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Comparing non-surgical treatment strategies for adhesive capsulitis: A narrative review

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ABSTRACT

Adhesive capsulitis is a debilitating shoulder disorder characterized by persistent pain and progressive restriction of motion due to fibrotic changes within the joint capsule. Although intra-articular corticosteroid injections are commonly used, variable outcomes have prompted interest in targeted injection techniques, alternative injectates, and non-invasive therapies. This narrative review summarizes findings from 49 randomized controlled trials evaluating non-surgical treatments for adhesive capsulitis, including corticosteroids, hyaluronic acid (HA), platelet-rich plasma (PRP), pulsed radiofrequency (PRF), extracorporeal shock wave therapy (ESWT), hydrodilatation (HD), suprascapular nerve block (SSNB), and targeted injection strategies based on anatomical involvement. Evidence suggests that targeting sites like the rotator interval or applying multimodal strategies may enhance early symptom relief. SSNB has also been explored as a pain-relieving adjunct to intra-articular injections. HA offers a steroid-sparing option with comparable long-term outcomes, while PRP may benefit chronic cases via regenerative effects. HD facilitates early mobility through mechanical capsular disruption, while ESWT and PRF offer alternative mechanisms targeting pain modulation and tissue restoration. Tailoring treatment to disease stage and anatomical involvement, rather than applying generalized approaches, may improve outcomes. Standardization of therapeutic protocols and further high-quality trials assessing long-term efficacy are essential to guide clinical decision-making in the management of adhesive capsulitis.

1. Introduction

Adhesive capsulitis, commonly known as frozen shoulder, is a disabling musculoskeletal disorder characterized by pain and marked limitation of both active and passive shoulder range of motion (ROM) [1]. The condition is caused by chronic synovial inflammation and progressive capsular fibrosis, often involving the rotator interval (RI) and coracohumeral ligament (CHL) [2]. These structural changes result in joint stiffness, reduced function, and prolonged disability. Adhesive capsulitis most commonly affects individuals between the ages of 40 and 60, with a higher prevalence observed in women and in those with metabolic conditions such as diabetes mellitus or thyroid disease [3]. Clinically, the condition follows a gradual progression through three overlapping stages: freezing, frozen, and thawing [4]. While adhesive capsulitis may eventually resolve spontaneously, recovery is often slow and incomplete, with symptoms lasting from months to several years [4].

Conventional non-surgical treatment options for adhesive capsulitis include oral nonsteroidal anti-inflammatory drugs (NSAIDs), supervised physical therapy, and intra-articular (IA) corticosteroid injections [5]. These strategies are typically used to reduce inflammation, alleviate pain, and improve functional mobility, especially during the early and intermediate stages of the disease [5]. Although widely used, the effectiveness of these interventions varies depending on disease stage and severity [5]. Physical therapy alone may be insufficient in the presence of significant pain or marked capsular stiffness, leading clinicians to consider more targeted interventions.

IA corticosteroid injection remains a frequently employed approach in non-surgical management due to its potent anti-inflammatory effect [6]. However, growing evidence suggests that clinical outcomes are influenced by the anatomical site of injection. Injections into the glenohumeral (GH) joint aim to reduce synovial inflammation, while subacromial (SA) injections may relieve symptoms associated with concurrent bursitis or rotator cuff pathology [6]. Injections into the RI target the anterior capsule and CHL, which are often involved in the early development of capsular contracture [7].

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In addition to the injection site, the selection of injectate has become an important consideration. Corticosteroids are still the most commonly used agents for their fast-acting anti-inflammatory effect; however, concerns about systemic side effects, particularly in patients with diabetes [8], have led to increasing interest in alternative therapeutic options. Hyaluronic acid (HA) aims to restore joint lubrication and may reduce friction-induced inflammation [9]. Platelet-rich plasma (PRP), an autologous biologic product rich in growth factors, is thought to modulate inflammation and promote capsular remodeling [10,11]. Other injectates such as NSAIDs and tramadol have also been investigated, although results have been inconsistent [12,13].

Beyond injection-based therapies, interest has grown in non-invasive and minimally invasive modalities that may serve as alternatives or adjuncts to traditional interventions. Extracorporeal shock wave therapy (ESWT) delivers mechanical energy to the shoulder region, which may enhance local blood flow, disrupt fibrotic adhesions, and modulate nociceptive signaling [14]. Pulsed radiofrequency (PRF) modulates inflammatory cytokines and alters synaptic transmission in periarticular tissues through electric and magnetic field effects without causing thermal injury [15,16]. Acupotomy, a technique involving the insertion of a flat-bladed needle, has been employed to mechanically release capsular adhesions, particularly in regions of localized thickening [17].

Although numerous randomized controlled trials (RCTs) have investigated these diverse approaches, a lack of consensus regarding the most effective treatment strategy continues to complicate clinical decision-making. Treatment choices are often based on physician preference and clinical experience, rather than integrated evidence. This narrative review aims to synthesize and compare findings from recent trials evaluating non-surgical treatments for adhesive capsulitis. By examining the impact of injection site, injectate type, and novel non-invasive modalities, this review seeks to provide clinicians with a structured and evidence-based overview to support individualized treatment planning for patients with frozen shoulder.

2. Methods

2.1. Literature search strategy

We conducted a comprehensive database search of PubMed and Embase for English-language papers, covering records from the earliest available to March 2025. To ensure thorough coverage, we also reviewed the references of key relevant articles. The search used the following Medical Subject Heading terms and keywords: ("adhesive capsulitis" OR "frozen shoulder") AND ("injection" OR "treatment" OR "therapy" OR "management"). This review considered only studies conducted on human participants and published in English. We included RCTs with appropriate group allocation and randomization procedures. Studies without adequate randomization, as well as conference abstracts and those involving pediatric populations, were excluded from analysis.

2.2. Eligibility criteria

Studies were considered eligible if they met the following inclusion criteria: (1) RCT design; (2) adult participants with a clinical diagnosis of adhesive capsulitis at any stage or duration; (3) comparison between two or more non-surgical treatment strategies, including different injection sites such as IA or SA approaches, different types of injectates such as corticosteroids, HA, or PRP, or novel non-invasive or minimally invasive modalities; and (4) reporting of at least one relevant clinical outcome, such as pain intensity, functional assessment scores, or shoulder ROM.

Studies were excluded if they involved surgical interventions; compared non-surgical treatments with oral medications or physiotherapy alone; evaluated only pharmacologic dosages or rehabilitation protocols; or lacked extractable clinical outcomes. Review articles, case series, conference abstracts, biomechanical or animal studies, and non-randomized designs were also excluded.

2.3. Data collection process

Two authors independently screened the search results based on titles and abstracts to identify potentially eligible studies. Full-text articles were retrieved for further assessment. Data extraction was then performed using a standardized template. Relevant information was collected and organized into summary tables, which included details such as study design, participant characteristics, geographical location, intervention and comparator descriptions, clinical outcomes, key findings, and study conclusions.

2.4. Risk of bias and synthesis

Given the narrative nature of this review, a formal meta-analysis was not performed. However, all included studies were peer-reviewed randomized trials. Methodological characteristics such as randomization procedures, blinding, outcome reporting, and follow-up completeness were qualitatively considered when interpreting findings.

3. Results

Fig. 1 illustrates the flow diagram of the study selection process. An initial search of the databases restricted to English-language publications identified 498 articles based on the predefined criteria. After duplicates were removed, 168 articles were retained. After screening titles, abstracts, and full-text articles based on the predefined eligibility criteria, 49 RCTs were included in the final review.

3.1. Injection site comparison in the management of adhesive capsulitis

Twenty-four RCTs evaluated the effects of different injection sites for corticosteroids or other agents in the management of adhesive capsulitis [7,18–40]. Table 1 summarizes the study designs and outcomes related to injection site comparisons. The most commonly investigated anatomical locations included the GH joint, SA space, and RI. Several studies also explored the combined use of multiple injection sites or compared different anatomical approaches, such as anterior versus posterior access. Clinical outcomes were assessed using shoulder pain scores, such as the Visual Analog Scale (VAS) and Numeric Rating Scale (NRS), functional outcome measures including the Shoulder Pain and Disability Index (SPADI), Disability of Arm, Hand, and Shoulder (DASH), and the American Shoulder and Elbow Surgeons score (ASES), as well as passive and active shoulder ROM in multiple directions.

3.2. IA vs SA injection

IA injection was generally associated with earlier pain relief and faster functional recovery than SA injection [18,23]. Cho et al. found that both IA and combined IA + SA injections significantly outperformed SA alone in improving ASES, subjective shoulder value, and VAS scores, with the combined group showing enhanced internal rotation [23]. Oh et al. reported that IA injection led to quicker pain relief at 3 weeks, although no significant differences in Constant score or ROM were observed between IA and SA groups by 6 or 12 weeks [18]. In contrast, Shin et al. showed that IA, SA, and IA + SA injections all provided more rapid improvements in pain and function than oral medication up to 16 weeks; however, no significant differences were observed among the three injection groups at any time point, and by 24 weeks, there were no significant differences in shoulder pain or functional outcomes among any for the four groups [19]. Similarly, Yoon et al. reported more rapid early improvements in the IA and hydrodilatation (HD) groups; however, by 6 months, the clinical outcomes among the IA, SA, and HD groups showed no significant differences [22]. Kim et al. used a lidocaine-based diagnostic approach to identify the most symptomatic

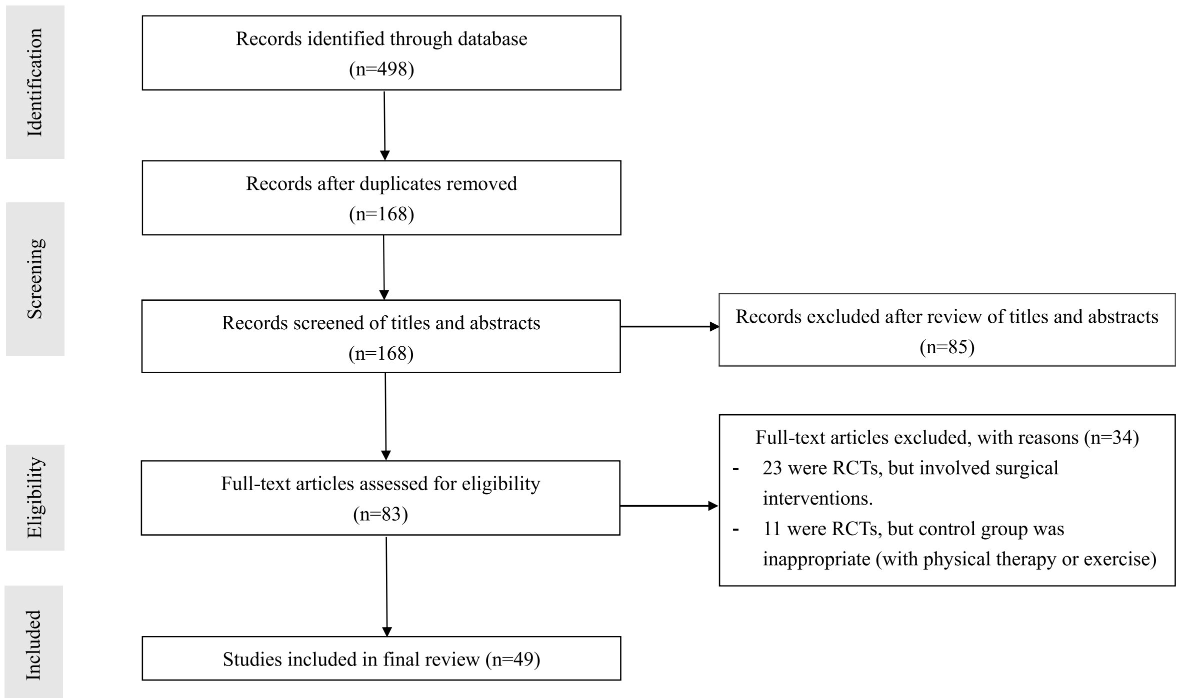

Fig. 1. PRISMA diagram detailing the screening processes.

region prior to steroid injection. Patients who received treatment at their most pain-responsive site, primarily the IA space, experienced greater pain relief and improvements in ROM compared to those who received injections at a predetermined site, suggesting that symptom-guided targeting may be more effective [21].

3.3. *Different approaches of IA injection*

The approach used to access the GH joint appears to affect treatment outcomes. Deng et al. reported that anatomical-guided anterior IA injection resulted in better early outcomes in VAS, Constant score, and external rotation compared to the posterior approach [36]. In addition, multiple studies emphasized the RI as a critical early-stage target [20, 26]. Sun et al. found RI injection produced faster and greater improvements in VAS, Constant, and DASH scores than IA or SA, especially in abduction and external rotation [26]. However, Prestgaard et al. found no additional benefit of combining RI with IA injection versus IA alone [20]. Cho et al. compared RI and posterior capsule approaches for IA injection and found greater improvements in flexion and abduction in the RI group at 12 weeks [23].

Elnady et al. and Wang et al. found that anterior HD via the RI led to greater pain relief and improvements in ROM compared to the conventional posterior IA HD approach [7,30]. Lee et al. demonstrated that corticosteroid injection into the CHL and inferior capsule resulted in greater pain reduction and ROM gains than posterior GH recess injection [34]. However, a trial by Sensoz et al. found no significant differences between anterior extra-articular and posterior IA injections, suggesting that both approaches can be effective when appropriately administered under ultrasound guidance [37].

With regard to guided-techniques, Park et al. compared conventional ultrasound-guided corticosteroid injections with a combined handheld ultrasound and fluoroscopy-guided approach [40]. Both techniques resulted in significant clinical improvements by six weeks, with no statistically significant differences in VAS, SPADI, or ROM [40]. However, combined guidance improved injection accuracy and procedural visualization, potentially enhancing operator confidence and precision in selected cases.

3.4. *Single vs multiple injection sites*

Multisite injections targeting IA, SA, and additional regions consistently resulted in earlier and more substantial improvements in clinical outcomes compared to injections administered at a single site [24]. Pushpasekaran et al. demonstrated that a three-site injection (IA, SA, subcoracoid) produced faster improvements in Constant scores and ROM, particularly in external rotation [24]. Similarly, Koraman et al. reported that injections administered to multiple anatomical targets, including the GH joint, bursa, biceps long head tendon, and CHL, resulted in significantly greater pain relief and functional recovery compared to IA injection alone, with sustained benefits over 12 months [31].

3.5. *Suprascapular nerve block (SSNB)*

SSNB was examined as both an alternative and adjunct to IA injection [28,29,32,33,38]. Gencer Atalay et al. found that combining SSNB with IA injection resulted in greater immediate pain relief and more pronounced improvements in ROM during the early phase of treatment [32]. Shanahan et al. demonstrated that the combination of SSNB and IA injection significantly reduced the overall symptom duration and led to greater improvements in SPADI scores compared to IA injection [33]. In a head-to- head comparison, Lin et al. found that IA injection offered slightly better results in SPADI and ROM than SSNB [38]. In contrast, Haque et al. reported that SSNB was more effective than IA injection at 12 weeks, showing greater improvements in VAS, SPADI, and modified Constant score, along with fewer side effects. The authors proposed that SSNB may prolong analgesia by reducing dorsal horn sensitization, depleting inflammatory neuropeptides, and normalizing cortical excitability. Additionally, by blocking sympathetic fibers, SSNB may disrupt the pain-stiffness cycle in adhesive capsulitis, thereby promoting lasting functional improvement [29]. With regard to injection site of SSNB, Bae et al. compared proximal and distal SSNB approaches, with the distal approach offering marginally higher early ASES scores [28].

In summary, IA corticosteroid injections are associated with more rapid initial improvements in pain and functional recovery compared to

Table 1
Summary of studies comparing injection sites for the treatment of adhesive capsulitis.

Author, year, country	Groups (number of participants); injectate; sessions/duration	Follow-up measurements	Pain outcome	Functional outcome	Shoulder ROM outcome	Main findings
Oh et al., 2011, South Korea [18]	IA (37); 1 ml TC (40 mg) + 4 ml LC (2 %); once SA (34); 1 ml TC (40 mg) + 4 ml LC (2 %); once	3, 6, 12 weeks	VAS decreased in all groups; IA group had lower scores at 3 weeks, no differences at 6 and 12 weeks	Constant scores improved in both groups; no significant difference at any time point	ROM improved in both groups; no significant differences at any time point	Both IA and SA injections led to pain relief and functional improvement; IA injection showed faster early pain relief, but overall outcomes were similar
Shin et al., 2013, South Korea [19]	SA (41); 1 ml TC (40 mg) + 4 ml LC (2 %); once IA (42); 1 ml TC (40 mg) + 4 ml LC (2 %); once IA + SA (39); 1 ml TC (40 mg) + 4 ml LC (2 %); once Oral NSAID (36); no injection	2, 4, 8, 16, 24 weeks	VAS improved in all groups; injection groups had faster pain relief than oral NSAID at 16 weeks; no significant difference at 24 weeks	ASES scores improved in all groups; steroid groups showed greater improvement than the oral NSAID group up to 16 weeks, with no significant difference at 24 weeks	ROM improved in all groups; steroid groups showed faster gains in forward flexion up to 16 weeks, with no significant difference at 24 weeks	Steroid injection led to faster pain relief, higher satisfaction, and earlier functional improvement than oral NSAID, regardless of site
Prestgaard et al., 2015, Norway [20]	IA (42); 1 ml TC (20 mg) + 2.5 ml LC (1 %); once IA + RI (40); 0.5 ml TC (10 mg) + 3 ml LC (1 %) into IA and RI each; once Sham (40); 3.5 ml LC (1 %); once	3, 6, 12, 26 weeks	NRS decreased significantly in IA and IA + RI groups vs sham at 6 and 12 weeks; no difference among groups at 26 weeks. No significant differences between IA and IA + RI at any time point	SPADI improved in IA and IA + RI groups at 6 and 12 weeks; no significant difference at 26 weeks	NR	IA and IA + RI injections were similarly effective for 12 weeks
Kim et al., 2015, South Korea [21]	SA or IA (based on LC test) (46); 1 ml TC (40 mg) + 4 ml LC (1 %); once IA (46); 1 ml TC (40 mg) + 4 ml LC (1 %); once	2 weeks, 3 months	Greater NRS improvement in LC test group at 2 weeks, sustained at 3 months	NR	Both groups showed improved passive ROM at 3 months; no significant differences at any time point	SA LC test prior to injection led to better pain relief
Yoon et al., 2016, South Korea [22]	IA (29); 1 ml TC (40 mg) + 4 ml LC (2 %) + 5 ml NS; once SA (29); 1 ml TC (40 mg) + 4 ml LC (2 %) + 5 ml NS; once HD (28); 1 ml TC (40 mg) + 4 ml LC (2 %) + 40 ml NS; once	1, 3, 6 months	VAS decreased in all groups; HD group had lower scores at 1 month, no differences at 6 months	SST and Constant scores improved in all groups; HD group showed greater improvement at 1 and 3 months; no differences at 6 months	Greater flexion and external rotation in HD group at 1 month; no differences at 6 months	HD provided faster symptom improvement; all groups showed similar results by 6 months
Cho et al., 2016, South Korea [23]	IA (36); 1 ml TC (40 mg) + 4 ml LC (1 %); once SA (37); 1 ml TC (40 mg) + 4 ml LC (1 %); once IA + SA (37); 0.5 ml TC (20 mg) + 2 ml LC (1 %) into IA and SA each; once	3, 6, 12, weeks	VAS improved in all groups; IA and IA + SA groups had greater reductions than SA alone	ASES and SSV scores improved in all groups through 12 weeks; IA and IA + SA groups showed greater gains	Passive ROM improved in all groups; IA and IA + SA groups showed greater gains, especially in internal rotation. IA + SA had the greatest improvement	IA + SA injection was more effective than SA alone over 12 weeks
Pushpasekaran et al., 2017, India [24]	IA (43); 1 ml MP (40 mg) + 2 ml LC (2 %); once IA + SA + SC (42); 1 ml MP (40 mg) + 2 ml LC (2 %) + 8 ml NS; once	3 weeks, 6 weeks 6 months	Pain improved in both groups; faster and greater improvement in IA + SA + SC group	Constant scores and ADL improved in both groups; faster and greater improvement in IA + SA + SC group	ROM improved in both groups; IA + SA + SC group showed greater gains in abduction and external rotation, reaching near-normal range by 6 weeks	Three-site injection provided faster recovery, better function, and fewer relapses than single-site injection
Kim et al., 2017, South Korea [25]	IA-anterior (23); 1 ml TC (40 mg) + 4 ml LC (2 %) + 4 ml NS + 3 ml contrast; once IA-posterior (23); 1 ml TC (40 mg) + 4 ml LC (2 %) + 4 ml NS + 3 ml contrast; once	3, 7, 13 weeks	VAS improved in both groups; posterior approach showed greater reduction showed greater reduction at 7 and 13 weeks	ASES and Constant scores improved in both groups; posterior approach showed greater improvement at 7 and 13 weeks	ROM improved in both groups; no significant differences at any time point	Both approaches were effective; posterior approach showed greater improvements in pain and function at 7 and 13 weeks
Sun et al., 2018, China [26]	IA (30); 1 ml TC (40 mg) + 2 ml LC (2 %); once SA (34); 1 ml TC (40 mg) + 2 ml LC (2 %); once RI (33); 1 ml TC (40 mg) + 2 ml LC (2 %); once	4, 8, 12 weeks	VAS improved in all groups; RI group showed the fastest and greatest pain relief	Constant and DASH scores improved in all groups; RI group showed the fastest functional recovery, followed by IA and SA	ROM improved in all groups; RI group showed earlier and greater gains, SA group showed minimal change	RI injection provided superior improvement in pain, ROM, and function compared to IA or SA injection
Elnady et al., 2020, Egypt [7]	HD–posterior (32); 1 ml MP (40 mg) + 1 ml LC (2 %) + 15 ml NS; once HD–anterior RI (32); 1 ml	12 weeks	VAS improved in both groups, anterior RI group showed greater pain reduction	SPADI improved in both groups; anterior RI group showed greater improvement	ROM improved in both groups; anterior RI group showed greater gains in flexion,	HD via anterior RI was more effective than posterior approach in improving clinical and functional outcomes

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Table 1 (*continued*)

Author, year, country	Groups (number of participants); injectate; sessions/duration	Follow-up measurements	Pain outcome	Functional outcome	Shoulder ROM outcome	Main findings
	MP (40 mg) + 1 ml LC (2 %) + 15 ml NS; once				abduction, and external rotation	
Parashar et al., 2021, India [27]	PT (20); no injection SSNB (20) + PT; 2 ml MP (80 mg) + 10 ml bupivacaine (0.5 %); once IA (20) + PT; 2 ml MP (80 mg) + 3 ml LC (1 %) + 7 ml NS; once	12 weeks	VAS improved in all groups; SSNB group had the greatest reduction, followed by IA group	SPADI improved in all groups, SSNB group had the greatest improvement, followed by IA group	ROM improved in all groups, SSNB group had the greatest improvement, followed by IA group	SSNB with PT was more effective than PT alone or IA + PT
Bae et al., 2021, South Korea [28]	Proximal SSNB (27); 2 ml ropivacaine (0.2 %) at supraclavicular region; once Distal SSNB (28); 2 ml ropivacaine (0.2 %) at suprascapular notch; once	2, 6, 12 weeks	VAS improved in both groups; no significant differences at any time point	ASES, UCLA, and SF-36 PCS improved in both groups; higher ASES in distal group at 2 weeks only	NR	Proximal SSNB provided comparable outcomes to distal SSNB; proximal approach may improve injection accuracy
Haque et al., 2021, Australia [29]	SSNB (43); 10 ml bupivacaine (0.5 %); once IA (43); 1 ml TC (40 mg) + 1 ml LC (2 %); once	1, 6, 12 weeks	VAS improved in both groups at all time points; SSNB group showed greater reduction at 12 weeks	SPADI and modified Constant scores improved in both groups; greater improvement in SSNB group at 12 weeks	NR	Both treatments were effective; SSNB provided longer pain relief
Wang et al., 2021, Taiwan [30]	HD–posterior (32); 4 ml TC (40 mg) + 4 ml LC (2 %) + 12 ml NS; once HD–anterior RI (32); 4 ml TC (40 mg) + 4 ml LC (2 %) + 12 ml NS; once	6, 12 weeks	VAS improved in both groups; greater reduction in motion pain in anterior RI group	SPADI improved in both groups; no significant differences between groups over time	ROM improved in all directions in both groups; no significant differences between groups over time	Both approaches were effective, but HD via anterior RI provided greater motion-related pain relief
Koraman et al., 2021, Turkey [31]	Multisite (38); 2 ml TC (80 mg) + 4 ml bupivacaine (0.5 %) + 34 ml NS into GH joint, SA space, posterosuperior capsule, BL, CHL; once IA (38); 1 ml triamcinolone (40 mg) + 2 ml bupivacaine (0.5 %); once	1 month, 3 months, 6 months, 1 year	VAS improved in both groups; multisite group showed greater reduction at all time points	ASES and UCLA scores improved in both groups; multisite group had significantly greater improvement	Active and passive ROM improved in both groups; multisite group showed significantly greater gains at all time points	Multisite injection provided superior outcomes in pain, ROM, and function compared to single IA injection
Gencer Atalay et al., 2021, Turkey [32]	IA + SSNB (19); 1 ml betamethasone (7 mg) + 4 ml bupivacaine (0.5 %) into GH joint, 5 ml bupivacaine (0.5 %) for SSNB; once IA (19); 1 ml betamethasone (7 mg) + 4 ml bupivacaine (0.5 %); once	1 h, 3 weeks, 3 months, 1 year	NRS improved in both groups; IA + SSNB group showed greater reduction at 1 h; no difference at later time points	SPADI and SF-36 scores improved in both groups; no significant between-group differences	ROM improved in both groups; greater improvement in flexion at 1 h in IA + SSNB group; no differences at later time points	IA + SSNB provided greater short-term benefit in pain and flexion, but no added long-term effect over IA alone
Shanahan et al., 2022, Australia [33]	IA + SSNB (27); 1 ml TC (20 mg) + 2 ml LC (2 %) into GH joint, 10 ml bupivacaine (0.5 %) + 1 ml MP (40 mg) into suprascapular fossa; every 12 weeks if needed IA + Placebo (27); 1 ml TC (20 mg) + 2 ml LC (2 %) into GH joint + 2 ml NS subcutaneously over suprascapular fossa; every 12 weeks if needed	3, 6, 9 months	VAS improved in both groups; IA + SSNB group showed significantly greater pain reduction at all time points	SPADI scores improved in both groups; IA + SSNB group showed significantly greater improvement at all time points	ROM improved in both groups; IA + SSNB group showed greater gains at all time points	IA + SSNB reduced symptom duration and enhanced pain, ROM, and functional outcomes compared to IA + placebo
Lee et al., 2022, South Korea [34]	CHL + IGHC (60); 1 ml dexamethasone (3.5 mg) into CHL + 0.5 ml TC (20 mg) into IGHC; 0, 2, 4 weeks IA (60); 1 ml dexamethasone (3.5 mg) + 0.5 ml TC (20 mg); 0, 2, 4 weeks	2, 4 months	VAS improved in both groups; CHL + IGHC group showed significantly greater reduction	NR	Abduction, external rotation, and internal rotation improved in both groups; CHL + IGHC group showed significantly greater gains	CHL + IGHC injection provided greater pain and ROM improvements than IA injection
Cho et al., 2022, South Korea [35]	RI (43); 1 ml TC (40 mg) + 3 ml LC (1 %) + 3 ml contrast + 3 ml NS; once IA (45); 1 ml TC (40 mg) +	3, 6, 12 weeks	VAS improved in both groups at all time points; no significant difference between groups	ASES and SSV improved in both groups at all time points; no significant difference between groups	ROM improved in both groups; RI group showed greater gains in forward flexion and abduction at 12 weeks	Both approaches were effective; RI approach led to superior ROM gains

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Table 1 (*continued*)

Author, year, country	Groups (number of participants); injectate; sessions/duration	Follow-up measurements	Pain outcome	Functional outcome	Shoulder ROM outcome	Main findings
Park et al., 2022, South Korea [40]	3 ml LC (1 %) + 3 ml contrast + 3 ml NS; once FL + US IA (19): TC (20 mg) + 7 ml LC (0.5 %) + 2 ml contrast; 0, 2 weeks US IA (20): TC (20 mg) + 7 ml LC (0.5 %) + 2 ml contrast; 0, 2 weeks	2, 6 weeks	VNS improved in both groups, with no significant difference between groups	SPADI improved in both groups, with no significant difference between groups	Passive ROM improved in both groups, with no significant difference between groups	Both FL + US-guided and US-guided IA steroid injections significantly improved pain, function, and ROM, with no significant difference between two techniques
Deng et al., 2023, China [36]	IA-anterior (30); 1 ml TC (40 mg) + 4 ml LC (2 %); once IA-posterior (30); 1 ml TC (40 mg) + 4 ml LC (2 %); once	4, 8, 12 weeks	VAS improved in both groups at all time points; anterior approach showed greater reduction	Constant scores improved in both groups; anterior group had significantly greater improvement at 4 and 8 weeks	ROM improved in both groups at all time points; anterior group showed significantly greater external rotation at 4 weeks	Both approaches were effective; anterior approach provided better pain control, faster function recovery, and early ROM improvement
Sensoz et al., 2024, Turkey [37]	CHL (20); 1 ml TC (20 mg) + 1 ml prilocaine (2 %); once IA (18); 1 ml TC (20 mg) + 1 ml prilocaine (2 %); once	1, 3, 6 weeks	VAS improved in both groups at all time points; no significant difference between groups	ASES and QuickDASH improved in both groups at all time points; no significant difference between groups	ROM improved in both groups at all time points; no significant difference between groups	Both anterior extra-articular and posterior IA injections were effective; no significant difference between groups
Lin et al., 2024, Taiwan [38]	SSNB (38); TC (20 mg) + 3 ml LC (2 %); 0, 2 weeks IA (38); TC (20 mg) +3 ml LC (2 %); 0, 2 weeks	4, 12 weeks	SPADI pain subscale and SF-36 bodily pain scores significantly improved in both groups at 4 and 12 weeks. IA group showed greater pain relief at 12 weeks	SPADI and SDQ scores significantly improved in both groups at 4 and 12 weeks. IA group showed greater improvement in SDQ scores at 12 weeks	Abduction and external rotation significantly improved in both groups at 4 and 12 weeks; no significant difference between groups	Both treatments were effective; IA yielded slightly more favorable outcomes at 12 weeks
Mülkoğlu et al., 2024, Turkey [39]	SSNB + HD (25): 6 ml bupivacaine (0.5 %) + 4 ml NS for SSNB, followed by 4 ml bupivacaine (0.5 %) + 12 ml NS for HD; once SSNB (23): 6 ml bupivacaine (0.5 %) + 4 ml NS; once	1, 3 months	VAS improved in both groups at all time points; no significant difference between groups	QuickDASH improved in both groups at all time points; no significant difference between groups	ROM improved in both groups at all time points; SSNB group showed significantly greater gains in abduction and external rotation at 3 months	Both SSNB + HD and SSNB alone significantly improved pain, function, and ROM; adding HD to SSNB did not provide additional benefit

Abbreviations: ROM, range of motion; SA, subacromial; IA, intra-articular; TC, triamcinolone; LC, lidocaine; VAS, Visual Analogue Scale; NSAID, nonsteroidal anti-inflammatory drug; ASES, American Shoulder and Elbow Surgeons; RI, rotator interval; NRS, Numeric Rating Scale; SPADI, Shoulder Pain and Disability Index; NR, not reported; HD, hydrodilatation; NS, normal saline; SST, Simple Shoulder Test; SSV, subjective shoulder value; FL, fluoroscopy; US, ultrasound; VNS, Verbal Numeric Scale; SC, subcoracoid; MP, methylprednisolone; ADL, activities of daily living; DASH, Disability of Arm, Hand, and Shoulder; SSNB, suprascapular nerve block; PT, physical therapy; UCLA, University of California Los Angeles; SF36-PCS, Short Form-36 Physical Component Summary; GH, glenohumeral joint; BL, biceps long head tendon; CHL, coracohumeral ligament; SF-36, Short Form 36; IGHC, inferior glenohumeral capsule; QuickDASH, Quick Disabilities of the Arm, Shoulder, and Hand; SF-36, Short Form-36; SDQ, Shoulder Disability Questionnaire.

SA injections or oral medication; however, no significant long-term differences are observed among treatment groups, consistent with the self-limiting course of adhesive capsulitis. Targeted injection into the RI appears to provide greater early gains in pain reduction and shoulder mobility relative to GH joint injection alone, although current evidence remains limited. Furthermore, multisite injection strategies addressing multiple anatomical structures have demonstrated superior short-term outcomes compared to single-site injections; nevertheless, the available data are limited and longer-term advantages have yet to be clearly established.

3.6. *Injectate comparison in the management of adhesive capsulitis*

Twenty-one RCTs evaluated the therapeutic effects of different injectable agents and injection strategies in the management of adhesive capsulitis [12,13,41–59]. Table 2 summarizes the study designs, treatment protocols, and clinical outcomes of these trials. The most frequently investigated injectates included corticosteroids (at various dosages), HA, PRP, and NSAIDs. Several studies also explored combination treatments, such as corticosteroids plus HA or tramadol. A number of trials investigated variations in HD protocols using different injectates or fluid volumes.

3.7. *Corticosteroid dosage: high vs low*

Three studies investigated the therapeutic effects of varying IA corticosteroid dosages [41,46,51]. While de Jong et al. reported superior early symptom relief with 40 mg of triamcinolone acetonide compared to 10 mg [41], subsequent trials by Yoon et al. and Kim et al. found no significant differences in clinical outcomes including SPADI, VAS, or ROM between the 40 mg and 20 mg doses [46,51]. Furthermore, Kim et al. noted higher short-term blood glucose levels among diabetic patients receiving the higher dose [51]. These findings suggest that low-dose corticosteroid injections may offer comparable therapeutic benefits with reduced systemic risk.

3.8. *HA vs. corticosteroids*

Multiple RCTs have compared IA HA with corticosteroids [13,43,45,47]. Calis et al. and Lim et al. showed that both agents significantly improved pain and shoulder mobility, while corticosteroids provided more rapid symptom relief [43,47]. Park et al. further demonstrated that capsular distension with HA yielded greater short-term improvement in external rotation [45]. Overall, HA appears to be a clinically effective alternative, especially for patients contraindicated for corticosteroids. In

Table 2
Summary of studies comparing injectates for the treatment of adhesive capsulitis.

Author, year, country	Groups (number of participants); Injectate; Sessions/duration	Follow-up measurements	Pain outcome	Functional outcome	Shoulder ROM outcome	Main findings
de Jong et al., 1998, Netherlands [41]	IA high-dose steroid (25); TC (40 mg); 0, 1, 3 weeks IA low-dose steroid (32); TC (10 mg); 0, 1, 3 weeks	1, 3, 6 weeks	VAS improved in both groups; Greater improvement in high-dose group at all time points	Functional scores improved in both groups; high-dose group showed significantly greater improvement in arm use	ROM improved in both groups; greater improvement in high-dose group	Both steroid doses were effective; High dose provided faster and greater symptom relief
Gam et al., 1998, Denmark [42]	IA steroid + capsular distension (12); 1 ml TC (20 mg) + 19 mL LC (0.5 %); once weekly, up to 6 sessions IA steroid (8); 1 ml TC (20 mg); once weekly, up to 6 sessions	3, 6, 12 weeks	VAS at rest and during function improved in both groups; no significant difference between groups at any time point. Analgesic usage was significantly lower in distension group at 12 weeks	Functional scores improved in both groups; distension group showed significantly better physician-assessed shoulder mobility at 6 and 12 weeks	Distension group showed significantly greater improvement in ROM in most directions, including external rotation and flexion. Physician-assessed ROM also favored the distension group at 6 and 12 weeks	Distension plus steroid improved ROM more than steroid alone. No significant difference in pain or function, but lower analgesic use and better physician-assessed outcomes favored the distension group
Calis et al., 2006, Turkey [43]	IA HA (27); HA (30 mg); 0, 1 weeks IA steroid (26); TC (40 mg); single injection PT (22); PT; daily for 10 sessions Control (20); home-based stretching exercises; no treatment	15 days, 3 months	VAS improved in all groups. IA HA and IA steroid groups showed significantly greater pain reduction compared to PT and control groups, with no significant difference between HA and steroid groups at 3 months	Constant score and SPADI improved in all groups. IA HA and IA steroid groups showed greater improvements compared to the PT and control groups. IA HA group had the highest gains at 3 months	ROM improved in all groups. IA HA and IA steroid groups showed greater improvements in shoulder flexion, abduction, and external rotation compared to PT and control groups.	IA HA and steroid injections demonstrated significantly better outcomes in pain, function and ROM
Tveitå et al., 2008, Norway [44]	IA steroid + distension (39): 2 ml TC (20 mg) + 4 ml local anesthetic + 4 ml contrast + 10 ml NS; 0, 2, 4 weeks IA steroid (37): 2 ml TC (20 mg) + 3-4 ml local anesthetic + 3-4 ml contrast; 0, 2, 4 weeks	6 weeks	NR	SPADI improved in both groups; no significant difference between groups at 6 weeks	ROM improved in both groups; no significant difference between groups at 6 weeks	IA steroid with capsular distension was as effective as IA steroid for function and ROM
Park et al., 2013, South Korea [45]	IA steroid (45); 1 mL TC (40 mg) + 4 mL LC (0.5 %); 0, 2, 4 weeks IA HA + capsular distension (45); 2 mL sodium hyaluronate (20 mg) + 18 ml LC (0.5 %); 0, 2, 4 weeks.	2, 6 weeks	VNS improved in both groups; no significant difference between groups at 2 and 6 weeks	SPADI improved in both groups; no significant difference between groups at 2 and 6 weeks	Passive ROM improved in both groups; greater improvement in external rotation in HA + capsular distension group at 2 and 6 weeks	HA with capsular distension was as effective as steroid for pain and function, and more effective for improving external rotation
Yoon et al., 2013, South Korea [46]	IA high-dose steroid (20); 4 mL TC (40 mg) + 1 mL LC (1 %); single injection IA low-dose steroid (20); 2 mL TC (20 mg) + 3 mL LC (1 %); single injection IA placebo (13); 5 ml LC (1 %); single injection	1, 3, 6, 12 weeks	VAS improved in all groups; greater improvement in both steroid groups vs placebo, with no difference between high- and low-dose groups	SPADI improved in all groups; greater improvement in both steroid groups vs placebo, with no difference between high- and low-dose groups	Greater improvement in flexion, abduction, and internal rotation in both steroid groups compared to placebo; no difference between high- and low-dose groups	Both steroid doses were effective; low dose may be preferable due to similar efficacy with fewer potential risks
Lim et al., 2014, South Korea [] 47	IA steroid group (33): TC (dose not specified); singe injection IA HA group (29): sodium hyaluronate (dose not specified); 0, 2, 12 weeks	2, 12 weeks	VAS improved in both groups; no significant difference between groups at 2 and 12 weeks	ASES and Constant scores improved in both groups; no significant difference between groups at 2 and 12 weeks	ROM improved in both groups; no significant difference in flexion or external rotation; greater improvement in internal rotation in steroid group at 2 weeks, with no difference at 12 weeks	Both HA and steroid injections were effective; steroid was more effective for internal rotation at 2 weeks
Lee et al., 2015, South Korea [48]	HD-hypertonic saline (32); 1 mL TC (10 mg) + 4 mL LC (1 %) + hypertonic saline (3 % NaCl), total volume 20.2 mL; single injection HD-NS (32); 1 mL TC (10 mg) + 4 mL LC (1 %) + normal saline	2 weeks	SPADI pain scores improved in both groups; greater improvement observed in the hypertonic saline group at 2 weeks	SPADI disability scores improved in both groups; greater improvement in the hypertonic saline group at 2 weeks	Passive ROM improved in both groups; greater improvement in the hypertonic saline group at 2 weeks	HD with hypertonic saline was more effective than NS for improving pain, function, and ROM

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Table 2 (*continued*)

Author, year, country	Groups (number of participants); Injectate; Sessions/duration	Follow-up measurements	Pain outcome	Functional outcome	Shoulder ROM outcome	Main findings
	(0.9 % NaCl), total volume 19.5 mL; single injection					
Sharma et al., 2016, Norway [49]	IA steroid (35): 1 ml TC (20 mg) + 3 mL LC (1 %); days 1, 7, 17, 31 HD (34): 1 ml TC (20 mg) + 3 mL LC (1 %) + 4–16 ml NS; days 1, 7, 17, 31 Control (36): pain medication, PT; no injection	4 weeks, 8 weeks, 12 months	Greater NPRS reduction in IA steroid and HD groups compared to control at 4 and 8 weeks; no significant difference among groups at 12 months	Greater SPADI improvement in IA steroid and HD groups compared to control at 4 and 8 weeks; no significant difference among groups at 12 months	Passive ROM improved in all groups; greater improvement in IA steroid and HD groups vs control at 4 and 8 weeks; no significant difference at 12 months	IA steroid and HD were more effective than control in the short term; no difference among groups at 12 months
Lee et al., 2017, South Korea [50]	IA steroid (32): 1 mL TC (40 mg) + 3 mL LC (1 %); single injection HD (32): 1 mL TC (40 mg) + 6 mL LC (1 %) + NS; single injection	3, 6, 12 weeks	VAS improved in both groups at all time points; no significant difference between groups	SPADI scores improved in both groups at all time points; no significant difference between groups	Passive ROM improved in both groups at all time points, no significant difference between groups	Both IA steroid and HD were effective; no additional benefit of HD over IA steroid
Kim et al., 2017, South Korea [51]	IA high-dose steroid (76); TC (40 mg) + 1 mL LC (1 %); single injection IA low-dose steroid (71); TC (20 mg) + 1 mL LC (1 %); single injection	3, 6, 12 weeks; 6, 12 months	VAS improved in both groups at all time points; no significant difference between high- and low-dose groups	ASES and SST scores improved in both groups; no significant difference between high- and low-dose groups	ROM improved in both groups; no significant difference between high- and low-dose groups	Both high- and low-dose IA steroid injections were effective; low dose is recommended for diabetic patients due to less impact on blood glucose
Kim et al., 2017, South Korea [13]	IA HA (16); 2.5 mL hyaluronate (1 %); weekly × 5 sessions IA HA + tramadol (14); 2.5 mL hyaluronate (1 %) + 1 mL tramadol (50 mg), weekly × 3 sessions; then 2.5 ml hyaluronate (1 %), weekly × 2 sessions	1, 2, 3, 4, 6 weeks	VAS improved in both groups; greater reduction in the HA + Tramadol group at 1 and 2 weeks	SPADI scores improved in both groups over time; no significant difference between groups at any time point	Passive ROM improved in both groups; no significant difference between groups at any time point	HA + Tramadol provided faster and greater pain relief than HA alone, with similar functional and ROM improvements
Kim, et al., 2018, South Korea [52]	IA high-dose steroid (16); TC (40 mg) + 4 mL LC (1 %); single injection IA low-dose steroid (16); TC (20 mg) + 4 mL LC (1 %); single injection	3 weeks	NRS improved in both groups; no significant difference between high- and low-dose groups	SPADI improved in both groups; no significant difference between high- and low-dose groups	Passive ROM improved in both groups; no significant difference between high- and low-dose groups	Both high- and low-dose IA steroid injections were effective; 20 mg was sufficient for pain and functional improvement
Akhtar al., 2019, Pakistan [12]	IA NSAID (80); ketorolac (dose not specified); singe injection IA HA (80); HA (dose not specified); singe injection	4 weeks	UCLA pain score improved in both groups at 4 weeks; greater reduction observed in the NSAID group	NR	NR	IA NSAID injection provided greater pain relief than HA at 4 weeks
Paruthikunnanet et al., 2019, India [53]	IA steroid + capsular distension (44); 2 ml MP (80 mg) + 12–18 ml bupivacaine (0.25 %); single injection IA steroid (44); 2 ml MP (80 mg) + 2 ml bupivacaine (0.25 %); single injection	1.5, 3, 6 months	NR	SPADI improved in both groups at all time points; no significant difference between groups	NR	Both IA steroid and HD were effective; no additional benefit of HD over IA steroid
Oh et al., 2021, South Korea [54]	IA NS (15): 4 ml NS + 4 ml contrast media IA steroid (15): 1 ml TC (40 mg) + 3 mL NS + 4 mL contrast media IA HA (15): 2 mL HA + 2 ml NS + 4 mL contrast media IA steroid + HA (15): 1 mL TC (40 mg) + 2 mL HA + 1 mL NS + 4 mL contrast media	1 day, 1 week, 1 month, 3 months, 6 months	VAS improved in all groups; steroid + HA group had greater improvements in VAS at 1 day, 1 week, and 1 month than NS and HA groups. No significant differences at 3 or 6 months	All groups showed functional improvement. Steroid + HA group demonstrated greater improvement in SPADI, ASES, Constant, and DASH scores at 1 week and 1 month compared to the NS and HA groups. No significant differences at 3 or 6 months.	ROM improved in all groups. Steroid + HA group had greater increases in flexion, abduction, and internal rotation at 1 month compared to NS and HA groups.	Steroid + HA was more effective than steroid or HA alone in improving pain, ROM, and functional scores at 1 month, but differences were not sustained at 3 or 6 months

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Table 2 (*continued*)

Author, year, country	Groups (number of participants); Injectate; Sessions/duration	Follow-up measurements	Pain outcome	Functional outcome	Shoulder ROM outcome	Main findings
Shahzad et al., 2021, Pakistan [55]	IA PRP (102): 2 ml PRP; single injection IA steroid (100): 2 ml MP (80 mg); single injection	12 weeks	VAS improved in both groups at 12 weeks, with greater improvement in PRP group	UCLA scores improved in both groups at 12 weeks, with greater improvement in PRP group	ROM improved in both groups at 12 weeks, with greater improvement in PRP group	IA PRP injection was more effective than steroid injection in improving pain, function, and ROM at 12 weeks
Gupta et al., 2022, India [56]	IA PRP (30): 2 ml PRP; single injection IA steroid (30): 2 ml TC (80 mg); single injection	4, 12, 24 weeks	VAS improved in both groups. The steroid group showed greater pain relief at 4 and 12 weeks, while PRP group showed significantly greater improvement at 24 weeks.	DASH scores improved in both groups. No significant difference was observed at 4 and 12 weeks, while PRP group showed significantly greater improvement at 24 weeks	NR	Both PRP and steroid injections were effective; steroid showed better short-term results, while PRP provided superior long-term improvement in pain and function
Wang et al., 2023, Taiwan [57]	HD high-dose steroid (42): 4 ml TC (40 mg) + 4 ml LC (2 %) + 12 ml NS; single injection HD low-dose steroid (42): 1 ml TC (40 mg) + 4 ml LC (2 %) + 15 ml NS; single injection	6, 12 weeks	VAS improved in both groups; no significant difference between high- and low-dose groups	SPADI improved in both groups; no significant difference between high- and low-dose groups	ROM improved in both groups; no significant difference between high- and low-dose groups	Both high-dose and low-dose steroid HD led to similar improvements in pain, function, and ROM. Low dose is recommended for due to less side effects
Somisetty et al., 2023, India [58]	IA PRP (34): 4 ml PRP; single injection IA steroid (34): 2 ml MP (80 mg) + 2 ml NS; single injection	2, 4, 8, 12, 24 weeks	VAS improved in both groups over time, while PRP group showed significantly greater improvement at 24 weeks	QuickDASH and SPADI improved in both groups, while PRP group showed significantly greater improvements at 8, 12, and 24 weeks.	NR	IA PRP injection was more effective than steroid injection in improving pain and function at 8, 12, and 24 weeks
Swaroop et al., 2023, India [59]	IA steroid (54): 2 ml TC (80 mg) + 4 ml LC (2 %) + 4 mL ropivacaine (0.2 %); single injection HD (54): 2 ml TC (80 mg) + 4 ml LC (2 %) + 4 ml ropivacaine (0.2 %) + 40 ml NS; single injection	2 weeks, 6 weeks, 3 months	NR	SPADI scores improved in both groups, while IA steroid group showed significantly greater improvement in SPADI scores at 6 weeks and 3 months	NR	Both IA steroid and HD were effective; but the IA steroid group showed superior functional improvement at 6 weeks and 3 months

Abbreviations: ROM, range of motion; IA, intra-articular; TC, triamcinolone; VAS, Visual Analogue Scale; LC, lidocaine; HA, hyaluronic acid; PT, physical therapy; SPADI, Shoulder Pain and Disability Index; VNS, Verbal Numeric Scale; NS, normal saline; ASES, American Shoulder and Elbow Surgeons; HD, hydrodilatation; NPRS, numerical pain rating scale; SST, simple shoulder test; NSAID, nonsteroidal anti-inflammatory drug; UCLA, University of California Los Angeles; NR, not reported; DASH, Disability of Arm, Hand, and Shoulder; PRP, platelet-rich plasma; MP, methylprednisolone; QuickDASH, Quick Disabilities of the Arm, Shoulder, and Hand, UK, United Kindom

a four-arm trial, Oh et al. evaluated corticosteroid, HA, their combination, and saline placebo [54]. The combination group exhibited significantly greater improvements in SPADI and VAS scores at one week and one month post-injection compared to single-regiment injection. However, there was no significant difference between corticosteroid and HA groups alone in terms of pain or functional outcomes. Furthermore, the early benefits seen in the combination group were not maintained at three or six months [54]. These findings indicate that combined corticosteroid and HA injections may accelerate symptom resolution during the acute phase but do not appear to offer long-term superiority over monotherapy.

3.9. PRP vs corticosteroids

Three RCTs evaluated PRP as an alternative injectate [55,56,58]. Shahzad et al., Gupta et al., and Somisetty et al. consistently found that while corticosteroids provided faster early relief, PRP resulted in superior pain reduction, functional improvement, and ROM at 12–24 weeks [55,56,58]. These results suggest that PRP may be particularly beneficial for patients seeking prolonged symptom control.

3.10. NSAIDs and tramadol

Two studies examined the IA administration of alternative analgesic agents [12,13]. Akhtar et al. reported greater pain reduction at four weeks with IA ketorolac compared to HA at 4 weeks [12]. Kim et al. demonstrated that the combination of tramadol and HA led to greater improvements in VAS scores during the first two weeks post-injection compared to HA alone; however, by six weeks, clinical outcomes were comparable between the two groups [13]. These findings suggest that NSAIDs or tramadol may serve as effective adjuncts for early-phase symptom relief.

3.11. HD injectates

Seven trials investigated variations in HD protocols, including saline concentration, total volume, and corticosteroid combination [42,44,48,49,53,57,59]. Studies by Gam et al., Tveitå et al., and Sharma et al. reported faster ROM improvement with HD compared to corticosteroid injection alone, although long-term differences were minimal [42,44,49]. Lee et al. showed enhanced early outcomes with hypertonic saline versus normal saline [48]. Paruthikunnan et al. reported that both IA steroid and HD were effective, with no long-term benefit of HD over steroid alone [53]. In contrast, Swaroop et al. found that although SPADI scores improved in both groups, patients who received IA steroid alone experienced significantly greater improvements at 6 weeks and 3 months [59]. Wang et al. found that both high- and low-dose steroid HD produced similar improvements in pain, shoulder function, and ROM [57]. Overall, HD may lead to earlier improvements in shoulder mobility, but its long-term clinical advantage over IA steroid injections remains unclear.

In summary, low-dose corticosteroid injections appear to offer comparable therapeutic benefits to higher doses, with the added advantage of reduced systemic risks. HA demonstrated equivalent efficacy to corticosteroids in improving pain and shoulder mobility, although corticosteroids may provide faster initial symptom relief. PRP consistently showed superior long-term improvements in pain, function, and ROM compared to corticosteroids, suggesting its potential role for sustained symptom control. HD, regardless of injectate composition, was associated with earlier gains in shoulder mobility; however, its long-term outcomes did not differ significantly from those achieved with corticosteroid injections alone.

3.12. Novel non-invasive modalities in the management of adhesive capsulitis

Four RCTs investigated emerging non-invasive or minimally invasive interventions for adhesive capsulitis. These modalities included ESWT, PRF, IA ozone injection and acupotomy (Table 3) [16,17,60,61].

3.13. ESWT

Two studies demonstrated the efficacy of ESWT in patients with adhesive capsulitis [60,61]. El Naggar et al. compared four weekly sessions of radial ESWT (rESWT) with a single ultrasound-guided steroid injection (20 mg triamcinolone acetonide). At 12 weeks, the rESWT group showed significantly greater improvements in QuickDASH and VAS scores, although ROM gains were comparable between groups [60]. Saldiran et al. compared high-energy and medium-energy rESWT protocols. Both energy levels led to significant pain and functional improvement, with medium-energy rESWT yielding greater reductions in night pain and deltoid muscle stiffness, while high-energy rESWT achieved superior gains in external and internal rotation [61].

3.14. Acupotomy combined with HD

Xu et al. evaluated the combination of ultrasound-guided HD and acupotomy. Compared to HD alone, the combined approach yielded significantly greater improvements in Constant score and active ROM at three months [17]. Furthermore, ultrasonographic findings indicated greater reductions in CHL thickness and rotator cuff hypoechoic thickening, supporting a biomechanical benefit of pericapsular release [17].

3.15. IA PRF and IA ozone injection

In a prospective randomized trial, Foula et al. compared the efficacy of IA PRF, corticosteroid, and ozone injections in patients with adhesive capsulitis [16]. The PRF group demonstrated significantly greater and more sustained improvements in pain, as measured by VAS scores at rest and during movement, as well as superior functional gains in SPADI and ROM, compared to both steroid and ozone groups [16]. These findings suggest that IA PRF may provide more durable clinical benefits, while IA ozone injection offered only modest improvements, comparable to steroids but inferior to PRF.

In summary, emerging non-invasive and minimally invasive modalities such as ESWT, PRF, and acupotomy show potential as alternative or

Table 3
Summary of studies evaluating other novel treatments for adhesive capsulitis.

Author, year, country	Groups (number of participants); Treatment; Sessions/duration	Follow-up measurements	Pain outcome	Functional outcome	Shoulder ROM outcome	Main findings
El Naggar et al., 2020, Egypt [60]	rESWT (52): rESWT (2000 pulses/session); 4 weekly sessions IA steroid (51): 0.5 ml TC (20 mg) + 2 mL LC; single session	4, 8, 12 weeks	VAS improved in both groups; greater reduction in rESWT group at all timepoints	QuickDASH improved in both groups; greater improvement in rESWT group at all timepoints	ROM improved in both groups; no significant differences between groups over time	rESWT led to greater improvements in pain and function than low-dose steroid injection, with comparable effects on ROM
Saldiran et al., 2022, Turkey [61]	High-energy rESWT (13): 0.25 mJ/mm^2 (2000 pulses/session); twice/week × 6 weeks Medium-energy rESWT (13): 0.12 mJ/mm^2 (2000 pulses/session); same protocol Sham (13): 0.00 mJ/mm^2 (2000 impulses/session); same protocol	6 weeks	VAS at rest decreased in all groups. Night pain reduction was significant only in the medium-energy ESWT group at 6 weeks	SPADI scores improved in both medium- and high-energy ESWT groups at 6 weeks, with greater improvement in the medium-energy group	Both medium- and high-energy ESWT groups showed increased active ROM at 6 weeks, with greater improvements in external and internal rotation observed in the high-energy group	Regardless of energy level, rESWT was effective in improving pain, function, and ROM
Xu et al., 2022, China [17]	HD + acupotomy (33); HD with TC (10 mg) + 2 mL LC (2 %) + 2 mL HA + NS, combined with ultrasound-guided acupotomy targeting thickened CHL or rotator cuff space; 3 weekly sessions HD (30); HD with TC (10 mg) + 2 mL LC (2 %) + 2 mL HA + NS; 3 weekly sessions	3 months	VAS improved in both groups. HD + acupotomy group showed significantly greater pain reduction	Constant scores improved in both groups. HD + acupotomy group showed significantly greater improvement	Active ROM improved in both groups. HD + acupotomy group showed significantly greater improvement	HD + acupotomy was more effective than HD alone in improving pain, function and ROM
Foula et al., 2023, Egypt [16]	IA steroid (15); TC (40 mg) + 5 ml bupivacaine (0.125 %); single session IA ozone (15); 10 ml ozone (150 μg) + 5 ml bupivacaine (0.125 %); single session IA PRF (15); 5 ml bupivacaine (0.125 %) + PRF (4 min); single session	1, 2, 4, 8 weeks	VAS at rest and movement improved significantly in all groups over time. PRF group showed greatest pain reduction at 8 weeks	SPADI improved significantly in all groups over time. PRF group showed greatest improvement at 8 weeks	ROM significantly improved in all groups over time. PRF group showed greater improvement at weeks 2, 4, and 8	All treatments improved pain, function, and ROM. PRF group showed superior long-term outcomes compared to steroid and ozone groups

Abbreviations: ROM, range of motion; rESWT, radial extracorporeal shock wave therapy. IA, intra-articular; TC, triamcinolone; LC, lidocaine; VAS, visual analogue scale; QuickDASH, Quick Disabilities of the Arm, Shoulder and Hand; SPADI, Shoulder Pain and Disability Index; HA, hyaluronic acid; NS, normal saline; PRF, pulsed radiofrequency.

adjunctive treatments for adhesive capsulitis. ESWT demonstrated improvements in pain and function comparable or superior to corticosteroid injections, while PRF provided more durable pain relief and functional gains compared to both corticosteroids and ozone. Acupotomy combined with HD enhanced ROM and capsular remodeling beyond HD alone.

4. Discussion

This review demonstrates that non-surgical treatment strategies for adhesive capsulitis have expanded beyond traditional corticosteroid injections, incorporating more personalized approaches that consider injection site, selection of injectate, and incorporating novel treatment modalities. While IA corticosteroids remain commonly used for their rapid anti-inflammatory effects, evidence from recent randomized trials suggests that variations in injection technique and choice of agent can influence both the timing and duration of clinical improvement.

The pathophysiology of adhesive capsulitis is characterized by chronic synovial inflammation and progressive capsular fibrosis, especially affecting the RI and CHL [2]. This anatomical pattern forms the basis for targeted injection strategies. For example, IA injections directed at the GH joint primarily modulate synovial inflammation, while those into the SA space may reduce concurrent bursitis-related symptoms [6]. Injection into the RI, a region often involved in early capsular tightening, may offer more direct access to fibrotic tissue, potentially facilitating greater gains in shoulder mobility [7]. Findings from this review align with these anatomical considerations, as several studies reported better early outcomes when injection sites were chosen based on the location of maximal symptoms or administered via anterior approaches, particularly through the RI [21,35].

The therapeutic action of corticosteroids is well-established; they suppress local cytokine activity, reduce synovial hypertrophy, and inhibit fibroblast proliferation [62]. HA contributes to symptom relief by restoring joint viscoelasticity and limiting local inflammation through interaction with CD44 and other hyaladherins [63]. While corticosteroids generally deliver faster symptom relief, HA appears to yield comparable long-term functional outcomes and may be preferable in patients at risk for steroid-related complications [43]. Notably, HA combined with capsular distension has been shown to produce mechanical stretching of the capsule while enhancing joint lubrication, which may explain its specific benefit in restoring external rotation [45]. PRP, rich in growth factors such as platelet-derived growth factor and transforming growth factor-β, offers a distinct mechanism by modulating inflammation and promoting tissue remodeling [64]. PRP modulates all phases of tissue repair, promoting capsular healing by reducing synovial inflammation and hyperplasia [10]. This process supports pain relief and improves shoulder mobility, with some evidence suggesting greater synovial remodeling compared to corticosteroids [65]. This biological mechanism aligns with clinical observations of delayed but more durable improvements in pain and shoulder function seen in trials comparing PRP to corticosteroids [55,56,58]. These findings suggest that PRP may serve as a valuable option for long-term management, particularly in chronic or refractory cases.

HD offers a distinct mechanistic approach based on the mechanical disruption of capsular adhesions [66]. The controlled infusion of saline, typically combined with corticosteroids or local anesthetics, helps stretch and separate fibrotic layers within the joint capsule, resulting in immediate gains in ROM [66]. Early improvements in mobility are frequently observed, particularly when HD is administered in combination with corticosteroids [42,44,49]. However, its long-term advantage over corticosteroid injection alone remains uncertain [53]. Notably, hypertonic saline has been linked to greater early improvements, possibly due to osmotic effects that promote tissue expansion and reduce edema [48].

ESWT provides a non-invasive alternative that targets both mechanical and neurophysiological aspects of adhesive capsulitis [14]. By delivering focused or radial acoustic pulses, ESWT is thought to promote neovascularization, reduce fibrotic tissue accumulation, and modulate pain perception through mechanisms such as gate-control theory, hyperstimulation analgesia, and substance P downregulation [67]. Additional effects may include disruption of unmyelinated nerve fibers and increased nitric oxide production, contributing to both analgesia and tissue remodeling [67]. Both focused and radial forms of ESWT have been studied. Focused ESWT delivers high-energy waves that penetrate deeper tissues, which may be particularly useful for targeting the joint capsule [68,69]. Radial ESWT, on the other hand, disperses energy over a broader area, making it suitable for periarticular soft tissue involvement and easier to apply without anesthesia [68]. Its greater accessibility, tolerability, and ease of use likely explain why most existing RCTs, including those identified in this review, have focused on radial ESWT. These findings suggest that both focused and radial ESWT may have clinical value, although further direct comparative studies are needed. Trials comparing ESWT with steroid injections suggest comparable or even superior outcomes at mid-term follow-up, particularly in terms of function and disability scores [60]. Unlike pharmacologic agents, ESWT may directly address capsular stiffness, making it an appealing option for the frozen stage of the disease [14].

PRF delivers alternating electromagnetic fields to periarticular tissues, modulating cell membrane function, disrupting A-delta and C fiber transmission, and reducing inflammatory cytokines such as interleukin-1 beta, tumor necrosis factor-alpha, and interleukin-6 [70]. Without generating destructive heat, PRF may suppress chronic pain pathways, modulate immune responses, and promote capsular healing in adhesive capsulitis [16]. PRF has demonstrated superior mid-term pain relief and functional improvements compared to corticosteroids, likely through its combined effects on neuromodulation and immune response modulation [16].

Acupotomy targets dense fibrotic bands through percutaneous release, mechanically addressing capsular restrictions. When combined with HD, this technique may allow better joint expansion and quicker ROM gains [17]. Ozone injection, by contrast, exerts mild anti-inflammatory and analgesic effects through reactive oxygen species modulation but has not demonstrated clear superiority over standard injectates [16].

Taken together, these findings support a move toward more individualized and stage-specific treatment approaches for adhesive capsulitis. During the early phase, when pain is the predominant symptom, corticosteroid injections administered to anatomically relevant sites remain a practical first-line choice. For patients who are not suitable candidates for corticosteroids, injections with HA or NSAIDs may serve as effective alternatives. As the condition progresses into subacute or chronic stages characterized by increasing fibrosis and stiffness, interventions such as HD, PRP injection, and ESWT may offer more substantial therapeutic benefit. Clinical decision-making should take into account the evolving pathophysiology and changing symptom patterns throughout the course of the disease.

Non-surgical treatments for adhesive capsulitis are generally safe and well tolerated, but potential adverse effects should still be acknowledged. In a systematic review, corticosteroid injections may cause mild and transient side effects such as post-injection pain (29.8 %), facial flushing (12.3 %), or menstrual irregularities (10.1 %) [71]. Serious complications like tendon rupture or joint infection are exceedingly rare and were not reported in the RCTs included in this review. Meta-analyses have similarly shown a very low incidence of adverse events, most of which did not require additional medical intervention [71,72]. In patients with diabetes, local corticosteroid injections may lead to short-term increases in blood glucose levels; however, these changes typically resolve within a few days without adjustments in treatment [73]. HD may result in temporary discomfort [66], and ESWT can occasionally cause mild pain during or immediately after treatment [60,68]. Overall, these side effects are infrequent and non-serious, supporting the favorable safety profile of non-surgical treatment strategies when applied with appropriate patient selection and clinical monitoring.

Although the findings from this review offer valuable clinical insights, several important limitations and methodological issues should be acknowledged. First, considerable heterogeneity exists among the included studies in terms of patient characteristics, including age distribution, symptom duration, baseline functional status, and the presence of comorbidities such as diabetes or thyroid dysfunction. These factors are known to influence disease severity and treatment responsiveness, yet they were inconsistently reported or controlled across trials, making direct comparisons and pooled interpretation difficult. Second, most trials did not stratify patients by disease stage, despite well-established differences in treatment response across the freezing, frozen, and thawing phases. Third, while most studies evaluated short-to mid-term outcomes (typically within 12 weeks), relatively few provided long-term follow-up extending beyond six months. As a result, the durability of symptom relief, functional recovery, and recurrence rates remains poorly characterized, limiting conclusions about the sustained efficacy of various interventions. Finally, there was substantial variability in procedural and pharmacologic protocols. PRP preparation methods differed in terms of platelet concentration, leukocyte content, and activation technique; HA injections varied by molecular weight and viscosity; HD protocols used different volumes and compositions; and ESWT and PRF applications employed heterogeneous devices, energy levels, and treatment frequencies.

Future research should aim to establish standardized protocols for each treatment modality and stratify patients based on disease stage and symptom duration. Additionally, investigating the synergistic effects of combining therapies, such as the use of PRP in conjunction with ESWT, may offer further clinical benefits and should be explored in future studies. Finally, advancing care for adhesive capsulitis will require interdisciplinary collaboration among rehabilitation physicians, orthopedic surgeons, pain specialists, and musculoskeletal radiologists to develop comprehensive and stage-specific management strategies.

5. Conclusions

Non-surgical treatments for adhesive capsulitis, including targeted injections and novel non-invasive modalities, are effective in reducing pain and improving function. Treatment should be individualized based on disease stage and anatomy. Further research is needed to confirm long-term outcomes and optimize protocols.

Author statement

All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by Shu-Mei Yang, Shu-Chiang Hsu, and Ming-Yen Hsiao. The first draft of the manuscript was written by Shu-Mei Yang and Shu-Chiang Hsu, and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

Ethical approval

This narrative review is based on previously published studies and does not involve any new research conducted by the authors involving human participants or animals.

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Declaration of competing interest

The authors stated that there are no conflicts of interest related to the research, authorship, and/or publication of this article.

Data availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

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