Body mass index (kg/m ²)			29.8 $\pm$ 5.1		
Symptom duration (months)				12.0	16.5
Pre-procedural NRS-11			7.8 $\pm$ 1.7		
NRS at 1 hour			1.2 $\pm$ 2.0		
NRS at 3 weeks			3.0 $\pm$ 3.1		
NRS at 3 months			3.1 $\pm$ 2.9		
Presence of central sensitization	79	62.6			
Fluoroscopy-guided procedure	51	40.5			
Ultrasonography-guided procedure	75	59.5			

SD, standard deviation; IQR, interquartile range. Descriptive statistics: mean $\pm$ SD for normally distributed continuous variables, median (IQR) for non-normally distributed continuous variables, and n (%) for categorical variables.

Table 2. Changes in NRS scores throughout the treatment period

Comparison	Time point A	Time point B	<i>p</i>
	Mean $\pm$ SD	Mean $\pm$ SD	
Pre-procedure NRS vs. 1 hour post-procedure	7.8 $\pm$ 1.7	1.2 $\pm$ 2.0	< 0.001
Pre-procedure NRS vs. 3 weeks post-procedure	7.8 $\pm$ 1.7	3.0 $\pm$ 3.1	< 0.001
Pre-procedure NRS vs. 3 months post-procedure	7.8 $\pm$ 1.7	3.1 $\pm$ 2.9	< 0.001
1 hour vs. 3 weeks post-procedure	1.2 $\pm$ 2.0	3.0 $\pm$ 3.1	< 0.001
1 hour vs. 3 months post-procedure	1.2 $\pm$ 2.0	3.1 $\pm$ 2.9	< 0.001
3 weeks vs. 3 months post-procedure	3.0 $\pm$ 3.1	3.1 $\pm$ 2.9	1.000

SD, standard deviation; NRS, Numeric Rating Scale. Repeated-measures ANOVA with Bonferroni post hoc pairwise comparisons.

Table 3. Comparison of demographic and clinical characteristics according to 3-month treatment outcome

Variables	Responders (n = 85)			Non-responders (n = 41)			Test <i>p</i> -value	OR (95% CI) [†]	LR <i>p</i> -value
	n	%	Mean $\pm$ SD	n	%	Mean $\pm$ SD			
Age (years)			60.31 $\pm$ 10.32			61.95 $\pm$ 12.43	0.435	0.99 (0.95-1.02)	0.432
Sex									
Female	58	68.2		28	68.3		1.000	1.00 (0.45-2.22)	0.995
BMI (kg/m ²)			29.57 $\pm$ 5.10			30.26 $\pm$ 5.23	0.497	0.97 (0.90-1.05)	0.488
Symptom duration (months)			22.13 $\pm$ 40.45			26.24 $\pm$ 43.45	0.220	1.00 (0.99-1.01)	0.671
Pre-procedural NRS-11			7.91 $\pm$ 1.69			7.95 $\pm$ 1.40	0.919	0.98 (0.78-1.23)	0.881
Presence of central sensitization	53	62.4		26	63.4		1.000	0.95 (0.44-2.08)	0.908
Charlson Comorbidity Index			2.87 $\pm$ 3.92			2.78 $\pm$ 2.08	0.487	1.01 (0.90-1.12)	0.891
Fluoroscopy-guided procedure	34	40.0		17	41.5		1.000	0.94 (0.44-2.00)	0.875
Flexion limitation	38	44.7		12	29.3		0.121	1.96 (0.88-4.35)	0.100
Abduction limitation	13	15.3		5	12.2		0.789	1.30 (0.43-4.00)	0.642
External rotation limitation	8	9.4		5	12.2		0.756	0.75 (0.23-2.44)	0.631

SD, standard deviation; OR, odds ratio; CI, confidence interval; LR, Logistic regression *p*-value; [†], from univariate binary logistic regression for each variable individually. Continuous variables were compared using the independent samples *t*-test (normally distributed) or the Mann-Whitney *U* test (non-normally distributed), per Shapiro-Wilk test results; categorical variables were compared using the chi-square test, or Fisher's exact test.**Table 4.** Comparison of shoulder MRI findings according to 3-month treatment outcome

MRI finding	Responders (n = 85)		Non-responders (n = 41)		Test <i>p</i> -value	OR (95% CI) [†]	LR <i>p</i> -value
	n	%	n	%			
Rotator cuff tear	38	44.7	15	36.6	0.444	1.41 (0.65-3.03)	0.388
Acromioclavicular degeneration	55	64.7	34	82.9	0.039	0.38 (0.15-0.95)	0.039
Abnormal acromion	21	24.7	9	22.0	0.825	1.16 (0.48-2.86)	0.734
SLAP lesion	3	3.5	1	2.4	1.000	1.47 (0.15-14.29)	0.745
Labral tear	3	3.5	3	7.3	0.390	0.46 (0.09-2.38)	0.360
Synovitis	4	4.7	1	2.4	1.000	1.96 (0.21-20.00)	0.549
Abnormal humerus	21	24.7	12	29.3	0.667	0.79 (0.34-1.82)	0.586
Abnormal glenoid	5	5.9	2	4.9	1.000	1.22 (0.23-6.67)	0.818
Osteophyte	10	11.8	4	9.8	1.000	1.23 (0.36-4.17)	0.737
Bursitis	55	64.7	30	73.2	0.419	0.67 (0.30-1.54)	0.343

OR, odds ratio; CI, confidence interval; LR, Logistic regression *p*-value; [†], treatment success, based on univariate binary logistic regression. Chi-square test (or Fisher's exact test where expected cell counts were <5) used for between-group comparisons.

Definitions:

Abnormal acromion: Morphological changes such as hooked/curved acromion or subacromial spurs.*Abnormal humerus*: Cortical irregularity, cystic changes, marrow edema, or degenerative alterations of the humeral head.*Abnormal glenoid*: Cartilage loss, labral irregularity, subchondral cysts, sclerosis, or glenoid deformity.

Table 5. Multivariate logistic regression of MRI findings independently associated with treatment success

MRI finding	Adjusted OR	95% CI	<i>p</i>
Rotator cuff tear	1.33	0.60-2.94	0.473
Acromioclavicular degeneration	0.34	0.13-0.90	0.030
Abnormal acromion	1.15	0.46-2.86	0.763
Abnormal humerus	0.65	0.26-1.61	0.351
Osteophyte	1.37	0.37-5.26	0.638
Bursitis	0.59	0.25-1.39	0.226

OR, odds ratio; CI, confidence interval.

time point comparisons demonstrated statistically significant differences in NRS-11 scores ($p < 0.001$ for all).

The patients were divided into two groups based on treatment outcomes at three months following intra-articular shoulder injection: 85 patients (67%) achieved successful treatment (responder group), while 41 patients (33%) did not (non-responder group). The two treatment groups did not differ significantly in their baseline demographic or clinical characteristics, and this similarity was also supported by univariate logistic regression analysis (Table 3).

Non-responders exhibited a significantly higher incidence of acromioclavicular (AC) joint degeneration compared to responders (OR = 0.38, 95% CI: 0.15-0.95, $p = 0.039$). No other MRI finding differed significantly between the groups in the univariate analysis (Table 4). In the multivariate logistic regression including all MRI findings present in at least 10 patients, to account for the coexistence of multiple imaging findings within the same patient, AC degeneration remained the only finding independently associated with treatment success (adjusted OR = 0.34, 95% CI: 0.13-0.90, $p = 0.030$) (Table 5).

DISCUSSION

In the present study, we aimed to variables which influenced the efficacy of intra-articular corticosteroid injections in adhesive capsulitis and investigated the potential relationship between specific MRI findings and treatment success. Our study results showed that, although a statistically significant improvement was observed at each time point; a 50% reduction in pre-procedural NRS-11 scores was not consistently achieved. Contrary to our hypothesis, the rates of CS and comorbidities did

not significantly differ between the responders and non-responders. Additionally, pre-procedural NRS-11 scores and limitations in ROM were not significantly different between the two groups. More intriguingly, the presence of AC joint degeneration on MRI was more frequently observed in non-responders. These findings suggest that AC joint degeneration may be associated with treatment response in patients with adhesive capsulitis. Specifically, its higher prevalence among non-responders may indicate a potential relationship between concomitant AC joint pathology and the likelihood of achieving a clinically meaningful response to intra-articular corticosteroid injection.

Intra-articular corticosteroid injections are recognized as an effective intervention for reducing pain and improving function in adhesive capsulitis.^[3,7,21] However, some patients do not respond as favorably.^[9] Few studies have investigated the factors associated with suboptimal treatment outcomes.^[22] To the best of our knowledge, this is the first study to examine the association between CSI scores and CCI and treatment outcomes in this patient population. In our study, significant improvements in clinical outcomes were observed following intra-articular corticosteroid injection; however, treatment response varied among patients. Further studies are warranted to validate this association and to clarify the clinical significance of AC joint degeneration in predicting treatment response to intra-articular corticosteroid injections in patients with adhesive capsulitis.

Patients who have CS exhibit altered pain processing mechanisms, such as increased response of the central nervous system to sensory input, which may contribute to or worsen the clinical presentation of various musculoskeletal pathologies.^[23-26] Enhanced neural activity, combined with impaired

inhibitory pathways and overactive facilitatory mechanisms, results in abnormal sensory processing and increased pain sensitivity. A sensitized central nervous system amplifies pain perception, often beyond what would be expected based on the extent of tissue damage, making symptom severity disproportionate to clinical or imaging findings.^[27-29] In our study, the prevalence of CS was 62.6%, a notably high rate. Previous reports in the general population have reported a prevalence ranging from 4.2 to 24.8%, with higher rates consistently observed among women.^[30,31] Higher prevalence has also been documented in certain medical conditions; to illustrate, 44.9% in rheumatic diseases, 52.4% in post-polio syndrome, and 39.4% in rotator cuff tears.^[32-34] Notably, the relationship between CS and adhesive capsulitis specifically has received limited direct study, with existing literature acknowledging this as an unresolved question.^[35] Several factors may explain the comparatively high prevalence in our cohort. First, patients were recruited from a tertiary referral pain clinic, where more severe or chronic cases are typically seen, increasing the likelihood of CS. Second, the majority of participants were female (68.3%), consistent with prior evidence linking female sex to higher prevalence rates. Finally, the CSI was administered via telephone at the time of the study and assessed retrospectively rather than at the time of injection, a design feature that may have introduced potential sources of bias.

Although several previous studies have reported that CS negatively impacts post-treatment outcomes, our study found no significant difference in CS scores between the two groups.^[13] There are several potential reasons for this discrepancy. First, we employed the CSI, a validated and widely used tool favored for its ease of use and cost-effectiveness. CSI offers information on different aspects of pain sensitization and has been shown to predict treatment response in several patient groups.^[24,36] Moreover, it also correlates psychological and functional parameters such as disability which are important in treatment outcomes.^[37] However, other assessment methods, such as QST, which measures mechanical, thermal, or pressure pain thresholds, or functional MRI, exist and can provide objective data.^[26] These methods, however, are rarely feasible in clinical practice due to their time-consuming nature.^[11] Schiff and Eisenberg^[38] utilized QST and demonstrated that pre-procedural QST scores could predict the success of lumbar epidural steroid injections. Coronado and George,^[39] on the other hand, reported that

exclusive reliance on the CSI shows only a weak correlation with QST and is inadequate for identifying widespread pain. Thus, despite not being the gold standard and its time-consuming nature, pressure pain threshold testing within QST could have offered more valuable data in our study. Our use of a validated yet inherently subjective tool like the CSI may thus explain the absence of a significant difference between the two groups. Furthermore, in our study, CSI scores were obtained retrospectively, and those scores were compared with treatment outcomes from an earlier timepoint, which could introduce confounding variables. It is also plausible that the impact of CS on treatment outcomes varies depending on the specific condition. For instance, although a negative correlation between CS and treatment response has been demonstrated in subacromial impingement syndrome, such a relationship may not apply to adhesive capsulitis.^[13] As a more chronic condition characterized by distinct clinical stages—painful, ROM-limiting (freezing), frozen, and thawing phases—the effect of CS in adhesive capsulitis may differ according to the disease stage.^[40] However, our sample did not include a homogeneous distribution of patients across these stages, which may have influenced the findings.

Contrary to our hypothesis, responders and non-responders did not differ significantly in terms of CCI scores. It is well-established that obese individuals, as well as those with diabetes and thyroid dysfunction, are at increased risk for developing adhesive capsulitis.^[41] Moreover, previous studies have demonstrated that patients with diabetes tend to respond less favorably to intra-articular corticosteroid injections compared to non-diabetic individuals.^[42,43] Given these known associations, and observing no such patterns in our preliminary results, we used the CCI, a more comprehensive screening tool encompassing 19 conditions, with higher scores indicating greater comorbidity burden.^[19] This approach was intended to identify potential trends related to other comorbidities that could be more thoroughly explored in future studies. However, in our study, higher CCI scores did not correlate with poorer treatment outcomes. While some studies have reported that a higher comorbidity burden negatively affects general health and functional outcomes following spine surgery, Jenkins et al.^[44] found that, contrary to their hypothesis, the CCI was not a reliable predictor of outcomes after spinal fusion.^[44,45] In relation to cardiovascular

conditions, Kingston et al.^[41] reported that patients with hypertension were actually less likely to develop adhesive capsulitis. These findings suggest that a higher overall comorbidity burden may not necessarily predict poor treatment response. Future studies may benefit from examining the influence of specific medical conditions individually, rather than composite scores, on the efficacy of intra-articular corticosteroid injections in adhesive capsulitis.

Although the mean symptom duration and pre-procedural NRS-11 scores were higher in non-responders, these differences did not reach statistical significance. Hanish et al.^[9] reported that elevated baseline pain scores and greater ROM limitations, particularly in external rotation, were associated with treatment failure. In our study, we observed similar trends, with non-responders showing higher pre-procedural pain scores and more pronounced external rotation restriction; however, these findings may not have achieved statistical significance due to our limited sample size.

Finally, in terms of MRI findings, the only statistically significant difference between the two groups was a higher prevalence of AC joint degeneration among non-responders compared to responders. Although bursitis was also more frequent in non-responders, this difference did not reach statistical significance. One possible explanation is that existing but untreated AC joint degeneration may have been masked by the dominant clinical presentation of adhesive capsulitis. As a result, following intra-articular injection, residual pain may have been more attributable to the underlying AC joint pathology. Another possibility is that joint degeneration itself contributes to increased local inflammation, which may enhance pain through mechanisms of peripheral sensitization, thereby reducing the effectiveness of pain relief in that region.^[46]

While this study offers a novel contribution by being the first to investigate the relationship between CSI scores, CCI, and treatment outcomes in adhesive capsulitis, several limitations should be acknowledged. First, the final sample size was smaller than anticipated due to incomplete datasets and difficulties in contacting some patients. Second, follow-up adherence was suboptimal; many participants missed their scheduled three-week and three-month clinical visits, requiring outcome assessment via telephone interviews, which may have introduced reporting bias. Third, shoulder MRI pathologies were determined based on existing

radiology reports rather than a single standardized re-evaluation, which may represent a source of bias. Finally, inherent limitations of the retrospective design, such as reliance on retrospective CS assessment and incomplete access to patients' full medication lists, may have affected the consistency of the data. Future prospective studies with standardized follow-up protocols are needed to address these limitations.

In conclusion, intra-articular corticosteroid injections do not consistently yield favorable outcomes in patients with adhesive capsulitis. Based on our findings, neither CS nor composite comorbidity scores appear to be reliable predictors of treatment failure. However, the presence of additional degenerative changes, such as AC joint degeneration, may be associated with poorer outcomes. Future multi-center, large-scale, prospective studies are needed to confirm these findings and establish more definitive conclusions.

Author Contributions

M.S.T.: Investigation, data curation, formal analysis, writing-original draft, writing-review & editing; Y.O.Y.: Methodology, investigation, data curation, formal analysis, supervision; M.Y., Z.N.Y.: Conceptualization, methodology, investigation, data curation; B.E.: Methodology, investigation, data curation, formal analysis, writing-original draft; B.N.A.: Conceptualization, methodology, data curation, formal analysis; A.S.: Methodology, data curation, formal analysis; S.S.: Conceptualization, methodology, writing, supervision, project administration.

Conflict of Interest

The authors declared no conflicts of interest with respect to the authorship and/or publication of this article.

Funding

The authors received no financial support for the research and/or authorship of this article.

Data Sharing Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

AI Disclosure

The authors declare that artificial intelligence (AI) tools were not used, or were used solely for language editing, and had no role in data analysis, interpretation, or the formulation of conclusions. All scientific content, data interpretation, and conclusions are the sole responsibility of the authors. The authors further confirm that AI tools were not used to generate, fabricate, or 'hallucinate' references, and that all references have been carefully verified for accuracy.

REFERENCES

1. Ramirez J. Adhesive capsulitis: Diagnosis and management. *Am Fam Physician* 2019;99:297-300.

2. Cucchi D, Marmotti A, De Giorgi S, Costa A, D'Apolito R, Conca M, et al. Risk factors for shoulder stiffness: Current concepts. *Joints* 2017;5:217-23. doi: 10.1055/s-0037-1608951.
3. Ryans I, Montgomery A, Galway R, Kernohan WG, McKane R. A randomized controlled trial of intra-articular triamcinolone and/or physiotherapy in shoulder capsulitis. *Rheumatology (Oxford)* 2005;44:529-35. doi: 10.1093/rheumatology/keh535.
4. Prestgaard T, Wormgoor MEA, Haugen S, Harstad H, Mowinkel P, Brox JI. Ultrasound-guided intra-articular and rotator interval corticosteroid injections in adhesive capsulitis of the shoulder: A double-blind, sham-controlled randomized study. *Pain* 2015;156:1683-91. doi: 10.1097/j.pain.0000000000000209.
5. Rangan A, Brealey SD, Keding A, Corbacho B, Northgraves M, Kottam L, et al. Management of adults with primary frozen shoulder in secondary care (UK FROST): A multicentre, pragmatic, three-arm, superiority randomised clinical trial. *Lancet* 2020;396:977-89. doi: 10.1016/S0140-6736(20)31965-6.
6. Shin SJ, Lee SY. Efficacies of corticosteroid injection at different sites of the shoulder for the treatment of adhesive capsulitis. *J Shoulder Elbow Surg* 2013;22:521-7. doi: 10.1016/j.jse.2012.06.015.
7. Carotte S, Moffet H, Tardif J, Bessette L, Morin F, Frémont P, et al. Intraarticular corticosteroids, supervised physiotherapy, or a combination of the two in the treatment of adhesive capsulitis of the shoulder: A placebo-controlled trial. *Arthritis Rheum* 2003;48:829-38. doi: 10.1002/art.10954.
8. Hong JY, Yoon SH, Moon DJ, Kwack KS, Joen B, Lee HY. Comparison of high- and low-dose corticosteroid in subacromial injection for periarticular shoulder disorder: A randomized, triple-blind, placebo-controlled trial. *Arch Phys Med Rehabil* 2011;92:1951-60. doi: 10.1016/j.apmr.2011.06.033.
9. Hanish SJ, Resnick ML, Kim HM, Smith MJ. Predictive factors for failure of intraarticular injection in management of adhesive capsulitis of the shoulder. *J Clin Med* 2022;11:6212. doi: 10.3390/jcm11206212.
10. Navarro-Ledesma S, Hamed-Hamed D, Pruimboom L. A new perspective of frozen shoulder pathology: The interplay between the brain and the immune system. *Front Physiol* 2024;15:1248612. doi: 10.3389/fphys.2024.1248612.
11. Iio R, Manaka T, Nakazawa K, Hirakawa Y, Ito Y, Ogura A, et al. Assessment of prevalence and risk factors for central sensitization related to shoulder osteoarthritis and rotator cuff tears using the central sensitization inventory: A cross-sectional study in shoulder surgery patients. *J Clin Med* 2023;12:5633. doi: 10.3390/jcm12175633.
12. Latremoliere A, Woolf CJ. Central sensitization: A generator of pain hypersensitivity by central neural plasticity. *J Pain* 2009;10:895-926. doi: 10.1016/j.jpain.2009.06.012.
13. Şirin Ahışa B, Paker N, Kesiktaş N, Buğdaycı ND, Ahışa YC. Evaluation of inadequate response to ultrasound-guided subacromial corticosteroid injection in shoulder impingement syndrome: Treatment failure or central sensitization? *Arch Phys Med Rehabil* 2025;106:1227-37. doi: 10.1016/j.apmr.2025.01.469.
14. Buchbinder R, Green S, Youd JM. Corticosteroid injections for shoulder pain. *Cochrane Database Syst Rev* 2003;2003:CD004016. doi: 10.1002/14651858.CD004016.
15. Page MJ, Green S, Kramer S, Johnston RV, McBain B, Chau M, et al. Manual therapy and exercise for adhesive capsulitis (frozen shoulder). *Cochrane Database Syst Rev* 2014;2014:CD011275. doi: 10.1002/14651858.CD011275.
16. Wang L, Yu G, Zhang R, Wu G, He L, Chen Y. Positive effects of neuromuscular exercises on pain and active range of motion in idiopathic frozen shoulder: A randomized controlled trial. *BMC Musculoskelet Disord* 2023;24:50. doi: 10.1186/s12891-023-06173-8.
17. Mohamed AA, Jan YK, El Sayed WH, Wanis MEA, Yamany AA. Dynamic scapular recognition exercise improves scapular upward rotation and shoulder pain and disability in patients with adhesive capsulitis: A randomized controlled trial. *J Man Manip Ther* 2020;28:146-58. doi: 10.1080/10669817.2019.1622896.
18. Düzce Keleş E, Birtane M, Ekuklu G, Kılınçer C, Çaliyurt O, Taştekin N, et al. Validity and reliability of the Turkish version of the central sensitization inventory. *Arch Rheumatol* 2021;36:518-26. doi: 10.46497/ArchRheumatol.2022.8665.
19. Charlson ME, Pompei P, Ales KL, MacKenzie CR. A new method of classifying prognostic comorbidity in longitudinal studies: Development and validation. *J Chronic Dis* 1987;40:373-83. doi: 10.1016/0021-9681(87)90171-8.
20. Kokar S, Sacaklıdır R, Olgun Y, Sencan S, Gunduz OH. Predictive factors for treatment success of epidural steroid injections in patients with lumbar spinal surgery. *Eur Rev Med Pharmacol Sci* 2023;27:9815-21. doi: 10.26355/eurrev_202310_34157.
21. Sun Y, Zhang P, Liu S, Li H, Jiang J, Chen S, et al. Intra-articular steroid injection for frozen shoulder: A systematic review and meta-analysis of randomized controlled trials with trial sequential analysis. *Am J Sports Med* 2017;45:2171-9. doi: 10.1177/0363546516669944.
22. Liang CW, Cheng HY, Lee YH, De Liao C, Huang SW. Corticosteroid injection methods for frozen shoulder: A network meta-analysis. *Arch Phys Med Rehabil* 2024;105:750-9. doi: 10.1016/j.apmr.2024.01.003.
23. Sanchis MN, Lluch E, Nijs J, Struyf F, Kangasperko M. The role of central sensitization in shoulder pain: A systematic literature review. *Semin Arthritis Rheum* 2015;44:710-6. doi: 10.1016/j.semarthrit.2014.11.002.
24. Sacaklıdır R, Sanal-Toprak C, Yucel FN, Gunduz OH, Sencan S. The effect of central sensitization on interlaminar epidural steroid injection treatment outcomes in patients with cervical disc herniation: An observational study. *Pain Physician* 2022;25:E823-E9.
25. Wylde V, Sayers A, Odutola A, Gooberman-Hill R, Dieppe P, Blom AW. Central sensitization as a determinant of patients' benefit from total hip and knee replacement. *Eur J Pain* 2017;21:357-65. doi: 10.1002/ejp.929.
26. Pak DJ, Yong RJ, Kaye AD, Urman RD. Chronification of pain: Mechanisms, current understanding, and clinical implications. *Curr Pain Headache Rep* 2018;22:9. doi: 10.1007/s11916-018-0666-8.
27. Arendt-Nielsen L, Graven-Nielsen T. Translational musculoskeletal pain research. *Best Pract Res Clin Rheumatol* 2011;25:209-26. doi: 10.1016/j.berh.2010.01.013.
28. O'Neill S, Manniche C, Graven-Nielsen T, Arendt-Nielsen L. Generalized deep-tissue hyperalgesia in patients with chronic low-back pain. *Eur J Pain* 2007;11:415-20. doi: 10.1016/j.ejpain.2006.05.009.
29. Nijs J, Torres-Cuenco R, van Wilgen CP, Girbes EL, Struyf F, Roussel N, van Oosterwijck J, et al. Applying modern pain neuroscience in clinical practice: Criteria for the classification of central sensitization pain. *Pain Physician* 2014;17:447-57.
30. Sariyildiz A, Coskun Benlidayi I, Kaya B, Chalabiyev N, Seyrek N, Karayaylali I. Central sensitization: Its prevalence and impact on quality of life among hemodialyzed patients. *Ir J Med Sci* 2024;193:1595-602. doi: 10.1007/s11845-023-03601-5.
31. Neblett R, Hartzell MM, Mayer TG, Cohen H, Gatchel RJ. Establishing clinically relevant severity levels for the central sensitization inventory. *Pain Pract* 2017;17:166-75. doi: 10.1111/papr.12440.
32. Berrichi I, Taik FZ, Haddani F, Soba N, Fourtassi M, Abourazzak FE. Prevalence and associated factors of central sensitization in patients with chronic inflammatory rheumatic disease. *Curr Rheumatol Rev* 2025;21:418-23. doi: 10.2174/011573397130988524101105213.
33. On AY, Latifoglou E, Çınar E, Tanıgör G. Prevalence and severity of central sensitization in post-polio syndrome: Associations with clinical measures and quality of life. *Ann Indian Acad Neurol* 2024;27:282-8. doi: 10.4103/aian.aian_1040_23.
34. Peng R, Yang R, Ning N. Central sensitization syndrome in patients with rotator cuff tear: Prevalence and associated factors. *Postgrad Med* 2023;135:593-600. doi: 10.1080/00325481.2023.2241343.
35. de la Serna D, Navarro-Ledesma S, Alayón F, López E, Pruimboom L. A comprehensive view of frozen shoulder: A mystery syndrome. *Front Med (Lausanne)* 2021;8:663703. doi: 10.3389/fmed.2021.663703.

36. Yücel FN, Özgüç S, Bahar-Özdemir Y, Ata E. The impact of central sensitization-related symptoms on subacromial steroid injection outcomes in patients with subacromial impingement syndrome: An observational study. *Korean J Pain* 2025;38:29-42. doi: 10.3344/kjp.24290.
37. Dahmani D, Taik FZ, Berrichi I, Fourtassi M, Abourazzak FE. Impact of central sensitization on pain, disability and psychological distress in patients with knee osteoarthritis and chronic low back pain. *BMC Musculoskelet Disord* 2023;24:877. doi: 10.1186/s12891-023-07019-z.
38. Schiff E, Eisenberg E. Can quantitative sensory testing predict the outcome of epidural steroid injections in sciatica? A preliminary study. *Anesth Analg* 2003;97:828-32. doi: 10.1213/01.ANE.0000078583.47735.69.
39. Coronado RA, George SZ. The central sensitization inventory and pain sensitivity questionnaire: An exploration of construct validity and associations with widespread pain sensitivity among individuals with shoulder pain. *Musculoskelet Sci Pract* 2018;36:61-7. doi: 10.1016/j.msksp.2018.04.009.
40. Neviaser AS, Hannafin JA. Adhesive capsulitis: A review of current treatment. *Am J Sports Med* 2010;38:2346-56. doi: 10.1177/0363546509348048.
41. Kingston K, Curry EJ, Galvin JW, Li X. Shoulder adhesive capsulitis: Epidemiology and predictors of surgery. *J Shoulder Elbow Surg* 2018;27:1437-43. doi: 10.1016/j.jse.2018.04.004.
42. Roh YH, Yi SR, Noh JH, Lee SY, Oh JH, Gong HS, et al. Intra-articular corticosteroid injection in diabetic patients with adhesive capsulitis: A randomized controlled trial. *Knee Surg Sports Traumatol Arthrosc* 2012;20:1947-52. doi: 10.1007/s00167-011-1776-6.
43. Erickson BJ, Shishani Y, Bishop ME, Romeo AA, Gobeze R. Adhesive capsulitis: Demographics and predictive factors for success following steroid injections and surgical intervention. *Arthrosc Sports Med Rehabil* 2019;1:e35-40. doi: 10.1016/j.asmr.2019.07.005.
44. Jenkins NW, Parrish JM, Nolte MT, Jadcak CN, Geoghegan CE, Mohan S, et al. Charlson Comorbidity Index: An inaccurate predictor of minimally invasive lumbar spinal fusion outcomes. *Int J Spine Surg* 2021;15:770-9. doi: 10.14444/8099.
45. Slover J, Abdu WA, Hanscom B, Weinstein JN. The impact of comorbidities on the change in short-form 36 and oswestry scores following lumbar spine surgery. *Spine (Phila Pa 1976)* 2006;31:1974-80. doi: 10.1097/01.brs.0000229252.30903.b9.
46. Fregoso G, Wang A, Tseng K, Wang J. Transition from acute to chronic pain: Evaluating risk for chronic postsurgical pain. *Pain Physician* 2019;22:479-88.