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Pharmacological interventions for early-stage frozen shoulder: a systematic review and network meta-analysis

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Abstract

Objectives: To evaluate the efficacy of pharmacological interventions for treating early-stage, pain predominant, adhesive capsulitis, also known as frozen shoulder.

Methods: We performed a systematic review in accordance with Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) guidelines. Searches were conducted on MEDLINE, EMBASE and Cochrane Central Register of Controlled Trials on 24 February 2022. Outcomes were shoulder pain, shoulder function and range of movement. Synthesis involved both qualitative analysis for all studies and pairwise meta-analyses followed by a network meta-analysis for randomized controlled trials (RCTs).

Results: A total of 3252 articles were found, of which 31 met inclusion criteria, and 22 of these were RCTs. IA injection of CS (8 RCTs, 340 participants) and IA injection of platelet-rich plasma (PRP) (3 RCTs, 177 participants) showed benefit at 12 weeks compared with physical therapy in terms of shoulder pain and function, while oral NSAIDs (2 RCTs, 44 participants) and IA injection of hyaluronate (2 RCTs, 42 participants) did not show a benefit. Only IA PRP showed benefit over physical therapy for shoulder range of movement.

Conclusion: These results shows that IA CS and IA PRP injections are beneficial for early-stage frozen shoulder. These findings should be appraised with care considering the risk of bias, heterogeneity and inconsistency of the included studies. We believe that research focused on early interventions for frozen shoulder could improve patient outcomes and lead to cost-savings derived from avoiding long-term disability. Further well-designed studies comparing with standardized physical therapy or placebo are required to improve evidence to guide management.

Keywords: frozen shoulder, adhesive capsulitis, shoulder pain.

Rheumatology key messages

- Available evidence suggests that IA CS and platelet-rich plasma injections improve pain and function in early-stage frozen shoulder compared with physical therapy alone at 12 weeks post-treatment.
- Most eligible studies included in this network meta-analysis present considerable risk of bias; therefore, results should be appraised with caution.

Introduction

Adhesive capsulitis of the shoulder, or frozen shoulder, is a debilitating condition characterized by severe pain and progressive shoulder stiffness [1]. It is very common, affecting ~8.2% of working-age men and 10.1% working-age women in the UK [2]. The pain associated with frozen shoulder [3] not only restricts the ability to use the upper extremities for activities of daily living, but also impairs sleep quality that

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can lead to depression and anxiety [3]. This in turn results in significant impact on quality of life [4], with loss of independence and altered sense of self [5].

Primary, or idiopathic, frozen shoulder develops in the absence of an identifiable systemic condition or local injury [6]. Secondary frozen shoulder can occur because of prolonged immobilization, surgery, acute trauma, supraspinatus tendon impingement or rotator cuff pathology [7], and can also be associated with systemic conditions, such as RA, cerebrovascular disease and diabetes. Prevalence of adhesive capsulitis is higher in individuals with diabetes and is also less responsive to treatment in these patients [8].

Frozen shoulder typically evolves through three overlapping stages [9]. During the initial 'freezing' stage, pain is the predominant symptom, and this tends to last from 3 to 9 months. This is followed by a 'frozen' stage, in which pain decreases but there is increasing stiffness. During this phase, fibrosis of the shoulder capsule restricts range of motion, especially external rotation, and this typically lasts between 4 and 12 months. Finally, during the 'thawing' stage there is gradual recovery of range of motion, usually over 12–48 months. Although most affected individuals regain near full mobility and strength, up to 45% of patients will have persistent symptoms after 3 years [10, 11].

The precise pathophysiology of frozen shoulder is not fully understood, and multiple treatment modalities have been proposed. These include a range of pharmacological, physical and surgical interventions [12]. Previous systematic reviews have evaluated and compared the effectiveness of the available therapies for frozen shoulder in general. Two Cochrane reviews found that oral and injected steroids are associated with improvement in range of motion and pain, although the benefits are not maintained after 6 weeks [13, 14]. Cochrane reviews of physiotherapy or US did not find any evidence to support their effectiveness [15, 16]. The UK Frozen Shoulder Trial (UK FROST) compared outcomes of patients recruited from secondary care following physiotherapy and CS injection, manipulation under anaesthesia and CS injection or arthroscopic release and CS injection [17]. None of these treatments achieved the threshold for improvement at 12 months in a patient outcome measure (Oxford Shoulder Score).

To our knowledge there are no previous systematic reviews focusing on treatments for early-stage frozen shoulder [18]; therefore, the aim of this study is to systematically evaluate the effectiveness of pharmacological interventions for treating early-stage adhesive capsulitis of the shoulder.

Methods

Protocol and registration

We performed a systematic review and network meta-analysis. The protocol was prospectively registered on PROSPERO (CRD42022322343). We followed the guidelines outlined in the Cochrane Handbook for Systematic Reviews of Interventions and adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Statement for Network Meta-Analyses [19].

Information sources and search

We searched three databases: MEDLINE, EMBASE and Cochrane Central Register of Controlled Trials, from inception to the 24 February 2022. A systematic search strategy was developed in association with a senior librarian (Supplementary Appendix 1, available at *Rheumatology* online). No filters or limitations were applied in terms of publication date or language of the manuscript. Narrative and systematic reviews were excluded although they were identified and used as a source of potential studies through their reference lists.

Eligibility criteria

We included randomized controlled trials (RCTs), cohort, case–control and case series, evaluating the effectiveness of pharmacological interventions in early-stage frozen shoulder. We included studies in which participants were diagnosed with this condition based on clinical assessment. Studies focusing on other shoulder conditions, or frozen shoulder secondary to stablished shoulder pathology, were excluded. We defined early-stage as the initial pain-predominant inflammatory phase and only selected studies that focused on this group. Where this information was not reported, we used a median duration of symptoms of <6 months as a proxy measure. We included all pharmacological interventions, regardless of dose, route of administration or duration. We excluded invasive treatments for frozen shoulder, including surgery, joint capsule distension and forced manipulation under anaesthetic.

Study selection

We exported all identified studies to the EndNote 20 reference management software (Clarivate Analytics, Philadelphia, USA) for collating searches and removing duplicate entries. Subsequently, the Rayyan QCRI software (Qatar Computing Research Institute, Ar-Rayyan, Qatar) was employed for a two-stage screening process to assess the eligibility. This involved title and abstract screening, followed by full-text screening, which were conducted by two authors (J. E.B. and G.P.). Any discrepancies were resolved by a third senior author (J.N.).

Data collection

We developed a data gathering pro-forma including patient demographics, comorbidities, stage of the disease and/or duration of symptoms, characteristics of treatments provided and outcomes. Data were collected by two independent reviewers (S.A. and M.N.), and extracted to a Microsoft Excel spreadsheet, which was subsequently reviewed by a third reviewer (J.E.B.) for any discrepancies.

Outcomes and definitions

The primary outcome of this study was shoulder pain at 6 weeks, 12 weeks and 6 months post-treatment. Where multiple pain measurement methods were employed within the same study, we prioritized the inclusion of data obtained using the visual analogue scale. The secondary outcomes assessed in this study were shoulder function and shoulder range of movement.

We used 'physical therapy' as an umbrella term for any supervised or unsupervised physiotherapy intervention. Where any of these treatments were administered alongside a pharmacological therapy, we categorized them within the 'pharmacological therapy' group rather than the physical therapy group. We employed the term 'placebo' to refer to any group that underwent no treatment, or received placebo tablet or injection only.

Data analysis

A formal risk of bias assessment was performed by two authors (S.A. and M.N.) using the Cochrane Risk of Bias Tool for Randomised Controlled Trials (RoB2) and the National Institute of Health Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies.

We synthesized evidence qualitatively and quantitively. Only RCTs that reported results by providing exact mean and S.D. values were included in the quantitative synthesis using standardized mean differences. Studies that only reported mean change from baseline were not included in the meta-analysis and were included in qualitative synthesis instead. Additionally, studies that reported median and interquartile ranges were also included in the qualitative synthesis as there was insufficient evidence to suggest adherence to a normal distribution. Studies that combined two or more pharmacological therapies within the same arm were only included in the qualitative synthesis.

We conducted pairwise meta-analyses using the netmeta package in R software (Version 4.30, The R Foundation for Statistical Computing, Vienna, Austria) using standardized mean difference. We assessed heterogeneity using the I^2 statistic and Cochran's Q test. We defined 0% to indicate no heterogeneity, 25% as low heterogeneity, 50% as moderate heterogeneity and 75% as high heterogeneity for the I^2 values. The netmeta package in R and the nvmenta package in Stata (Version 18.0, StataCorp) were used for network meta-analyses. The most frequent approach with random effects model was used to estimate treatment effects, and adjusted standard errors were employed for studies with multiple treatment arms. To further evaluate the ranking of the different pharmacological interventions, a netrank analysis was conducted using the P-score approach. The P-score represents the probability of each treatment being ranked as the best, with higher scores indicating a higher likelihood of superiority.

Results

A total of 3252 articles were retrieved from our systematic search strategy; 1750 were obtained from EMBASE, 1023 from MEDLINE and 479 from Cochrane Central. Deduplication resulted in a 2179 publications, of which 31 met the pre-specified inclusion criteria (Fig. 1). The definitive list of included manuscripts comprised articles published between 1986 and 2021. Out of these, 22 were RCTs, while the remainder were non-randomized studies. All the included articles were published in English (Table 1).

IA CS injection *vs* physical therapy and/or placebo

Van der Windt *et al.* [20] ($n = 109$ participants) found improved outcomes with CS injections compared with physical therapy at 7 weeks, although the differences diminished after 13 weeks. Ryans *et al.* [21] ($n = 78$ participants) reported better functional and pain outcomes for CS injections compared with no injections at 6 weeks, with sustained improvements observed at 16 weeks. Bal *et al.* [22] ($n = 80$ participants) showed significant improvements in passive abduction and function scores favouring the CS injection group at 2 weeks, but no significant differences at 16 weeks. Yoon *et al.* [23] ($n = 53$ participants) reported that IA CS injections were comparable to placebo. Kothari *et al.* [24] ($n = 180$ participants) found that CS treatment resulted in significant improvements compared with US therapy in range of motion, pain and disability at 12 weeks. Anjum *et al.* [25] ($n = 52$ participants) reported significant improvements in range of motion and shoulder disability scores with CS injections compared with physical therapy at 6 weeks and 3 months. Khan *et al.* [26] ($n = 80$ participants) found CS treatment to be superior to physical therapy alone in function at 6 weeks, but no differences were observed after stratifying by disease duration. Oh *et al.* [27] ($n = 60$ participants) showed that CS with hyaluronate injections led to significantly greater improvements in function, pain and range of motion compared with saline or hyaluronate alone.

IA platelet-rich plasma injection *vs* physical therapy and/or placebo

Kothari *et al.* [24] ($n = 180$ participants) reported that treatment with platelet-rich plasma (PRP) resulted in improvement in active and passive range of motion, pain and function compared with US therapy at both 6 and 12 weeks. Thu *et al.* [28] ($n = 61$ participants) found that both PRP and physical therapy groups demonstrated improvement in pain, functional scores and range of movement, although there were no significant differences between the two groups. Karabaş *et al.* [29] ($n = 40$ participants) found significant differences in pain, function and range of movement scores at all time points after treatment compared with baseline in both the PRP and physical therapy groups. Ünlü *et al.* [30] ($n = 32$ participants) reported that both PRP and the group who had saline IA injections showed improvement in function and range of movement, which were better in the PRP group.

CS *vs* platelet-rich plasma IA injection

Kothari *et al.* [24] ($n = 180$ participants) in their RCT, found that at 12 weeks PRP treatment led to improvements in active and passive range of motion, pain and function compared with CS therapy. Barman *et al.* [31] ($n = 55$ participants) in their prospective cohort study reported that a single dose of PRP injection was more effective than CS injection for improving pain, function and shoulder range of movement at 12 weeks. Shahzad *et al.* [32] ($n = 202$ participants) in their RCT found that IA PRP injection resulted in greater improvements in range of shoulder motion compared with IA CS injection.

IA CS injection *vs* oral NSAID therapy

Arslan and Çeliker [33] ($n = 20$ participants) found that both the CS injection and oral NSAID groups demonstrated significant improvement at 12 weeks compared with baseline. However, no significant difference was observed between the two groups. Ranalletta *et al.* [34] ($n = 69$ participants), reported that patients treated with CS injections experienced more rapid pain relief during the first 8 weeks compared with those receiving oral NSAIDs. However, no significant difference in pain was noted at 12 weeks. Both groups showed improvements in shoulder function and motion throughout the study, with no significant differences throughout the study between these groups.

Oral CS *vs* physical therapy

In an RCT by Binder *et al.* [35] ($n = 40$ participants), the oral CS group experienced a more rapid improvement in night pain. However, there were no significant differences between

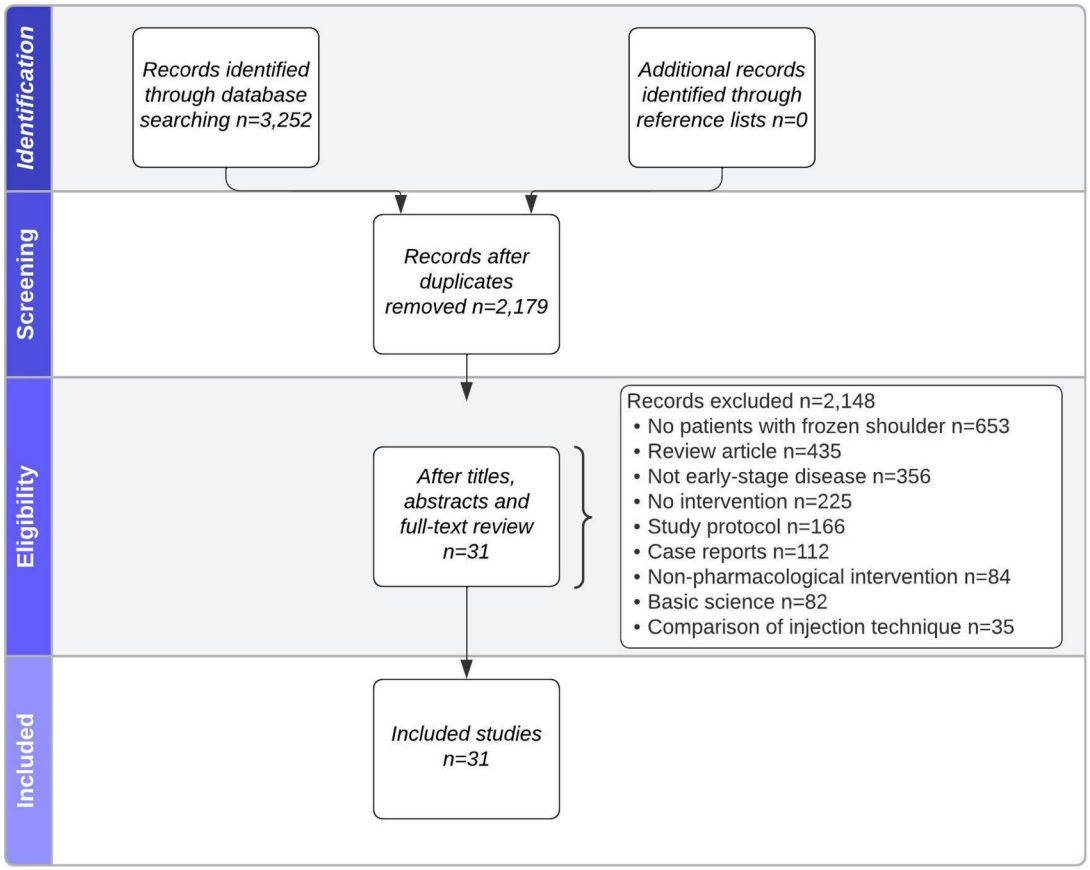

Figure 1. Modified Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) flowchart: illustrating the study selection process and inclusion criteria for the systematic review

the groups in terms of pain on movement, pain at rest and recovery in the range of movement. At 6 months, both groups still exhibited a marked restriction in range compared with controls who underwent a home exercise program [36].

High- *vs* low-dose IA CS injection

Limited evidence from studies comparing high- and low-dose IA CS injection therapy for the treatment of adhesive capsulitis of the shoulder suggests that there is likely no significant difference [23, 36]. In the study by Lee *et al.* [37] ($n = 29$ participants), both groups showed improvements in pain, function and shoulder range of motion compared with baseline, with the 40 mg triamcinolone injection resulting in better functional outcomes compared with 20 mg triamcinolone.

Subscapular nerve block *vs* IA CS injection

The RCT by Verma *et al.* [38] ($n = 70$ participants) found that both groups showed significant improvement in pain, function and passive shoulder range of movement at various follow-up time points compared with baseline. However, no significant differences were observed between the two groups. In the study by Jain *et al.* [39] ($n = 100$ participants), both treatment groups demonstrated significant improvement in pain, range of movement and function at 12 weeks, although the CS-only group had greater benefit in terms of pain and range of motion.

Hyaluronate IA injection *vs* physical therapy and hyaluronate and tramadol

In the RCT by Hsieh *et al.* [40] ($n = 63$ participants), both the hyaluronate therapy group and the physical therapy group showed improvements in pain, disability and quality of life. However, no significant differences were found between the two groups at 12 weeks. Kim *et al.* [41] ($n = 30$ participants) found that both the hyaluronate therapy group and the hyaluronate with tramadol group demonstrated an improvement in pain, passive range of shoulder movement and function scores.

S.c. adalimumab injection *vs* IA CS injection

In the RCT by Schydlowsky *et al.* [42] ($n = 30$ participants), the authors compared the effects of systemic s.c. adalimumab injections with IA CS injections. The study found no improvement in frozen shoulder symptoms in patients treated with s.c. adalimumab injection, while there was a significant benefit in the group that received 40 mg IA methylprednisolone injection for range of movement and functional outcomes.

S.c. injection therapy *vs* oral NSAID with muscle relaxant therapy

In a prospective cohort study by Abu-Zaid *et al.* [43] ($n = 100$ participants), patients undergoing s.c. dextrose injections for adhesive capsulitis of the shoulder experienced faster pain relief and greater functional improvement compared with patients receiving oral NSAIDs and muscle

Table 1. List of articles eligible for inclusion in systematic review

Study	Design	Number of participants total	Mean age (years)	Symptom duration (months)	Study arms, number	Outcomes (assessment method)	Timing of measurement (weeks)	Risk of bias (ROB2 or NIH)	Included in network meta-analysis
CS injection *vs* physical therapy or placebo									
Van der Windt *et al.* (1998)	RCT	109	58.8	Early stage	• IA injections of 40 mg triamcinolone acetonide (maximum 3 injections in 6 weeks), $N = 53$ • Physiotherapy for 6 weeks, $N = 56$	• Pain (VAS) • Function (Shoulder disability questionnaire) • ROM (ER, AB) • Adverse reactions (frequency)	3, 7, 13, 26, 52	High	No
Ryans *et al.* (2005)	RCT	78	54.1	Early stage	• Injection of triamcinolone 20 mg (1 ml) and normal saline 2 ml and physiotherapy treatment (injection and physiotherapy group), $N = 20$ • Injection of triamcinolone 20 mg (1 ml) and normal saline 2 ml and no physiotherapy treatment (injection only group), $N = 19$ • Injection with normal saline 3 ml and physiotherapy (physiotherapy group), $N = 20$ • Injection of normal saline 3 ml and no physiotherapy (placebo group), $N = 19$	• Pain (VAS) • AROM and PROM (FL, AB, ER, IR) • Function (VAS and SDQ score) • SF-36 general health assessment • HADS	0, 6, 16, 24	High	No
Bal *et al.* (2008)	RCT	80	56.7	Early stage	• Single IA 40 mg methylprednisolone injection and 12-week home exercise program, $N = 40$ (24) • Single IA saline injection and 12-week home exercise program, $N = 40$ (24)	• Function (SPADI and UCLA) • Night pain (VAS) • PROM (FL, AB, ER, IR)	0, 2, 12	High	No
Yoon *et al.* (2013)	RCT	53	53.8	5.1	• Single IA injection of 40 mg triamcinolone and 1 ml of 1% lidocaine, plus home exercise program, $N = 20$ • Single IA injection of 20 mg triamcinolone and 1 ml of 1% lidocaine, plus home exercise program, $N = 20$ • Single IA injection of 5 ml 1% lidocaine injection and home exercise program, $N = 13$	• Pain (VAS) • PROM (FL, AB, EX, ER, IR) • Function (SPADI)	0, 1, 3, 6, 12	Low	Yes
Kothari *et al.* (2017)	RCT	180	51.9	4.7	• Single IA PRP injection and exercise program, $N = 62$ • Single IA methylprednisolone 80 mg and exercise program, $N = 60$ • Ultrasonic therapy on alternate days for 14 days and exercises program, $N = 58$	• Pain (VAS) • AROM and PROM (FL, AB, IR, ER) • Function (QuickDASH)	0, 3, 6, 12	High	Yes
Anjum *et al.* (2019)	RCT	52	42.8	Early stage	• Single IA 80 mg methylprednisolone and 0.5% bupivacaine injection and physiotherapy, $N = 26$ • Physiotherapy only, $N = 26$	• Pain (VAS) • ROM (FL, IR, ER, AB) • Function (SPADI)	0, 2, 6, 13	High	Yes

(continued)

Table 1. (continued)

Study	Design	Number of participants total	Mean age (years)	Symptom duration (months)	Study arms, number	Outcomes (assessment method)	Timing of measurement (weeks)	Risk of bias (ROB2 or NIH)	Included in network meta-analysis
Khan *et al.* (2021)	RCT	80	45.2	3.3	• Single IA methylprednisolone and 20 mg lidocaine injection and physiotherapy regime, $N = 40$ • Physiotherapy regime, $N = 40$	• Function (SPADI)	0, 6	High	No
Oh *et al.* (2021)	RCT	60	52.4	8	• Single IA 2 ml hyaluronate, 2 ml saline and 4 ml contrast media injection, $N = 15$ • Single IA 40 mg triamcinolone, 3 ml saline and 4 ml contrast media injection, $N = 15$ • Single IA 40 mg triamcinolone, 2 ml hyaluronate, 1 ml saline and 4 ml contrast media injection, $N = 15$ • Single IA injection of saline, $N = 15$	• AROM (FL, AB, ER, IR) • Pain (VAS) • Function (SPADI, ASES, Constant, UCLA, DASH, Simple Shoulder Test)	0, 1, 4, 13, 26	Low	No
PRP injection *vs* physical therapy or placebo									
Kothari *et al.* (2017)	RCT	180	51.9	4.7	• Single IA PRP injection and exercise program, $N = 62$ • Single IA methylprednisolone 80 mg and exercise program, $N = 60$ • Ultrasonic therapy on alternate days for 14 days and exercise program, $N = 58$	• Pain (VAS) • AROM and PROM (FL, AB, IR, ER) • Function (QuickDASH)	0, 3, 6, 12	High	Yes
Thu *et al.* (2020)	RCT	61	55	Early stage	• Single IA PRP injection, $N = 31$ • Conventional physical therapy, $N = 30$	• Pain (VAS) • PROM (FL, AB, ER) • Function (DASH)	0, 1, 3, 6	High	No
Karabaş *et al.* (2021)	RCT	40	57.1	4.5	• Two IA PRP injections separated by 2 weeks, $N = 20$ • Home exercise program, $N = 20$	• Pain (VAS) • AROM and PROM (FL, EX, AB, IR, ER) • Function (SPADI)	0, 2, 6, 12	Some concern	ROM only
Ünlü *et al.* (2021)	RCT	32	57	5	• Three IA 2 ml PRP injections separated by 2 weeks each, plus exercise program, $N = 17$ • Three IA saline injections separated by 2 weeks each, plus exercise program, $N = 15$	• Pain (VAS, SPADI) • AROM and PROM (FL, AB, IR, ER) • Function (VAS, SPADI) • Need for analgesics	0, 4, 13	Some concerns	Yes
PRP injection *vs* CS injection									
Kothari *et al.* (2017)	RCT	180	51.9	4.7	• Single IA PRP injection and exercise program, $N = 62$ • Single IA methylprednisolone 80 mg and exercise program, $N = 60$ • Ultrasonic therapy on alternate days for 14 days and exercises program, $N = 58$	• Pain (VAS) • AROM and PROM (FL, AB, IR, ER) • Function (QuickDASH)	0, 3, 6, 12	High	Yes
Barman *et al.* (2019)	Prospective cohort study	55	50.1	4.1	• Single IA 4 ml PRP injection 4 ml, $N = 28$ • Single IA 40 mg methylprednisolone 40 mg lidocaine injection, $N = 27$	• Pain (VAS, SPADI) • AROM and PROM (FL, EX, AB, IR, ER) • Function (SPADI) • Satisfaction (%)	0, 3, 6, 12	Fair	No

(continued)

Table 1. (continued)

Study	Design	Number of participants total	Mean age (years)	Symptom duration (months)	Study arms, number	Outcomes (assessment method)	Timing of measurement (weeks)	Risk of bias (ROB2 or NIH)	Included in network meta-analysis
Shahzad *et al.* (2021)	RCT	202	52.7	5.2	• Single IA PRP injection, $N = 102$ • Single IA 80 mg methylprednisolone injection, $N = 100$	• Pain (VAS) • ROM (FL, AB, ER, IR) • Function (UCLA)	0, 12	High	Yes
CS injection *vs* oral NSAID									
Arslan and Çeliker (2001)	RCT	20	56	4.1	• Single IA 40 mg methylprednisolone acetate and 20 mg lidocaine injection, $N = 10$ • Oral daily 120 mg acemetacin and physiotherapy regime, $N = 10$	• Pain (VAS) • AROM and PROM (FL, AB, IR, ER)	0, 2, 12	High	Pain only
Ranalletta *et al.* (2015)	RCT	69	63.4	2.8	• Single IA CS injection, $N = 35$ • Oral 75 mg diclofenac twice daily, $N = 34$	• Pain (VAS) • Function (ASES, QuickDASH, abbreviated CM) • PROM (FL, EX, AB, ER, IR)	0, 2, 4, 8, 12	Some concerns	Pain and function only
Oral CS *vs* physical therapy									
Binder *et al.* (1986)	RCT	40	54.8	5.5	• Oral 10 mg prednisolone for 4 weeks, then tapered 5 mg a day for 2 weeks, $N = 20$ • Home exercise program, $N = 20$	• Pain (VAS) • ROM (FL, AB, ER, TR)	0, 2, 4, 6, 13, 17, 22, 26, 30, 35	High	No
Takase (2010)	Case series	76	55.5	5.7	• Oral 5 mg prednisolone twice a day for 5 days, then once a day for the next 6 days and finally once a day every other day for the next 10 days and home exercise program, $N = 71$ • Home exercise program, $N = 5$	• Pain (VAS) • ROM (FL, ER, IR) • Function (JOA score) • Ga scintigraphy accumulation	0, 9	Poor	No
High-dose *vs* low-dose CS injection									
Yoon *et al.* (2013)	RCT	53	53.8	5.1	• Single IA 40 mg triamcinolone injection, $N = 20$ • Single IA 20 mg triamcinolone injection, $N = 20$ • Single IA 50 mg lidocaine injection, $N = 13$	• Pain (VAS) • PROM (FL, AB, EX, ER, IR) • Function (SPADI)	0, 1, 3, 6, 12	Low	No
Kim *et al.* (2018)	RCT	32	58.2	2.9	• Single IA 40 mg triamcinolone injection, $N = 16$ • Single IA 20 mg triamcinolone injection, $N = 16$	• Pain (NRS) • PROM (FL, AB, ER, IR) • Function (SPADI)	0, 3	High	No
Lee *et al.* (2021)	RCT	29	71.4	4.7	• Single IA 20 mg triamcinolone and 40 mg lidocaine injection, $N = 10$ • Single IA 40 mg triamcinolone and 40 mg lidocaine injection, $N = 9$ • Single IA 20 mg triamcinolone and 1 ml hyaluronidase and 40 mg lidocaine injection, $N = 10$	• Pain (VAS) • PROM (AB, ER) • Function (SDQ) • Imaging changes (intra-sheath fluid)	0, 2, 4, 8, 16	Some concern	No

(continued)

Table 1. (continued)

Study	Design	Number of participants total	Mean age (years)	Symptom duration (months)	Study arms, number	Outcomes (assessment method)	Timing of measurement (weeks)	Risk of bias (ROB2 or NIH)	Included in network meta-analysis
Subscapular nerve block *vs* IA CS injection									
Verma *et al.* (2019)	RCT	70	53	3	• Single 20 mg bupivacaine suprascapular nerve block, $N = 35$ • Single IA 80 mg triamcinolone injection, $N = 35$	• Pain (VAS) • PROM (FL, AB) • Function (SPADI)	0, 1, 3, 6	Low	No
Jain *et al.* (2021)	RCT	100	50.3	4.3	• Single IA 80 mg of methylprednisolone injection, $N = 50$ • Suprascapular nerve block with single 40 mg triamcinolone and 0.5% bupivacaine injection, $N = 50$	• Pain (NPRS) • AROM and PROM (FL, EX, AB, ER, IR) • Function (SPADI)	0, 1, 4, 12	Some concern	No
Hyaluronate injection *vs* physical therapy									
Hsieh *et al.* (2012)	RCT	63	54.5	4.5	• Three weekly IA 20 mg hyaluronate injections, $N = 32$ • Physiotherapy regime, $N = 31$	• Pain (SPADI) • AROM and PROM (FL, AB, IR, ER) • Function (SPADI, SDQ) • Quality of life (SF-36)	0, 7, 13	High	Pain and function only
Hyaluronate and tramadol injection *vs* hyaluronate injection									
Kim *et al.* (2017)	RCT	30	55.2	3.9	• Three IA 100 mg hyaluronate and 50 mg tramadol injections, followed by two further 100 mg hyaluronate injections, $N = 14$ • 5 weekly IA injections of 25 mg hyaluronate, $N = 16$	• Pain (VAS) • PROM (FL, AB, ER, IR) • Function (SPADI)	0, 1, 2, 3, 4, 6	Unclear	No
S.c. adalinumab injection *vs* IA CS injection									
Schydlowsky *et al.* (2012)	RCT	30	51	Early stage	• Single s.c. (systemic) adalimumab injection, $N = 15$ • Single IA 40 mg lidocaine and 40 mg methylprednisolone injection, $N = 15$	• AROM and PROM (FL, AB, ER) • Function (SPADI, Constant, SRQ) • Side effects	0, 2, 4, 8, 12, 24	High	No
Perineural injection therapy *vs* oral NSAID and muscle relaxants									
Abu-Zaid *et al.* (2020)	Prospective cohort study	100	NR	Early stage	• 6-weekly s.c. injections of 0.5-1 ml of dextrose 5% in chronic constriction injury and tender points and exercise regime, $N = 50$ • Oral NSAIDs and muscle relaxants for 6 weeks and exercise regime, $N = 50$	• Pain (VAS) • ROM • Function (SPADI, WORC Index)	0, 6, 13, 26	Poor	No
Single-arm studies									
Shah (2012)	Prospective cohort study	27	51.4	Early stage	• Single IA methylprednisolone 80 mg injection and supervised exercise regime, $N = 27$	• Pain (VAS) • AROM (AB, ER)	0, 6, 12	Poor	No
Song *et al.* (2014)	Prospective and retrospective cohort study	47	57.9	5.1	• Single IA 40 mg triamcinolone and 1% or 2% lidocaine injection and physiotherapy, $N = 47$	• Pain (VAS) • ROM (FL, AB, ER) • Function (SSV)	0, <13, >13	Poor	No

(continued)

Table 1. (continued)

Study	Design	Number of participants total	Mean age (years)	Symptom duration (months)	Study arms, number	Outcomes (assessment method)	Timing of measurement (weeks)	Risk of bias (ROB2 or NIH)	Included in network meta-analysis
Canbulat *et al.* (2015)	Case series	33	52	Early stage	• Oral 0.5 mg/kg/day methylprednisolone, dose was halved each week and ceased within month and 75 mg pregabalin bd for 6 weeks, $N = 33$	• Pain (VAS) • AROM and PROM (FL, AB, ER, IR) • Function (Constant, DASH ASES)	0, 1, 2, 3, 4, 12, 26, 52	Poor	No
Lamplot *et al.* (2018)	Prospective cohort study	60	52.6	5.3	• Single IA of 40 mg lidocaine, 20 mg bupivacaine, and 80 mg of methylprednisolone and 4 weeks supervised physiotherapy, $N = 60$	• AROM and PROM (FL, AB, ER, IR) • Function (ASES, SAS)	Varied	Poor	No
Çalış *et al.* (2019)	Case series	9	54.1	5.1	• Two IA PRP injections separated by 2 weeks and supervised physiotherapy, $N = 9$	• Pain (VAS) • AROM and PROM (NR) • Function (SPADI)	0, 2, 6, 12	Poor	No
Atici *et al.* (2021)	Retrospective cohort study	18	55	2	• Oral prednisolone (1 mg/kg/day) for 3 days and then tapered down in 10 mg every 3 days and home exercise program, $N = 18$	• Pain (VAS) • AROM and PROM (FL, AB, IR, ER) • Function (DASH, CM, ASES)	0, 4, 26	Fair	No

AB: abduction; AROM: Active Range of Movement; ASES: American Shoulder and Elbow Surgeons; CM: Constant–Murley; DASH: Disabilities of the Arm; Shoulder and Hand; ER: external rotation; FL: flexion; HADS: Hospital Anxiety and Depression Scale; IR: internal rotation; JOA: Japanese Orthopaedic Association; *N*: number; NIH: National Institutes of Health; NR: not reported; NPRS: Numerical Pain Rating Scale; PRP: platelet-rich plasma; PROM: Passive Range of Movement; RCT: randomized controlled trial; ROM: range of movement; SF-36: 36-Item Short-Form Health Survey; SSV: Subjective Shoulder Value; SPADI: Shoulder Pain and Disability Index; SRQ: Shoulder rating questionnaire; SDQ: Shoulder Disability Questionnaire; TR: total rotation; UCLA: University of California-Los Angeles end-result score; VAS: visual analogue scale; WORC: Western Ontario Rotator Cuff.

relaxants. Both treatment groups showed improvement after 3 and 6 months, although the perineural injection therapy group exhibited superior pain relief and functional improvement.

Single-arm studies

Shah *et al.* [44] administered IA methylprednisolone injections, resulting in decreased pain and improved abduction and external rotation. Song *et al.* [45] reported that US-guided CS injections resulted in significant pain relief and improvement in range of motion. Canbulat *et al.* [46] reported that combined glucocorticoid therapy, pregabalin and home exercise resulted in significant improvements in function scores and range of motion. Lamplot *et al.* [47] treated patients with IA injections and supervised physical therapy, resulting in improved function scores. Talay Çalış *et al.* [48] used PRP therapy, showing significant improvements in pain, function and range of motion. Atici *et al.* [49] evaluated high-dose prednisolone, which led to rapid recovery of shoulder motion and improved function scores.

Network meta-analysis

Shoulder pain

Due to variability in timelines for assessing outcomes, we only included data from RCTs at 12 weeks post-treatment as this was the most common assessment point. We included 9 RCTs with a total of 11 pairwise comparisons involving 5 treatments: physical therapy, IA CS injection, IA PPR, oral NSAIDs and IA hyaluronate (Figs 2 and 3).

Compared with the reference treatment of physical therapy, IA CS [8 RCTs, 340 participants; standardized mean difference (SMD) = –0.732 95% CI (–1.166; –0.3), $P = 0.0009$] and IA PRP [3 RCTs, 177 participants; SMD = –1.577, 95% CI (–2.06; –1.093), $P < 0.0001$] showed a reduction in shoulder pain at 12 weeks. Conversely, there was no difference between IA hyaluronate [2 RCTs, 48 participants; SMD = 0.291, 95% CI (–0.479; 1.06), $P = 0.459$], oral NSAIDs [2 RCTs, 44 participants; SMD = –0.566, 95% CI (–1.319; 0.186), $P = 0.14$] and physical therapy (Fig. 4).

There was a moderate level of heterogeneity among the included studies; tau-squared value of 0.09 (tau = 0.3) and an I^2 value of 57.5%. The tests of heterogeneity within designs and inconsistency between designs were statistically significant ($P < 0.05$).

According to the netrank analysis, IA PRP obtained the highest P-score of 0.9989, indicating the highest probability of being the most effective treatment for pain reduction at 12 weeks. Following IA PRP, IA CS exhibited a P-score of 0.673, suggesting a substantial likelihood of being ranked second. Oral NSAIDs ranked third (P-score 0.543), physical therapy fourth (P-score 0.21) and IA hyaluronate last (P-score 0.075).

Shoulder function

Network meta-analysis included 8 RCTs, resulting in a total of 10 pairwise comparisons involving 5 treatments: physical therapy, IA CS, IA PRP, oral NSAIDs and IA hyaluronate. The analysis revealed a significant difference in treatment effects between IA CS and physical therapy [7 RCTs, 330 participants; SMD = –0.994, 95% CI (–1.432; –0.558), $P < 0.0001$] and IA PRP and physical therapy [3 RCTs, 177 participants; SMD = –1.696, 95% CI (–2.184; –1.208), $P < 0.0001$]. However, there was no difference between IA hyaluronate [2 RCTs, 48 participants; SMD = 0.205, 95% CI (–0.559; 0.969), $P = 0.599$] and oral NSAIDs [1 RCTs, 34 participants; SMD = –0.782, 95% CI (–1.65; 0.086), $P = 0.078$]. IA PRP had the highest P-score (0.995), followed by IA CS (0.677), oral NSAIDs (0.556), physical therapy (0.185) and IA hyaluronate (0.088).

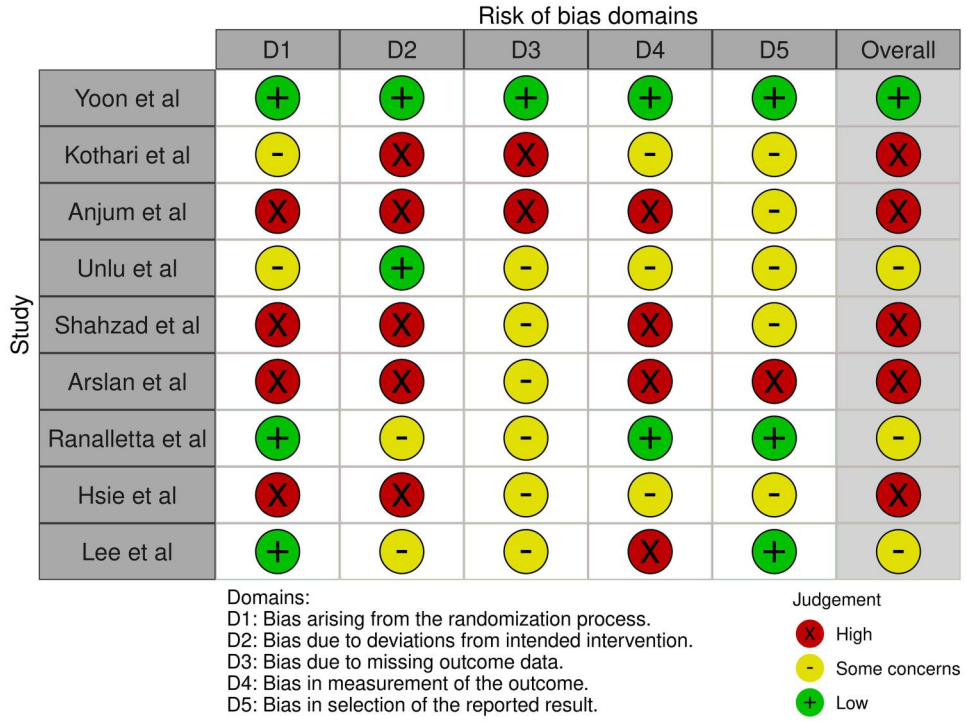

Figure 2. Risk of bias assessment for randomized controlled trials included in network meta-analysis

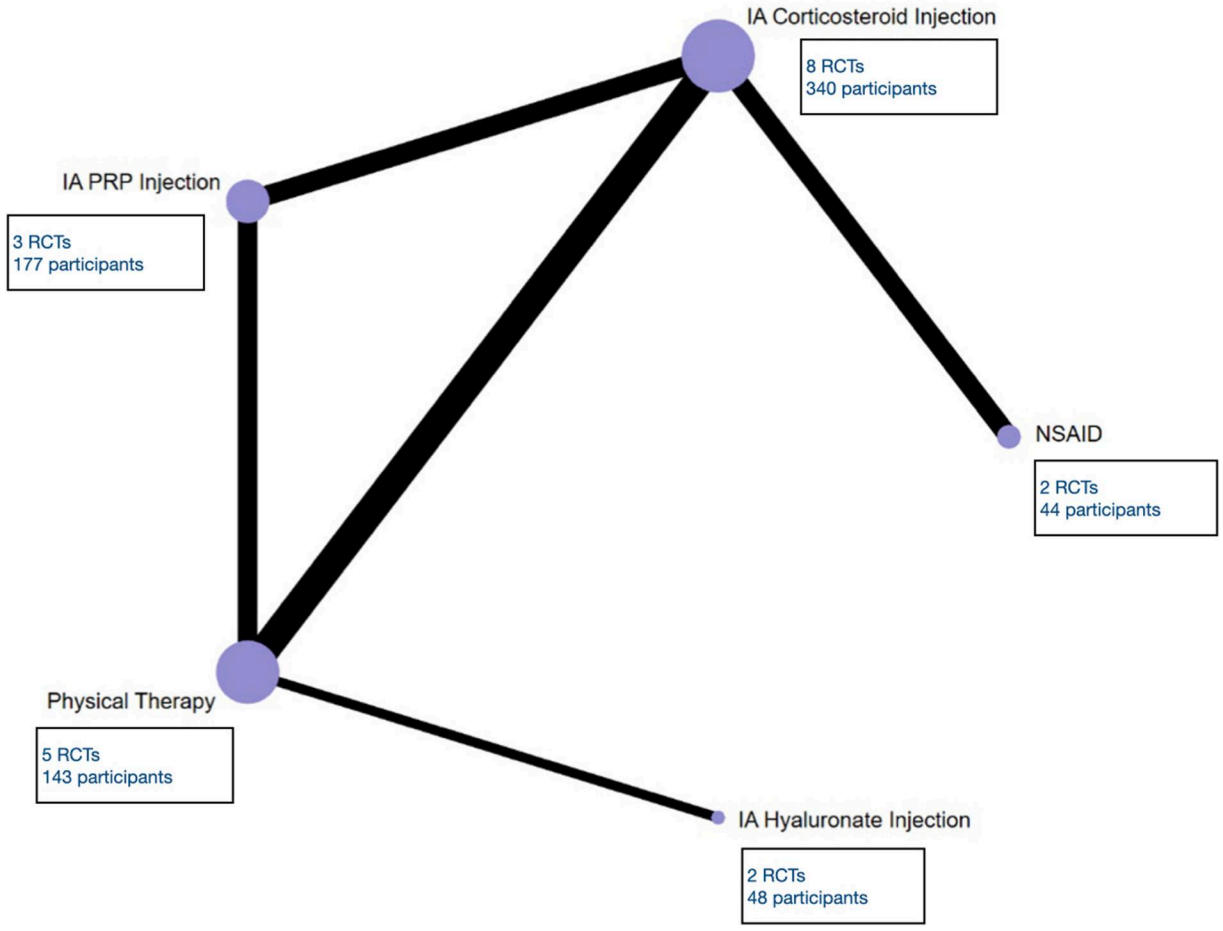

Figure 3. Network graph illustrating the comparative effectiveness of pharmacological interventions for the treatment of frozen shoulder in reducing pain at 12 weeks

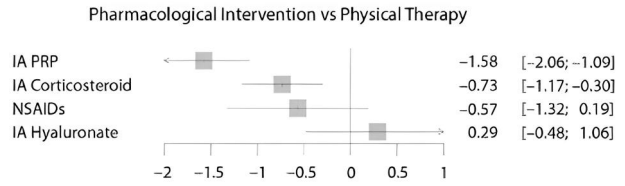

Figure 4. Forest plot presenting the treatment effects of different pharmacological interventions for pain reduction at 12 weeks in patients with frozen shoulder. The horizontal lines represent the 95% CI for the treatment effects, with the centre point indicating the estimated effect size [standardized mean difference (SMD)] for each intervention

Range of shoulder movement—external rotation

Network meta-analysis included six RCTs, resulting in a total of eight pairwise comparisons involving three treatments: physical therapy, IA CS and IA PRP injections. The analysis revealed that IA PRP showed a significant difference in treatment effects compared with physical therapy [3 RCTs, 177 participants; SMD = 1.516, 95% CI (0.557; 2.475), $P = 0.002$], while there was no difference between IA CS compared with physical therapy [8 RCTs, 340 participants; SMD = 0.445, 95% CI (–0.509; 1.398), $P = 0.361$]. In terms of treatment rankings based on the P-score, IA PRP had the highest P-score (0.989), followed by IA CS (0.421) and physical therapy (0.091).

Discussion

Frozen shoulder is a debilitating condition, significantly impacting physical health and quality of life. Treating during the initial pain-predominant phase could potentially prevent progression, relieve pain and restore function, as well as avoid the necessity for invasive therapies for late-stage disease.

Whilst previous systematic reviews have reviewed and summarized the evidence regarding therapeutic modalities for treating frozen shoulder [18], to our knowledge this review is the first to focus on early-stage disease. We achieved this by excluding studies that recruited patients in later stages or those requiring surgical interventions.

Despite considerable study heterogeneity, we were able to build a network meta-analysis of eligible RCTs, but only at 12 weeks post-treatment. Both IA CS and PRP showed a beneficial effect regarding pain compared with physical therapy as a baseline treatment, with oral NSAIDs and IA hyaluronate not proving significant benefit. There was a similar effect for functional shoulder scores. IA PRP but not IA CS showed an improvement in range of shoulder motion compared with physical therapy.

The majority of the eligible studies presented considerable risk of bias (Table 1 and Fig. 2). This was also confirmed by our network meta-analysis which demonstrated within-study heterogeneity and between-study inconsistency. Furthermore, the variability in control groups, encompassing both placebo-

controlled trials and open-label comparison studies like physical therapy, introduces heterogeneity in treatment modalities. While this approach mirrors real-world clinical scenarios, it may pose challenges in directly comparing the efficacy of different interventions. Therefore, the results should be interpreted with caution and based on the available data, we are not able to recommend any of the treatments. Whilst we were able to explore the role of oral NSAIDs and IA hyaluronate, we were not able to do the same for relatively novel interventions, such as adalimumab, due to the limited number of studies available.

We have attempted to provide a comprehensive summary of the evidence on the treatment of early-stage frozen shoulder with a search strategy not limited by date or language of publication. Whilst the external validity of our findings is limited by the quality of the available evidence, it highlights the merits of studying treatments for early-stage disease. It was not our intention to explore what is the best approach for treating stablished adhesive capsulitis of the shoulder in its later stages. Previous systematic reviews have addressed this by including all patients with adhesive capsulitis, including those with long-term disability.

Our study primarily focused on pain improvement at the 12 weeks post-treatment mark due to the availability of data, and we acknowledge the limitation of not having evidence for sustained benefits beyond this timeframe. It is also essential to approach our negative conclusions regarding hyaluronate and NSAIDs with caution due to the relatively small sample sizes compared with steroids and PRP. Furthermore, the observation that our network was not closed indicates important gaps in the available evidence, emphasizing the necessity for additional research to address these gaps comprehensively. Further well-designed studies comparing the use of IA CS and IA PRP against a defined physical therapy regime or placebo would be required to provide definitive evidence for the effectiveness for either of these interventions. Ideally the trials should incorporate larger sample sizes, with standardized outcome measures and assessment times beyond 12 weeks post-treatment, ideally 1 year.

At the time of writing, there were 129 projects registered in ClinicalTrials.gov for frozen shoulder. Of these, we found 25 that would be potentially eligible for inclusion in the study here presented, once completed. According to their registered protocols, these studies are investigating interventions included in our review, such as systemic and IA CS, IA PRP, hyaluronate, hyaluronidase, NSAIDs, suprascapular nerve block or adalimumab. However, they are also looking into treatments we were not able to capture such as IA ozone, IA collagenase, connective tissue allografts and gabapentin.

By shifting attention towards the quality of the evidence for interventions for early-stage disease we hope to address the burden of the symptoms that patients with frozen shoulder live with, and the associated impact on quality of life [3–5]. Identification of effective treatments during the early pain-predominant phase would alleviate symptoms and potentially avoid the need for surgical interventions for late-stage disease.

Supplementary material

Supplementary material is available at *Rheumatology* online.

Data availability

The data underlying this article will be shared on reasonable request to the corresponding author.

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References

1. Robinson CM, Seah KTM, Chee YH, Hindle P, Murray IR. Frozen shoulder. J Bone Joint Surg Br 2012;94:1–9.
2. Walker-Bone K, Palmer KT, Reading I, Coggon D, Cooper C. Prevalence and impact of musculoskeletal disorders of the upper limb in the general population. Arthritis Care Res (Hoboken) 2004;51:642–51.
3. Cho C-H, Jung S-W, Park J-Y, Song K-S, Yu K-I. Is shoulder pain for three months or longer correlated with depression, anxiety, and sleep disturbance? J Shoulder Elbow Surg 2013; 22:222–8.
4. Ebrahimzadeh M, Moradi A, Bidgoli H, Zarei B. The relationship between depression or anxiety symptoms and objective and subjective symptoms of patients with frozen shoulder. Int J Prev Med 2019;10:38.
5. Lyne SA, Goldblatt FM, Shanahan EM. Living with a frozen shoulder—a phenomenological inquiry. BMC Musculoskelet Disord 2022;23:318.
6. Cho CH, Lee YH, Kim DH *et al.* Definition, diagnosis, treatment, and prognosis of frozen shoulder: a consensus survey of shoulder specialists. Clin Orthop Surg 2020;12:60–7.
7. Itoi E, Arce G, Bain GI *et al.* Shoulder stiffness: current concepts and concerns. Arthroscopy 2016;32:1402–14.
8. Maund E, Craig D, Suekarran S *et al.* Management of frozen shoulder: a systematic review and cost-effectiveness analysis. Health Technol Assess 2012;16:1–264.
9. Le HV, Lee SJ, Nazarian A, Rodriguez EK. Adhesive capsulitis of the shoulder: review of pathophysiology and current clinical treatments. Shoulder Elbow 2017;9:75–84.
10. Millar NL, Meakins A, Struyf F *et al.* Frozen shoulder. Nat Rev Dis Primers 2022;8:59.
11. Binder AI, Bulgen DY, Hazleman BL, Roberts S. Frozen shoulder: a long-term prospective study. Ann Rheum Dis 1984;43:361–4.
12. Redler LH, Dennis ER. Treatment of adhesive capsulitis of the shoulder. J Am Acad Orthop Surg 2019;27:e544–54.
13. Buchbinder R, Green S, Youd JM; Cochrane Musculoskeletal Group. Corticosteroid injections for shoulder pain. Cochrane Database Syst Rev 2003;2003:CD004016.
14. Buchbinder R, Green S, Youd JM, Johnston RV. Oral steroids for adhesive capsulitis. Cochrane Database Syst Rev 2006; 2006:CD006189.
15. Page MJ, Green S, Kramer S *et al.* Electrotherapy modalities for adhesive capsulitis (frozen shoulder). Cochrane Database Syst Rev 2014;2014:CD011324.
16. Page MJ, Green S, Kramer S *et al.*; Cochrane Musculoskeletal Group. Manual therapy and exercise for adhesive capsulitis (frozen shoulder). Cochrane Database Syst Rev 2014;2014:CD011275.

17. Rangan A, Brealey SD, Keding A *et al.*; UK FROST Study Group. 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.
18. Kitridis D, Tsikopoulos K, Bisbinas I, Papaioannidou P, Givissis P. Efficacy of pharmacological therapies for adhesive capsulitis of the shoulder: a systematic review and network meta-analysis. Am J Sports Med 2019;47:3552–60.
19. Moher D, Liberati A, Tetzlaff J, Altman DG, Group TP; PRISMA Group. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. PLoS Med 2009; 6:e1000097.
20. Van der Windt DAW, Koes BW, Deville W *et al.* Effectiveness of corticosteroid injections versus physiotherapy for treatment of painful stiff shoulder in primary care: randomised trial. Br Med J 1998;317:1292–6.
21. 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 2005; 44:529–35.
22. Bal A, Eksioglu E, Gulec B *et al.* Effectiveness of corticosteroid injection in adhesive capsulitis. Clin Rehabil 2008;22:503–12.
23. Yoon SH, Lee HY, Lee HJ, Kwack KS. Optimal dose of intra-articular corticosteroids for adhesive capsulitis: a randomized, triple-blind, placebo-controlled trial. Am J Sports Med 2013; 41:1133–9.
24. Kothari SY, Srikumar V, Singh N. Comparative efficacy of platelet rich plasma injection, corticosteroid injection and ultrasonic therapy in the treatment of periarthritis shoulder. J Clin Diagnost Res 2017;11:RC15–RC18.
25. Anjum R, Aggarwal J, Gautam R, Pathak S, Sharma A. Evaluating the outcome of two different regimes in adhesive capsulitis: a prospective clinical study. Med Princ Pract 2020;29:225–30.
26. Khan RDA, Shahzad K, Khan S, Israr M, Zahid FM. Comparison of physiotherapy with and without intra-articular corticosteroid injection for treatment of frozen shoulder: a comparative study. J Pak Med Assoc 2021;71:S17–20.
27. Oh SH, Sung WS, Oh SH, Jo CH. Comparative analysis of intra-articular injection of steroid and/or sodium hyaluronate in adhesive capsulitis: prospective, double-blind, randomized, placebo-controlled study. JSES Int 2021;5:1091–104.
28. Thu AC, Kwak SG, Shein WN *et al.* Comparison of ultrasound-guided platelet-rich plasma injection and conventional physical therapy for management of adhesive capsulitis: a randomized trial. J Int Med Res 2020;48:030006052097603.
29. Karabaş Ç, Çalış HT, Topaloğlu US, Karakükçü Ç. Effects of platelet-rich plasma injection on pain, range of motion, and disability in adhesive capsulitis: a prospective, randomized-controlled study. Turk J Phys Med Rehabil 2021;67:462–72.
30. Ünlü B, Çalış FA, Karapolat H *et al.* Efficacy of platelet-rich plasma injections in patients with adhesive capsulitis of the shoulder. Int Orthop 2021;45:181–90.
31. Barman A, Mukherjee S, Sahoo J *et al.* Single intra-articular platelet-rich plasma versus corticosteroid injections in the treatment of adhesive capsulitis of the shoulder: a cohort study. Am J Phys Med Rehabil 2019;98:549–57.
32. Shahzad HF, Taqi M, Gillani S, Masood F, Ali M. Comparison of functional outcome between intra-articular injection of corticosteroid versus platelet-rich plasma in frozen shoulder: a randomized controlled trial. Cureus 2021;13:e20560.
33. Arslan S, Çeliker R. Comparison of the efficacy of local corticosteroid injection and physical therapy for the treatment of adhesive capsulitis. Rheumatol Int 2001;21:20–3.
34. Ranalletta M, Rossi LA, Bongiovanni SL *et al.* Corticosteroid injections accelerate pain relief and recovery of function compared with oral NSAIDs in patients with adhesive capsulitis: a randomized controlled trial. Am J Sports Med 2016;44:474–81.
35. Binder A, Hazleman BL, Parr G, Roberts S. A controlled study of oral prednisolone in frozen shoulder. Rheumatology 1986; 25:288–92.
36. Kim KH, Park JW, Kim SJ. High-vs low-dose corticosteroid injection in the treatment of adhesive capsulitis with severe pain: a randomized controlled double-blind study. Pain Med (United States) 2018;19:735–41.
37. Lee JH, Choi EJ, Han SC *et al.* Therapeutic efficacy of low-dose steroid combined with hyaluronidase in ultrasonography-guided intra-articular injections into the shoulder for adhesive capsulitis. Ultrasonography 2021;40:555–64.
38. Verma DK, Neyaz O, Nanda S, Handa G. Comparison of outcome of ultrasound-guided suprascapular nerve block versus intra-articular steroid injection in adhesive capsulitis of shoulder: a randomized control trial. Indian J Rheumatol 2019;14:113–8.
39. Jain S, Borah D, Meena DS, Ali J. Ultrasound guided suprascapular nerve block versus intra-articular steroid injection in the treatment of periarthritis shoulder: a randomised clinical trial. J Clin Diagn Res 2021;15:1–5.
40. Hsieh LF, Hsu WC, Lin YJ *et al.* Addition of intra-articular hyaluronate injection to physical therapy program produces no extra benefits in patients with adhesive capsulitis of the shoulder: A randomized controlled trial. Arch Phys Med Rehabil 2012; 93:957–64.
41. Kim KH, Suh JW, Oh KY. The effect of intra-articular hyaluronate and tramadol injection on patients with adhesive capsulitis of the shoulder. J Back Musculoskelet Rehabil 2017;30:913–20.
42. Schydlowsky P, Szkudlarek M, Madsen OR. Treatment of frozen shoulder with subcutaneous TNF-alpha blockade compared with local glucocorticoid injection: a randomised pilot study. Clin Rheumatol 2012;31:1247–51.
43. Abu-Zaid MH, Tabra SAA, Elmorsy S. The Effect of Perineural Injection Therapy in Periarthritis Shoulder. Ann Rheum Dis 2020; 79:480–1.
44. Shah FA. Outcome of intra-articular injection of methylprednisolone in idiopathic frozen shoulder. Rawal Med J 2012;37:34–7.
45. Song A, Katz J, Higgins L *et al.* Outcomes of ultrasound-guided glen humeral corticosteroid injections in adhesive capsulitis. Br J Med Med Res 2015;5:570–8.
46. Canbulat N, Eren I, Atalar AC *et al.* Nonoperative treatment of frozen shoulder: oral glucocorticoids. Int Orthop 2015; 39:249–54.
47. Lamplot JD, Lillegraven O, Brophy RH. Outcomes from conservative treatment of shoulder idiopathic adhesive capsulitis and factors associated with developing contralateral disease. Orthop J Sports Med 2018;6:2325967118785169–8.
48. Talay Çalış H. Effects of platelet rich plasma injection on adhesive capsulitis: an interventional case series. Erciyes Medical Journal 2019;41:102–4.
49. Atici T, Ermutlu C, Akesen S, Özyalçin A. High-dose short-course oral corticosteroid protocol for treatment of primary frozen shoulder: a retrospective cohort study. J Int Med Res 2021;49: 030006052110248.

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