Systematic Review

Comparison of Effectiveness of Intraarticular Hyaluronate and Corticosteroid injections in Adhesive Capsulitis: A Systematic Review and Meta-analysis

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Background: Adhesive capsulitis of the shoulder causes inflammation and adhesions in the shoulder joint capsule, leading to pain and limited range of motion (ROM). Intraarticular corticosteroid (CS) and hyaluronic acid (HA) injections are common therapeutic options for adhesive capsulitis, but their comparative effectiveness remains unclear.

Objectives: To provide a robust comparison of the outcomes of HA and CS, we conducted a meta-analysis of relevant previous studies that examined the therapeutic effects of intraarticular HA and CS injections in patients with adhesive capsulitis.

Study Design: Systematic review and meta-analysis.

Methods: This meta-analysis of randomized controlled trials compared the effectiveness of intraarticular HA and CS injections. Of the 10,205 articles, 7 met our predetermined criteria and were included in the analysis.

Results: Patients who received CS injections demonstrated superior pain reduction and functional improvement at 2-4 weeks after injection to those who received HA injections. Nevertheless, comparable outcomes were observed between the 2 groups at 6 and 12 weeks. The active or passive range of motion of the shoulder joint was not significantly different between patients who received HA injections and those who received CS injections.

Limitations: The meta-analysis included only a small number of studies, and the number of HA injections examined in those studies varied from one to 3 at a time, whereas an CS injection was performed only once in most of the included studies.

Conclusions: The administration of intraarticular HA injection emerges as a commendable therapeutic option for patients with adhesive capsulitis, particularly for those requiring repetitive injections or at risk of developing side effects from injections of CS. Although intraarticular CS injections offer accelerated short-term (2-4 weeks) pain relief and functional improvement, comparable effects were observed within 6 and 12 weeks after intraarticular HA and CS injections.

Key words: Adhesive capsulitis, shoulder, corticosteroid, hyaluronic acid, pain, function, injection, meta-analysis

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Adhesive capsulitis of the shoulder, commonly known as frozen shoulder, is characterized by inflammation and adhesions of the shoulder joint capsule, resulting in reduced joint volume and the progressive restriction of joint motion in multiple directions, the latter of which is accompanied by shoulder pain (1,2). Additionally, muscle loss around the shoulder may occur (3). Although the risk factors for this condition include shoulder injury or surgery, diabetes, and thyroid disease, the etiology remains elusive in a majority of cases (4).

Patients often experience severe shoulder pain, sleep disturbances, and functional impairment in daily activities due to limited joint mobility (3,5). To manage the symptoms of adhesive capsulitis, various treatment methods, including shoulder-joint range of motion (ROM) exercises, physiotherapy, oral medications, and manipulation, are employed (6,7). However, these conservative treatments do not frequently yield satisfactory therapeutic results. Intraarticular corticosteroid (CS) injections are one of the most effective conservative treatments for alleviating symptoms associated with adhesive capsulitis (8). CS is a potent anti-inflammatory material that inhibits the synthesis of various pro-inflammatory mediators (9). Thus, CS injections can relieve pain and improve patients' shoulder-joint ROM and functioning in daily activities (9). However, the use of CS is accompanied by various adverse effects, such as articular cartilage degeneration, tissue atrophy, fat necrosis, hyperglycemia, hematoma, infection, and vascular necrosis (10), so careful consideration of these potential drawbacks is necessary before CS injections are utilized.

Hyaluronic acid (HA) is a component of the synovial fluid that is essential for joint lubrication and chondroprotection (11). HA functions as a lubricant, facilitating smooth movement between bones, and serves as a shock absorber for joint mechanical loads. Therefore, intraarticular HA injections can facilitate movement of the shoulder joint and reduce pain in patients with adhesive capsulitis (12). Furthermore, HA suppresses cytokine-induced reactions and reduces synovial inflammation, relieving pain and improving joint mobility (11). Many previous studies have demonstrated the efficacy of intraarticular HA injections in controlling the symptoms of adhesive capsulitis, leading to clinicians' widespread adoption of the technique for the treatment of this condition (12-14). However, clinicians often lack comprehensive knowledge of CS and HA's comparative effectiveness.

In this study, to provide a robust comparison of the outcomes of HA and CS, we conducted a meta-analysis of relevant studies that examined the therapeutic effects of intraarticular HA and CS injections on patients with adhesive capsulitis.

Methods

Search Strategy

This meta-analysis was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analysis guidelines. We searched PubMed, Embase, Cochrane Library, SCOPUS, and KMbase systematically to find relevant articles published from each database's inception up to March 4, 2024. The following keywords were used during the search: (["shoulder" OR "glenohumeral" OR "adhesive capsulitis" OR "osteoarthritis" OR "frozen"] AND ["steroid" OR "corticosteroid"] AND ["hyaluronic" OR "hyaluronic acid"]) (Supplementary 1). The protocol was registered in the International Database to Register Systematic Review (number: INPLASY202430072).

Inclusion and Exclusion Criteria

The articles were selected based on the following inclusion criteria: (1) participants: patients with a diagnosis of adhesive capsulitis of the shoulder; (2) intervention: intraarticular HA injection; (3) comparator: intraarticular CS injection; (4) outcome: pain, shoulder function, or ROM; and (5) study design: randomized controlled trial (RCT). Meanwhile, (1) case reports, conference presentations, reviews, letters, or other undistinctive forms; (2) studies written in neither English nor Korean; and (3) studies reporting insufficient data or results were excluded.

Data Extraction

After duplicate studies were removed, 2 reviewers (KEU and MCC) evaluated the potentially eligible studies independently. The eligibility of the articles was determined by reviewing the title and abstract, and disagreements were resolved through consensus. The full texts of the eligible articles were read independently by the same reviewers (KEU and MCC), and the eligibility of each article was reassessed. Subsequently, the following data were extracted: first author, publication date, study type, number of patients, demographic information (age and gender), number of HA and CS injections, injection method used, follow-up time, and clinical outcomes (Visual Analog Scale [VAS], Shoulder Pain and Disability Index [SPADI] score, American Shoulder and Elbow Surgeons [ASES] score, Constant score, and active and passive ROM).

Quality Assessment

The Cochrane Handbook for Systematic Reviews of Interventions was used for assessing the risk of bias in RCTs, and the evaluation factors used were as follows: (1) adequate sequence generation, (2) blinding, (3) incomplete outcome data, (4) allocation concealment, (5) selective outcome reporting, and (6) other potential

sources of bias. The judgment of bias was expressed as "low risk," "high risk," or "unclear risk" (15).

Statistical Analysis

The Review Manager 5.3 software program (The Nordic Cochrane Centre for the Cochrane Collaboration) was used to perform a statistical analysis of the pooled data. In each analysis, a heterogeneity test was performed using a *P*-value: when a *P*-value was ≥0.05, the pooled data were considered homogenous, and a fixed-effects model was applied. By contrast, when the *P*-value was < 0.05, the pooled data were considered heterogeneous, and a random-effects model was used.

Continuous variables were analyzed, and standardized mean differences (SMDs) and 95% confidence intervals (CIs) were calculated.

A *P*-value of < 0.05 was considered significant. A funnel plot and Egger's test were performed to evaluate the publication bias, using R version 4.1.2. The publication bias of individual studies was determined based on pooled estimates, using funnel plots. Egger's test was used to determine whether the funnel plot was symmetrical. A *P*-value of < 0.05 was considered the indication of possible publication bias.

Results

Study Selection

A total of 10,205 articles were searched, and 1,747 duplicated articles were removed (Fig. 1). After the articles were screened for eligibility and their titles and abstracts reviewed, 55 articles were selected for full-text reading. Following a detailed assessment, 48 articles were excluded (articles including discussion of diseases other than adhesive capsulitis = 2, articles including observations of other types of interventions = 11, articles with unavailable data = 3, non-RCTs = 8, reviews = 15, letters to editor = one, conference papers = 7, and articles not written in English or Korean = one). Therefore, 7 studies were finally included in our meta-analysis (Table 1) (16-22). All the included studies were RCTs.

Study Characteristics

Seven studies were selected, which, in this case, meant that a total of 163 patients were sorted into the HA group and a total of 165 patients were sorted into the CS group. The detailed characteristics of each study are discussed in Table 1 (16-22).

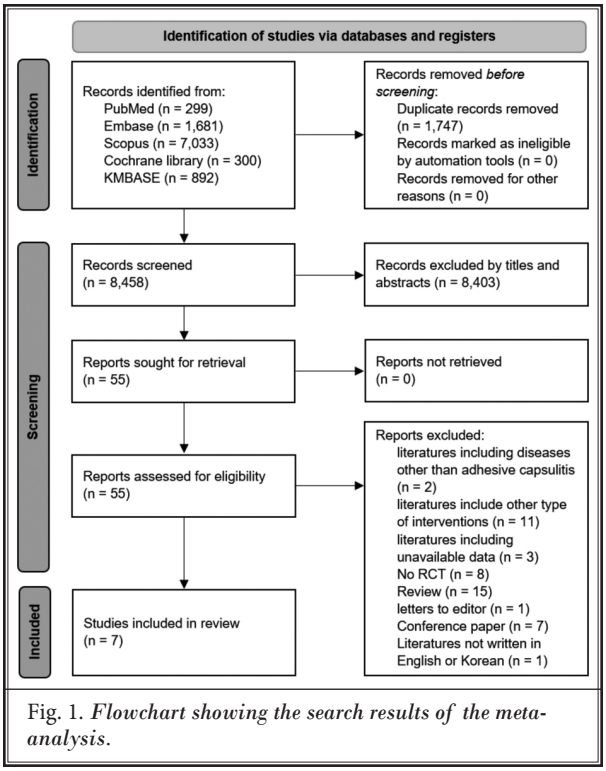

Fig. 1. *Flowchart showing the search results of the meta-analysis.*

Risk of Bias

Of the 7 included studies, 3 showed a low risk of bias in the random sequence generation category, while 2 studies showed a low risk of bias in the allocation concealment category (Fig. 2). Moveover, one and 4 studies were determined to have a low risk of bias in the blinding of patients and personnel and blinding of outcome assessment, respectively. In the incomplete outcome data category (21), all studies except for Park et al's were determined to have a low risk of bias. As for selective reporting and other biases, all 7 studies were also deemed to have a low risk of bias.

Meta-Analysis Results

In the analysis of VAS changes that occurred within 2-4 weeks after the HA and CS injections, the CS group exhibited a more pronounced reduction in VAS scores than did the HA group (Fig. 3A, random-effects model, $P < 0.001$, df = 5, SMD = –1.03, 95% CI = –1.52 to –0.55). However, no significant difference was observed in VAS changes between the HA and CS groups at 6 and 12 weeks (Fig. 3B and 3C, 6 weeks: random-effects model, $P = 0.14$, df = 1, SMD = –1.05, 95% CI = –2.43 to –0.33; 12 weeks: fixed-effects model, $P = 0.18$, df = 1, SMD = –0.29, 95% CI = –0.70 to 0.13).

In the analysis of SPADI score changes after the HA

Table 1. *Characteristics of the selected studies.*

No.	Study	Design	Patients	Intervention	Evaluation periods	Outcome measures
1	Calis et al 2005 (16)	Randomized controlled trial	HA group: n = 24 (joints = 27) (M:F = 10:14), age (mean ± SD) = 59.7 ± 9.81 years CS group: n = 25 (joints = 26) (M:F = 9:16), age (mean ± SD) = 56.36 ± 11.3 years	HA group: sodium hyaluronate 30 mg (Orthovisc 30 mg) was injected into the shoulder joint through the posterior approach weekly for 2 weeks. CS group: a 40 mg dose of triamsinolone asetonide (Kenakort-A) was injected into the shoulder joint through the posterior approach.	2 weeks and 3 months	VAS scores, Constant scores, and PROM (abduction and external rotation)
2	Kim et al 1999 (18)	Randomized controlled trial	HA group: n = 13 (M:F = 4:9), age (mean ± SD) = 54.9 ± 13.5 years CS group: n = 13 (M:F = 4:9), age (mean ± SD) = 52.7 ± 13.9 years	HA group: hyaluronic acid 2 mL + 1% lidocaine 3 mL (total: 5 mL) CS group: triamcinolone 1 mL (40 mg) + 1% lidocaine 3 mL + normal saline 25 mL (total: 29 mL)	30 min, one week, and 2 weeks	VAS scores and AROM (flexion, abduction, external rotation, and internal rotation)
3	Kim et al 2007 (17)	Randomized controlled trial	HA group: n = 14 (M:F = 9:5), age (mean ± SD) = 52.7 ± 7.89 years CS group: n = 12 (M:F = 9:3), age (mean ± SD) = 53.4 ± 7.23 years	HA group: 0.5% lidocaine 8 mL and hyaluronic acid 2 mL once a week for 3 times CS group: 0.5% Lidocaine 9 mL with triamcinolone 40 mg (1 mL) in the first and third week and 0.5% lidocaine 10 mL without triamcinolone in the second week	one week and 2 weeks	VAS scores, SPADI scores, and APROM/PROM (flexion, extension, abduction, external rotation, and internal rotation)
4	Lim et al 2014 (19)	Randomized controlled trial	HA group: n = 29 CS group: n = 34	HA group: patients received 2 mL injections of sodium hyaluronate at a dosage of 10 mg/mL, 3 times, one week apart (Hyruan Plus, LG Life Science Ltd.; a highly purified and high-molecular-weight hyaluronate with an average molecular weight of 3,000 kDa). CS group: patients received a single injection with a mixture of 1 mL 1% lidocaine and 1 mL (40 mg) methylprednisolone acetate (Depo-Medrol; Pfizer).	2 weeks and 12 weeks	VAS scores, ASES scores, Constant scores, and PROM (forward elevation, external rotation, and internal rotation)
5	Oh et al 2021 (20)	Randomized controlled trial	HA group: n = 15 (M:F = 9:6), age (mean ± SD) = 54.5 ± 5.1 years CS group: n = 15 (M:F = 5:10), age (mean ± SD) = 52.3 ± 8.5 years	HA group: 2 mL of high-molecular-weight hyaluronic acid with an average molecular weight of 3,000 kDa (Hyruan Plus), 2 mL of saline, and 4 mL of contrast media CS group: 1 mL of triamcinolone acetonide (40 mg/mL), 3 mL of saline, and 4 mL of contrast media	one day, one week, one month, 3 months, and 6 months	SPADI scores, ASES scores, Constant scores, UCLA scores, DASH scores, SST scores, VAS scores, and AROM/PROM (forward flexion, abduction, external rotation, and internal rotation)

Table 1 cont. *Characteristics of the selected studies.*

No.	Study	Design	Patients	Intervention	Evaluation periods	Outcome measures
6	Park et al 2013 (21)	Randomized controlled trial	HA group: n = 45 (M:F = 10:35), age (mean ± SD) = 56.33 ± 5.92 years CS group: n = 45 (M:F = 12:33), age (mean ± SD) = 55.23 ± 4.69 years	HA group: 0.5% lidocaine administered (18 mL) for capsular distension along with high molecular weight sodium hyaluronate (10 mg/mL, 2 mL) CS group: a mixture of 0.5% lidocaine (4 mL) plus triamcinolone (40 mg/mL, 1 mL) administered All injections were performed every 2 weeks three times.	2 weeks and 6 weeks	SPADI scores, VNS scores, and PROM (flexion, abduction, and external rotation)
7	Sayed et al 2022 (22)	Randomized controlled trial	HA group: n = 20 (M:F = 6:14), age (years) = 51.00 Median (IRQ) = (46.0-55.0) CS group: n = 20 (M:F = 4:16), age (years) = 51.50 Median (IRQ) = (42.0-60.0)	HA group: twenty patients received ultrasound-guided intraarticular injections of hyaluronic acid (4 mL of 2% lidocaine and 2 mL of hyaluronic acid). CS group: twenty patients received ultrasound-guided intraarticular injections of steroids (4 mL of 2% lidocaine and 2 mL of 40 mg/mL triamcinolone)	one week, 3 weeks, and 6 weeks	VAS scores, ARPM/ PROM (flexion, abduction, and external rotation), and disability scores

HA, hyaluronic acid; CS, corticosteroid; VAS, visual analog scale; AROM, active range of motion; PROM, passive range of motion; SPADI, Shoulder Pain and Disability Index; ASES, American Shoulder and Elbow Surgeons; Constant, Constant system; UCLA, University of California—Los Angeles system; DASH, Disabilities of the Arm, the Shoulder and Hand system; SST, Simple Shoulder test

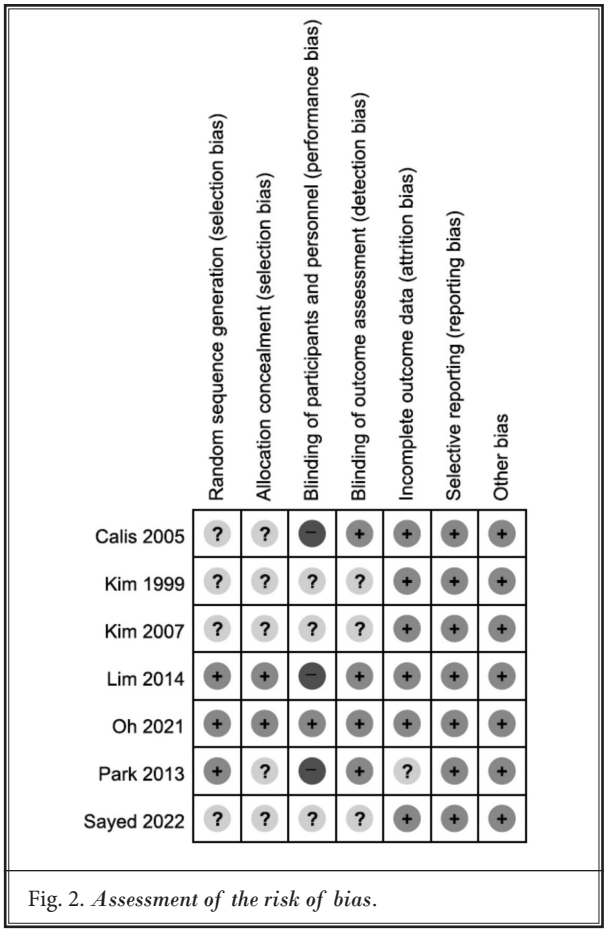

Fig. 2. *Assessment of the risk of bias.*

and CS injections, at 2-4, 6, and 12 weeks, no significant difference was observed between the 2 groups (Fig. 4A-C, 2-4 weeks: random-effects model, $P = 0.19$, df = 2, SMD = –1.06, 95% CI = –2.66, 0.54; 6 weeks: $P = 0.06$, SMD = –0.41, 95% CI = –0.82 to 0.01; 12 weeks: $P = 0.16$, SMD = –0.52, 95% CI = –1.25 to 0.21).

At 2–4 weeks after HA and CS injections, ASES score changes were significantly larger in the CS group than in the HA group (Fig. 5A, fixed-effects model, $P = 0.04$, df = 1, SMD = 0.44, 95% CI = 0.03 to 0.86). However, at 12 weeks, no significant difference was observed in the ASES score changes between the HA and CS groups (Fig. 5B, fixed-effects model, $P = 0.20$, df = 1, SMD = 0.27, 95% CI = –0.14 to 0.68).

Constant score changes were significantly larger in the CS group than in the HA group at 2-4 weeks after the injections (Fig. 6A, fixed-effects model, $P = 0.006$, df = 2, SMD = 0.47, 95% CI = 0.14 to 0.80, small effect). At 12 weeks, however, no significant difference was observed in the Constant score changes between the

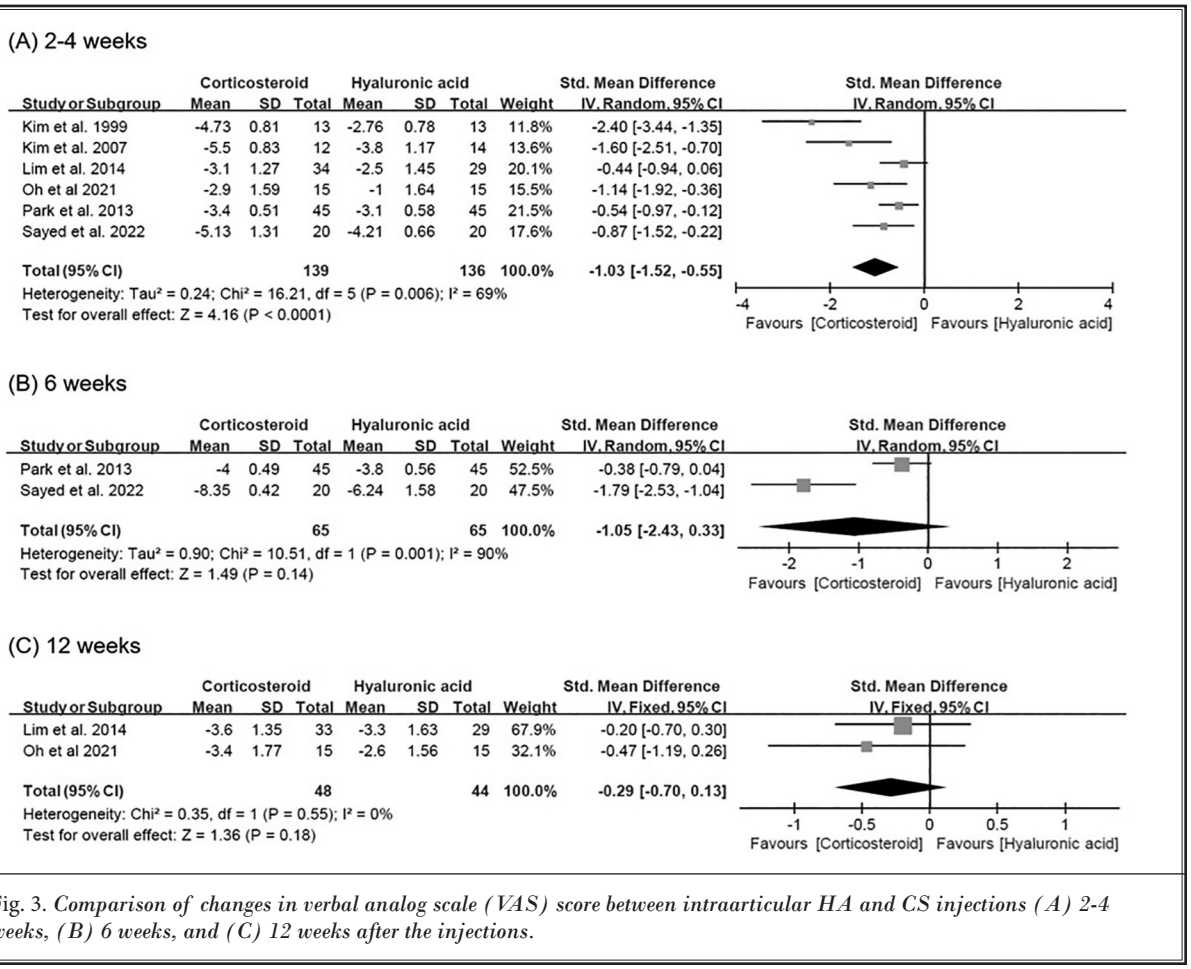

Fig. 3. *Comparison of changes in verbal analog scale (VAS) score between intraarticular HA and CS injections (A) 2-4 weeks, (B) 6 weeks, and (C) 12 weeks after the injections.*

groups (Fig. 6B, random-effects model, $P = 0.99$, df = 2, SMD = 0.00, 95% CI = –0.64 to 0.63).

The ROMs of active abduction, forward flexion, and external rotation were not significantly different between the 2 groups at 2-4, 6, or 12 weeks after the HA and CS injections (Fig. 7A-C, active abduction—2-4 weeks: fixed-effects model, $P = 0.05$, df = 2, SMD = 0.41, 95% CI = 0.00 to 0.83; 6 weeks: $P = 0.99$, SMD = 0.00, 95% CI = –0.62 to 0.61; 12 weeks: fixed-effects model, $P = 0.85$, df = 1, SMD = 0.04, 95% CI = –0.39 to 0.48; Fig. 8A-C, active forward flexion—2-4 weeks: random-effects model, $P = 0.05$, df = 2, SMD = 1.11, 95% CI = –0.02 to 2.23; 6 weeks: $P = 0.24$, SMD = 0.38, 95% CI = –0.25 to 1.00; 12 weeks: $P = 0.13$, SMD = 0.57, 95% CI = –0.17 to 1.30; Fig. 9A-C, active external rotation—2-4 weeks: fixed-effects model, $P = 0.26$, df = 2, SMD = 0.24, 95% CI = –0.17 to 0.64; 6 weeks: $P = 0.84$, SMD = 0.06, 95% CI = –0.56 to 0.68; 12 weeks: random-effects model, $P = 0.83$, df = 1, SMD = 0.14, 95% CI = –1.12 to 1.40). The ROMs of active internal rotation were significantly higher in the CS group than in the HA group at 2-4 and 12 weeks (Fig. 10A and 10B, 2-4 weeks: fixed-effects model, $P < 0.001$, df = 1, SMD = 1.15, 95% CI = 0.58 to 1.72; 12 weeks: $P = 0.009$, SMD = 1.02, 95% CI = 0.25 to 1.79).

The 2 groups' respective changes in ROM of passive abduction were not significantly different at 2-4, 6, and 12 weeks after the injections (Fig. 11A-C, 2-4 weeks: fixed-effects model, $P = 0.80$, df = 3, SMD = 0.03, 95% CI = –0.24 to 0.30; 6 weeks: fixed-effects model, $P = 0.42$, SMD = 0.14, 95% CI = –0.20 to 0.49; 12 weeks: random-effects model, $P = 0.61$, df = 1, SMD = 0.30, 95% CI = –0.85 to 1.45). The ROM changes of passive forward flexion were not significantly different at 2-4 and 6 weeks; at 12 weeks, the ROM changes were significantly larger in the CS group than in the HA group (Fig. 12A-C, 2-4 weeks: fixed-effects model, $P = 0.08$, df = 3, SMD = 0.27, 95% CI = 0.00 to 0.53; 6 weeks: fixed-effects model, P

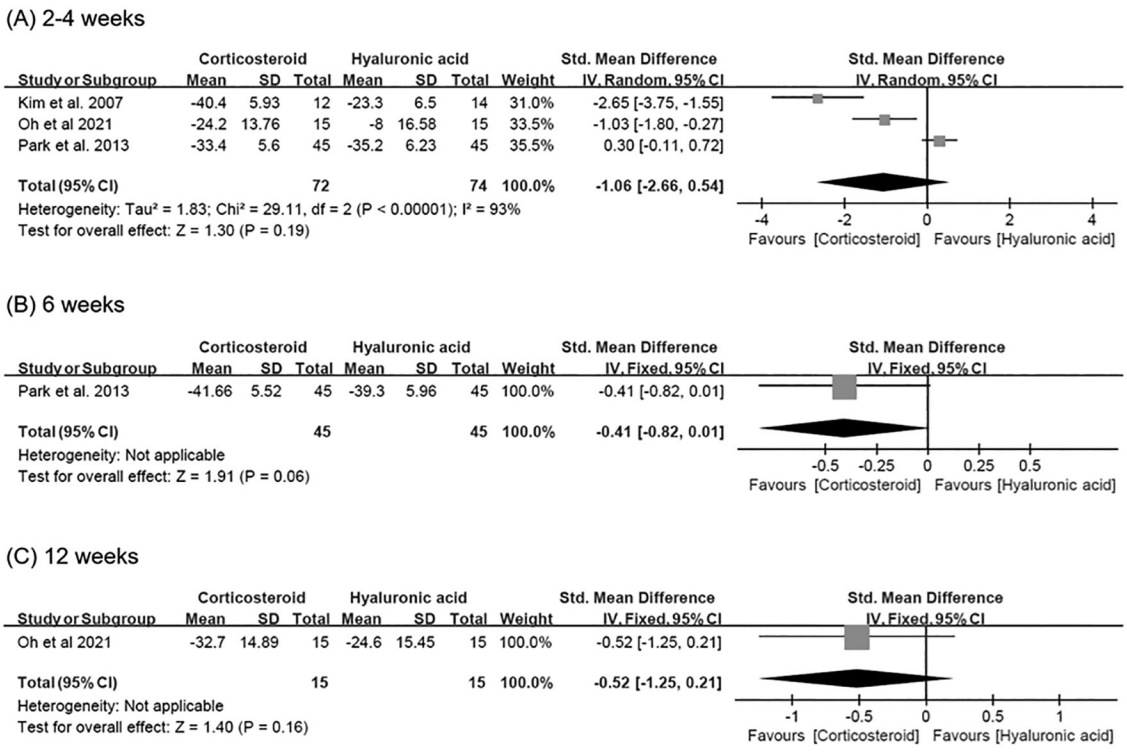

Fig. 4. *Comparison of changes in SPADI scores between intraarticular HA and CS injections at (A) 2-4 weeks, (B) 6 weeks, and (C) 12 weeks after the injections.*

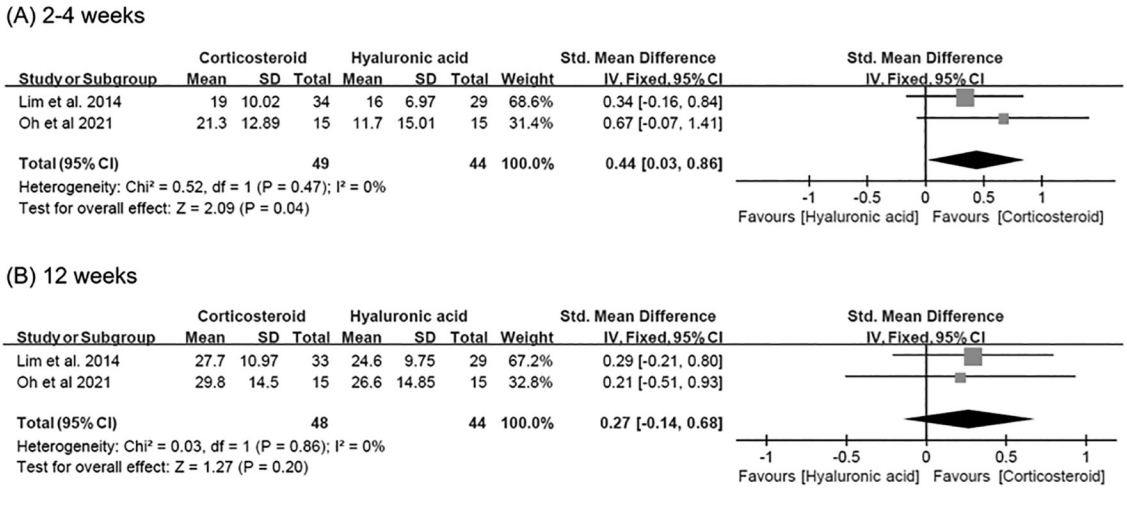

Fig. 5. *Comparison of changes in ASES scores between intraarticular HA and CS injections at (A) 2-4 weeks and (B) 12 weeks after the injections.*

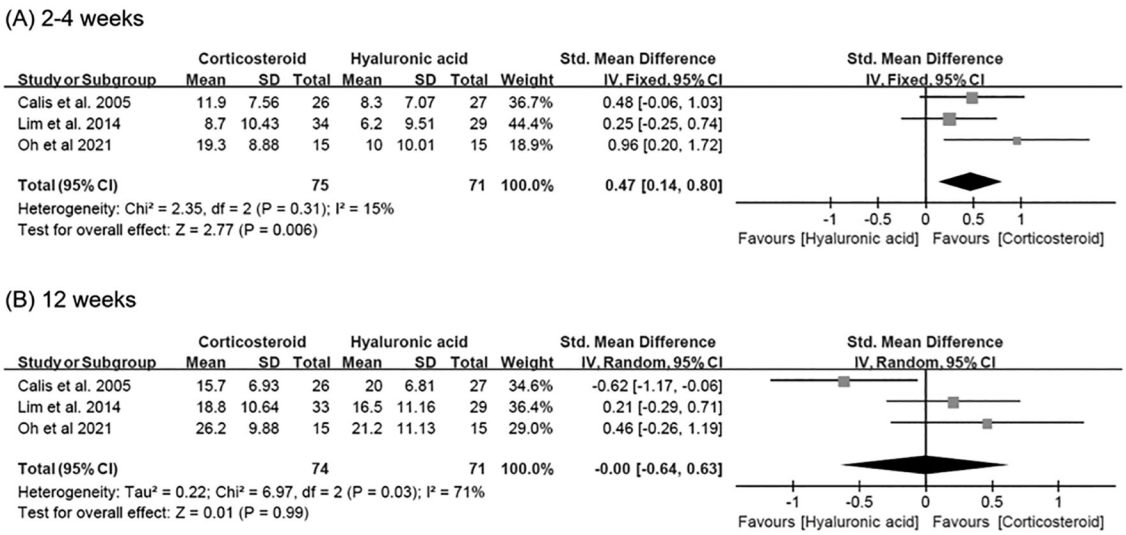

Fig. 6. *Comparison of changes in constant scores between intraarticular HA and CS injections at (A) 2-4 weeks and (B) 12 weeks after the injections.*

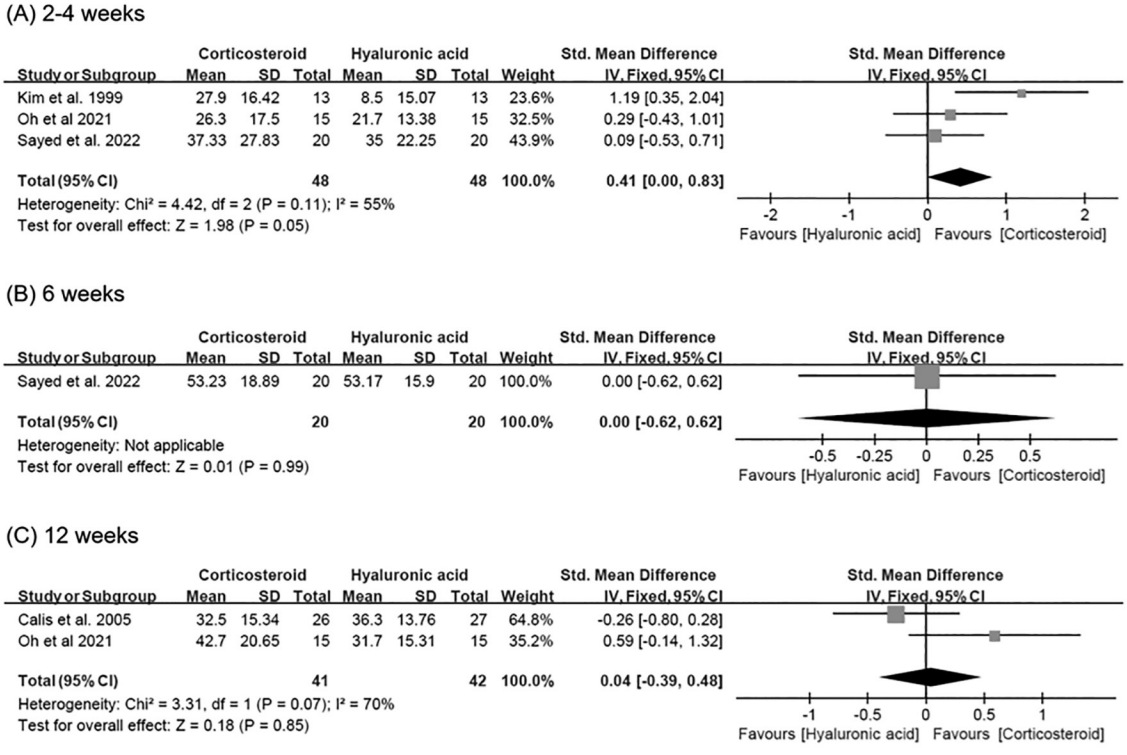

Fig. 7. *Comparison of changes in the ROM of active abduction between intraarticular HA and CS injections at (A) 2-4 weeks, (B) 6 weeks, and (C) 12 weeks after the injections.*

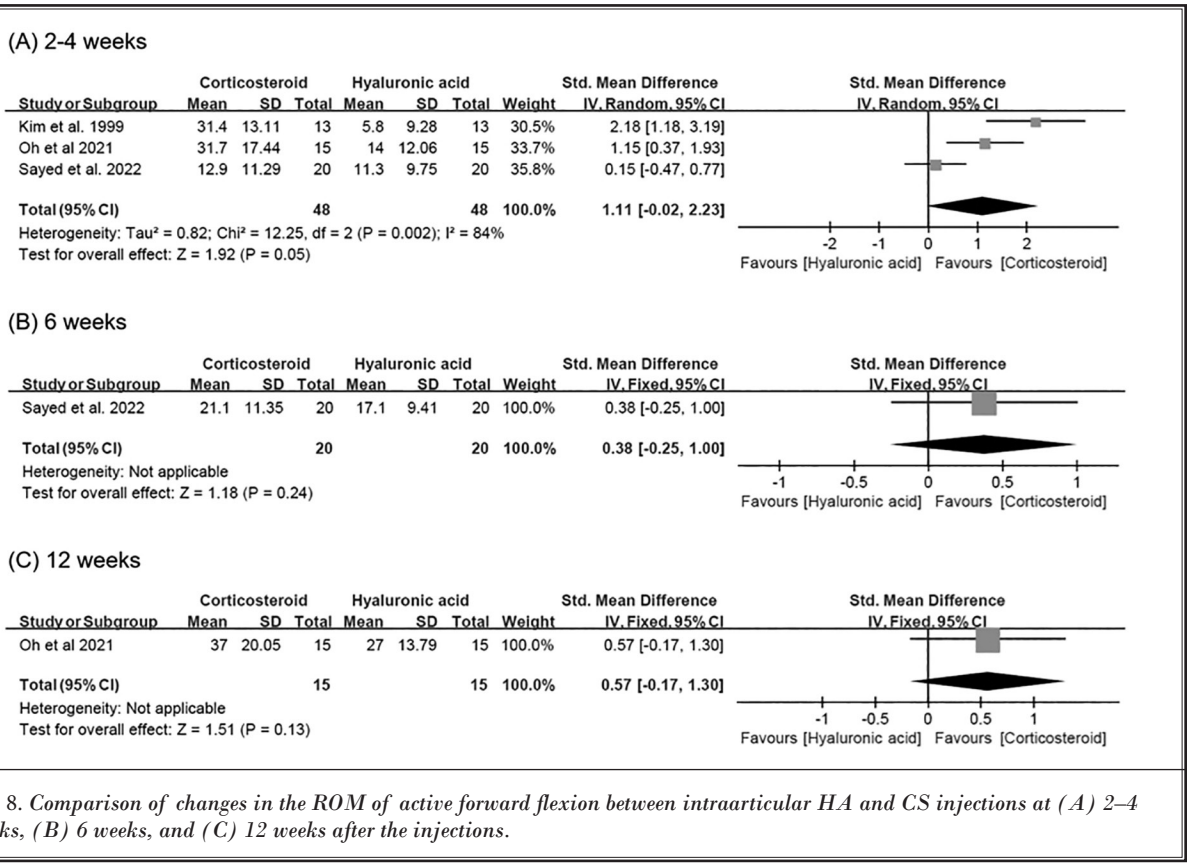

Fig. 8. *Comparison of changes in the ROM of active forward flexion between intraarticular HA and CS injections at (A) 2–4 weeks, (B) 6 weeks, and (C) 12 weeks after the injections.*

= 0.68, SMD = 0.07, 95% CI = –0.27 to 0.42; 12 weeks: fixed-effects model, *P* = 0.02, df = 1, SMD = 0.50, 95% CI = 0.08 to 0.91). No significant difference between the HA and CS groups' ROM changes of passive external rotation was observed at 2-4, 6, and 12 weeks after the injections (Fig. 13A-C, 2–4 weeks: random-effects model, *P* = 0.55, df = 4, SMD = 0.20, 95% CI = –0.45 to 0.84; 6 weeks: random-effects model, *P* = 0.09, SMD = 1.14, 95% CI = –0.16 to 2.43; 12 weeks: fixed-effects model, *P* = 0.75, df = 2, SMD = 0.17, 95% CI = –0.88 to 1.22). As for the ROM changes of passive internal rotation, the CS groups exhibited significantly larger changes than did the HA group at 2-4 and 12 weeks after the injections (Fig. 14A and 14B, 2-4 weeks: random-effects model, *P* < 0.001, SMD = 1.91, 95% CI = 1.02 to 2.79; 12 weeks: *P* = 0.005, SMD = 1.11, 95% CI = 0.34 to 1.89).

Publication Bias

A funnel plot analysis and Egger's test were conducted to analyze the VAS scores at 2-4 weeks, the SPADI scores at 2-4 weeks, the Constant scores at 2-4 weeks, the Constant scores at 12 weeks, the passive range of motion (PROM) of abduction at 2-4 weeks, the PROM of external rotation at 2-4 weeks, the PROM of external rotation at 12 weeks, the PROM of forward flexion at 2-4 weeks, the active range of motion (AROM) of abduction at 2-4 weeks, the AROM of external rotation at 2-4 weeks, and AROM of forward flexion at 2-4 weeks (Supplementary 2). The *P*-value for the Egger's test was > 0.05, except for 2 variables (VAS score at 2-4 weeks: *P* = 0.005; SPADI SCORE at 2-4 weeks: *P* = 0.046), indicating an insignificant publication bias (Constant score at 2-4 weeks: *P* = 0.124; Constant score at 12 weeks: *P* = 0.788; AROM abduction at 2-4 weeks: *P* = 0.200; AROM of forward flexion at 2-4 weeks: *P* = 0.055; AROM external rotation at 2-4 weeks: *P* = 0.211; PROM of abduction at 2-4 weeks: *P* = 0.830; PROM of forward flexion at 2-4 weeks: *P* = 0.534; PROM of external rotation at 2-4 weeks: *P* = 0.093; PROM of external rotation at 12 weeks: *P* = 0.134).

Discussion

In the current meta-analysis, significant reductions were observed in the VAS scores, indicative of pain in-

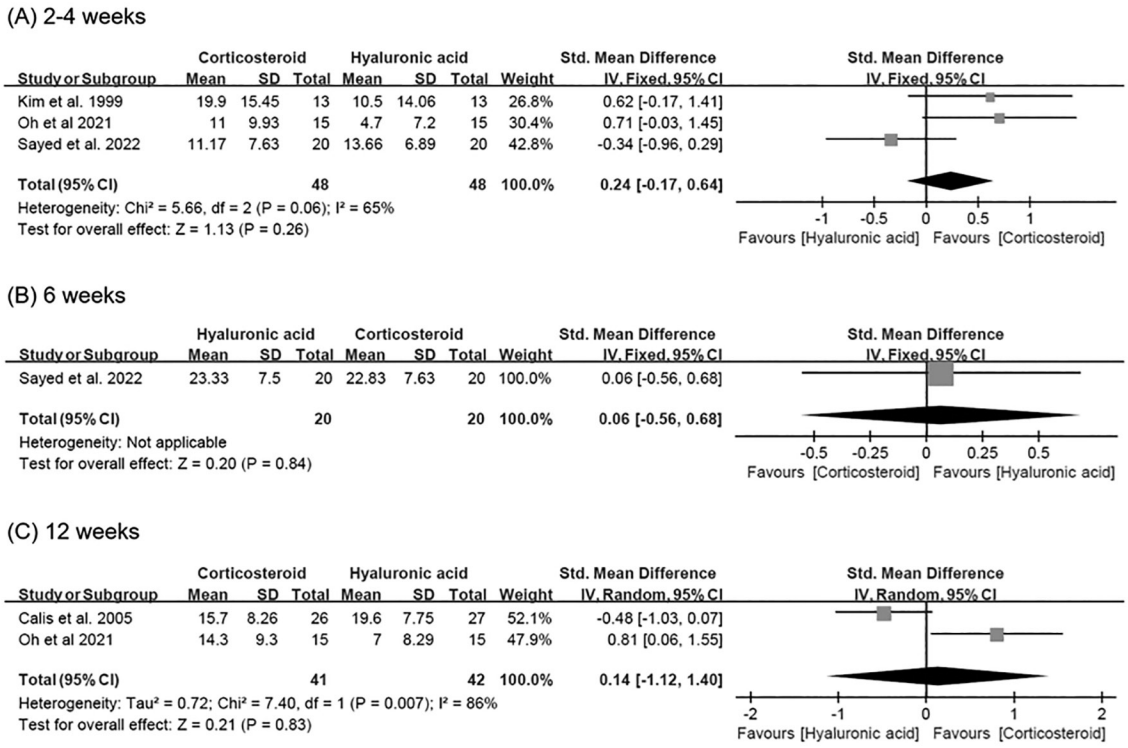

Fig. 9. *Comparison of changes in the ROM of active external rotation between intraarticular HA and CS injections at (A) 2-4 weeks, (B) 6 weeks, and (C) 12 weeks after the injections.*

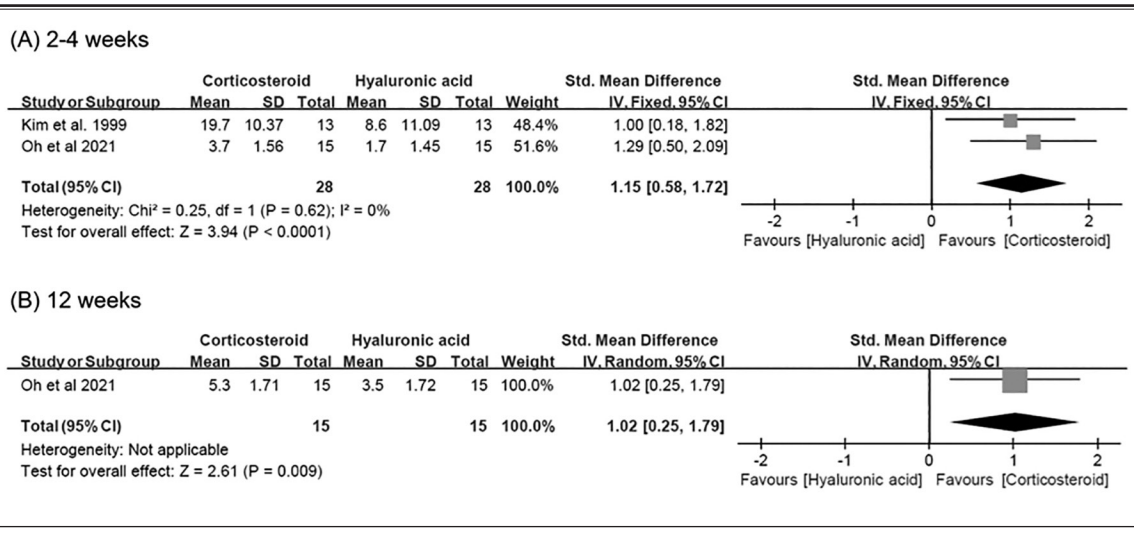

Fig. 10. *Comparison of changes in the ROM of active external rotation between intraarticular HA and CS injections at (A) 2-4 weeks and (B) 12 weeks after the injections.*

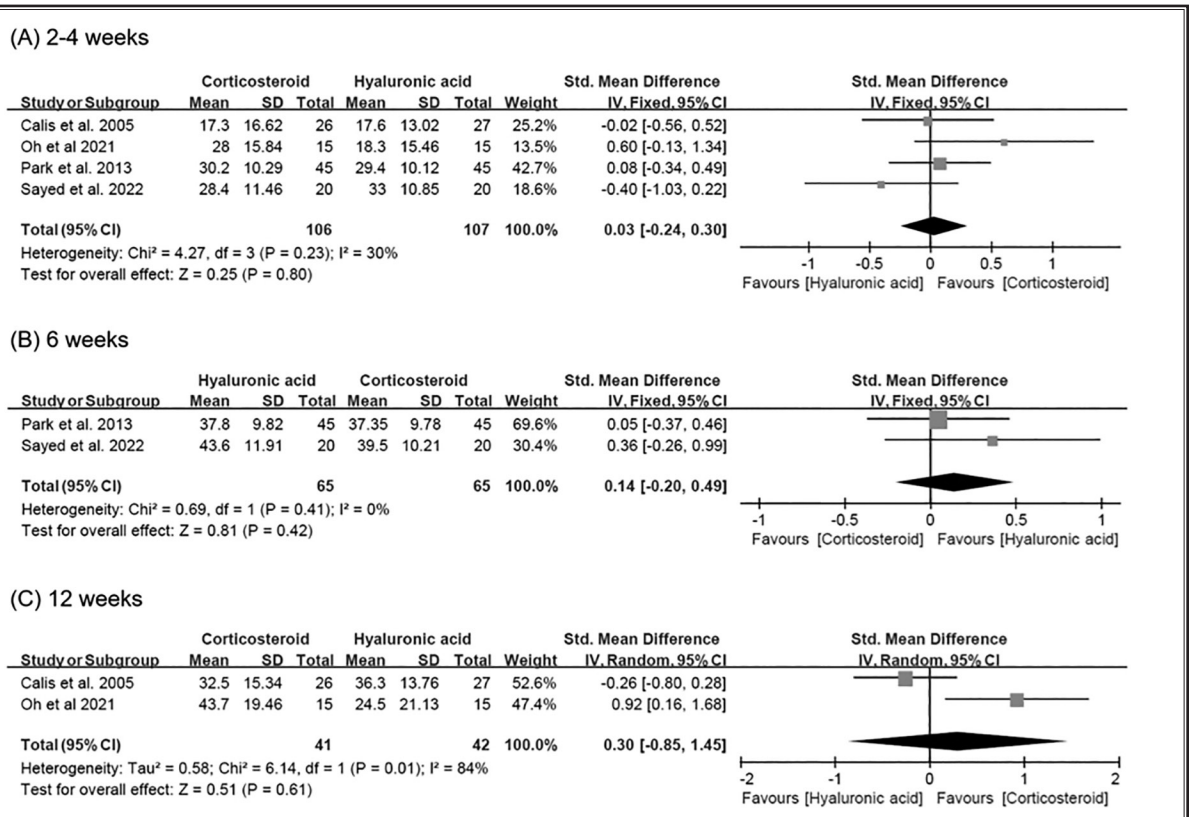

Fig. 11. *Comparison of changes in the ROM of passive abduction between intraarticular HA and CS injections at (A) 2-4 weeks, (B) 6 weeks, and (C) 12 weeks after the injections.*

tensity, of patients with adhesive capsulitis. The ASES and Constant scores, reflecting both pain degree and shoulder function, were significantly higher at 2-4 weeks after CS injections than were those after HA injections. However, we did not observe significant differences in the changes in these scores at 6 and 12 weeks after the CS or HA injections. Additionally, the changes in SPADI scores, which presented pain degree and shoulder function after CS and HA injections, were not significantly different at all evaluation time points. The improvements in the active and passive internal rotation of the shoulder joint after the CS injections were greater than those observed after the HA injections. Additionally, the improvement in passive forward flexion at 12 weeks was greater after the CS injections than it was after the HA injections. However, the improvements in the other ROMs, including active forward flexion, active and passive abduction, and external rotation, were not different between the patients who received HA injections and those who received CS injections.

Many previous studies have demonstrated that intraarticular HA and CS injections have short-term and long-term pain-reducing and function-improving effects in patients with adhesive capsulitis (12,16-23). In our meta-analysis, although CS injections showed more favorable outcomes in certain therapeutic aspects, including short-term pain reduction, functional improvement, and specific measures of ROMs, the CS group's results at ≥ 6 weeks post-injection were similar to the HA group's. Additionally, the ROMs of external rotation and abduction did not significantly differ between the 2 groups of patients. Considering these findings and the favorable safety profile of HA injections, which have minimal side effects (24,25), HA injections emerge as a viable therapeutic option that can potentially replace injections of CS for patients who are likely to experience adverse effects from CS or who require multiple CS injections. Conversely, intraarticular CS injections may be more beneficial for individuals who experience severe pain from adhesive capsulitis and require rapid pain relief.

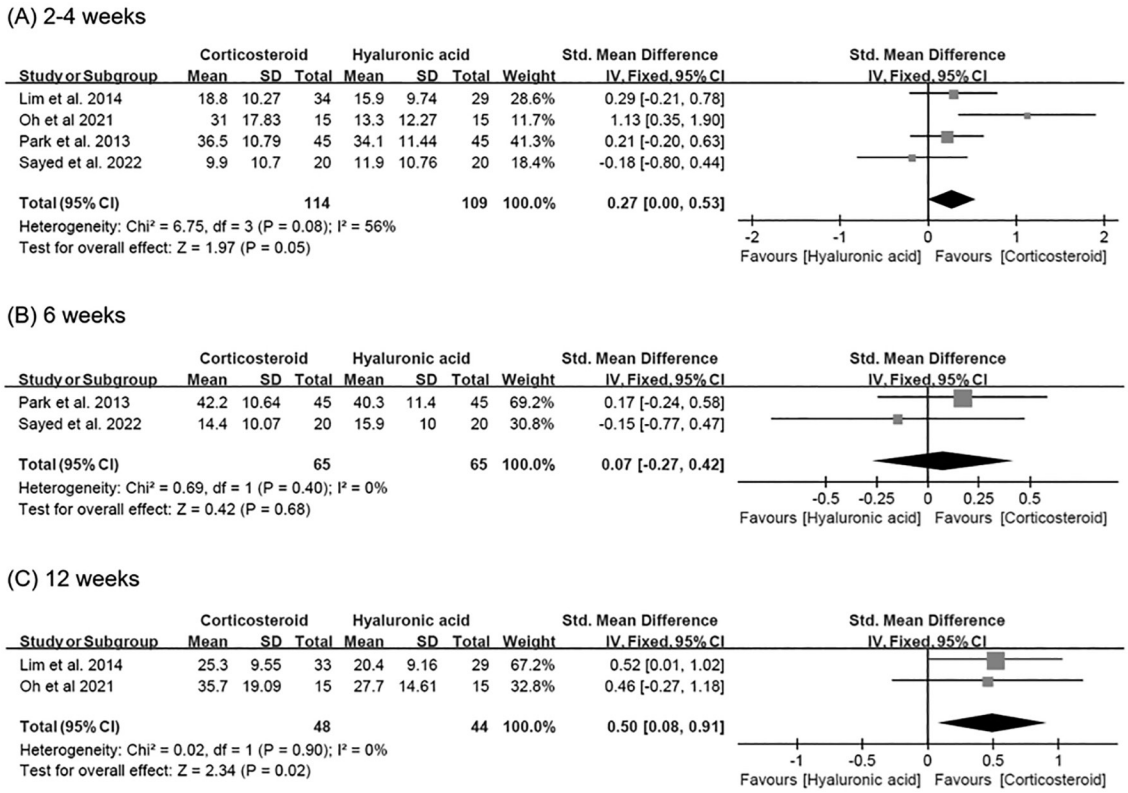

Fig. 12. *Comparison of changes in the ROM of passive forward flexion between intraarticular HA and CS injections at (A) 2-4 weeks, (B) 6 weeks, and (C) 12 weeks after the injections.*

Several mechanisms of stimulating HA action in the joints to manage the symptoms of adhesive capsulitis have been proposed (14,26,27). First, the injection of HA can increase viscoelasticity and reduce friction in the shoulder joint. Second, HA exhibits anti-inflammatory effects. Tamai et al reported that gadolinium-enhanced magnetic resonance imaging scans showed reduced enhancement of the shoulder synovium in patients with adhesive capsulitis after HA injections (27). Third, the injected HA coats the cartilage and prevents its damage. Through these mechanisms, the HA, once injected into the shoulder joint, seems to contribute to the decrease in pain and improvement of shoulder function in patients with adhesive capsulitis.

Limitations

The current meta-analysis has several limitations. First, our research included only a small number of studies. Second, the number of HA injections varied from one to 3 across the studies, whereas CS injection was performed only once in most of the included studies. Lastly, studies that evaluated the combined use of CS and HA injections, which was commonly performed in many clinical practices, was excluded from the analysis to allow for precise comparisons.

Conclusion

In conclusion, although CS injections were associated with better short-term effects on pain reduction and functional improvement in the shoulder joint than were HA injections, those effects became similar at 6 and 12 weeks after the injections were administered. Furthermore, no significant differences were observed in the ROMs of abduction and external rotation between the 2 groups. Based on the results of our meta-analysis, intraarticular HA injections could be considered an effective therapeutic option for managing the symptoms of adhesive capsulitis. Additional, well-designed studies should be conducted in the future to clarify this issue.

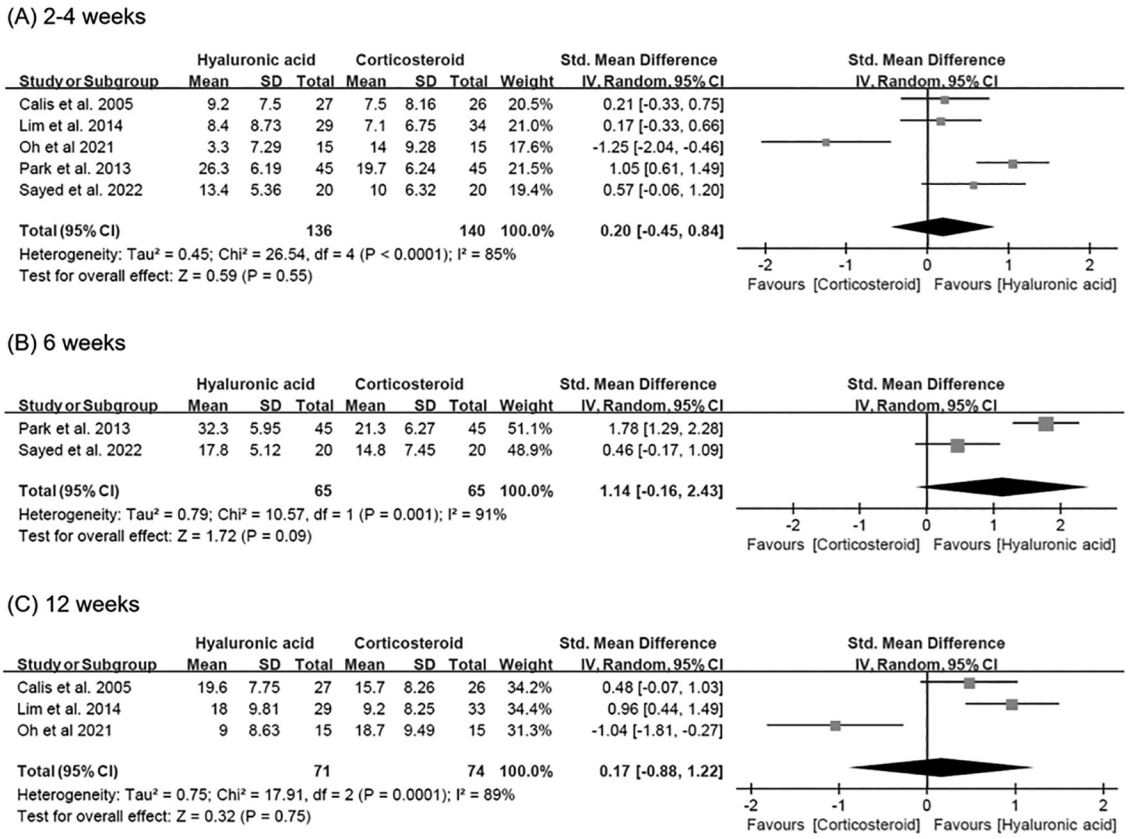

Fig. 13. *Comparison of changes in the ROM of passive external rotation between intraarticular HA and CS injections at (A) 2-4 weeks, (B) 6 weeks, and (C) 12 weeks after the injections.*

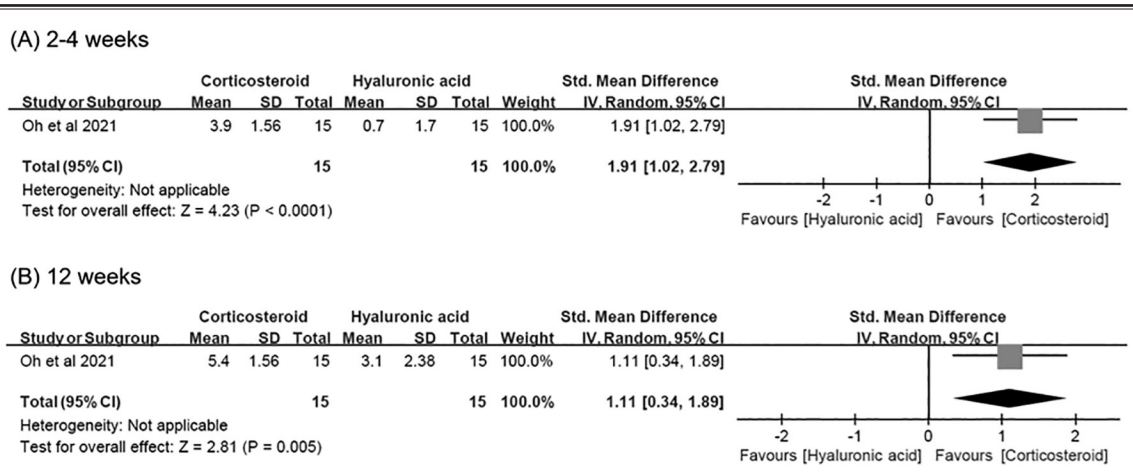

Fig. 14. *Comparison of changes in the ROM of passive internal rotation between intraarticular HA and CS injections at (A) 2-4 weeks and (B) 12 weeks after the injections.*

Supplemental material is available at www.painphysicianjournal.com

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Supplementary 1. *Search terms and strategies* .

Search strategy for PubMed

#1 Search: "shoulder" OR "glenohumeral" OR "adhesive capsulitis" OR "osteoarthritis" OR "frozen"

"Shoulder"[all fields] OR "glenohumeral"[all fields] OR "adhesive capsulitis"[all fields] OR "osteoarthritis"[all fields] OR "frozen"[all fields]

#2 Search: "steroid" OR "corticosteroid"

"Steroid"[all fields] OR "corticosteroid"[all fields]

#3 Search: "hyaluronic" OR "hyaluronic acid"

"Hyaluronic"[all fields] OR "hyaluronic acid"[all fields]

#4 Search: ((#1) AND (#2)) AND (#3)

("Shoulder"[all fields] OR "glenohumeral"[all fields] OR "adhesive capsulitis"[all fields] OR "osteoarthritis"[all fields] OR "frozen"[all fields]) AND ("steroid"[all fields] OR "corticosteroid"[all fields]) AND ("hyaluronic"[all fields] OR "hyaluronic acid"[all fields])

Search strategy for Embase

#1 "Shoulder" OR "glenohumeral" OR "adhesive capsulitis" OR "osteoarthritis" OR "frozen" 482,195

#2 "Steroid" OR "corticosteroid"

#3 "Hyaluronic" OR "hyaluronic acid"

#4 #1 AND #2 AND #3

Query: ("shoulder" OR "glenohumeral" OR "adhesive capsulitis" OR "osteoarthritis" OR "frozen") AND ("steroid" OR "corticosteroid") AND ("hyaluronic" OR "hyaluronic acid")

Search strategy for Scopus

#1 (ALL("shoulder" OR "glenohumeral" OR "adhesive capsulitis" OR "osteoarthritis" OR "frozen") AND ALL ("steroid" OR "corticosteroid") AND ALL ("hyaluronic" OR "hyaluronic acid"))

Search strategy for the Cochrane Library

#1 "Shoulder" OR "glenohumeral" OR "adhesive capsulitis" OR "osteoarthritis" OR "frozen"

#2 "Steroid" OR "corticosteroid"

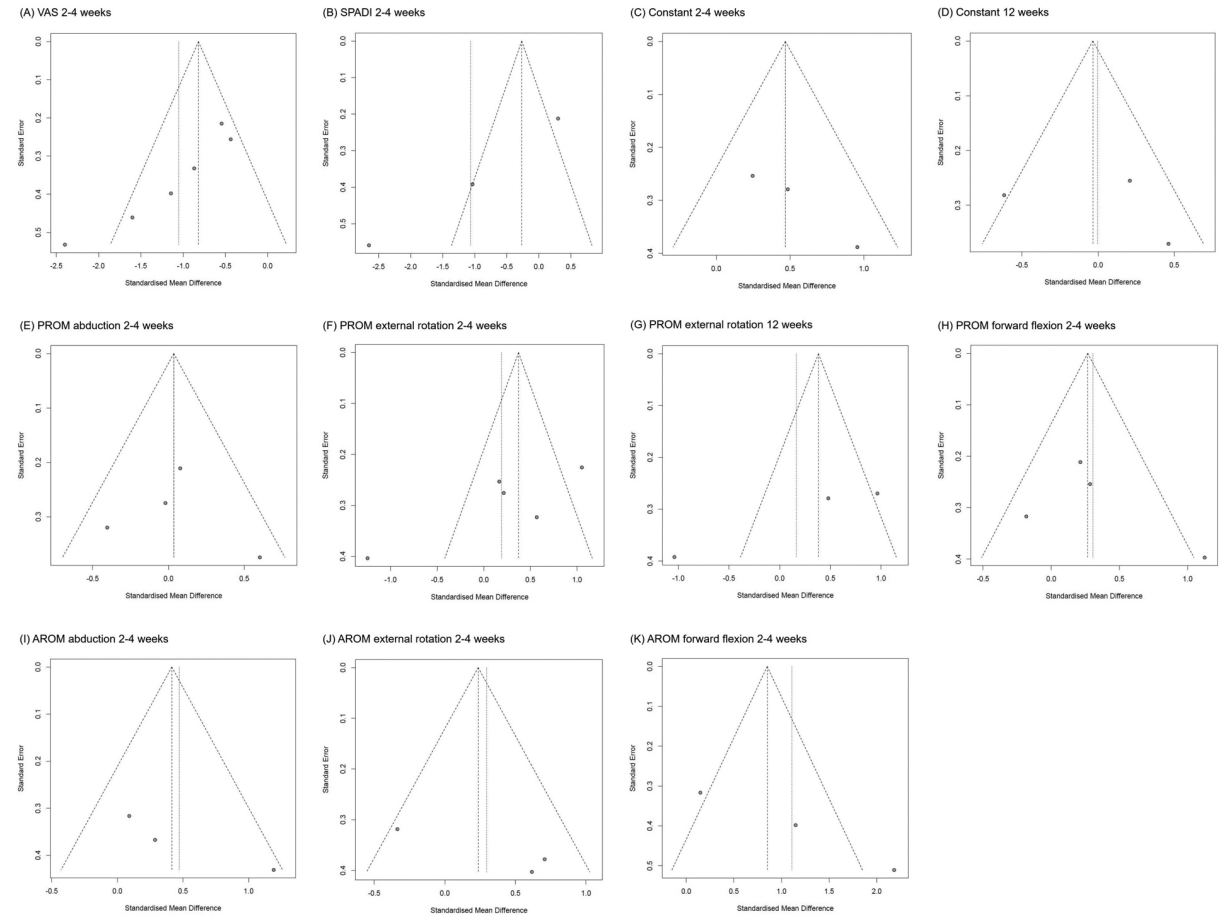
#3 "Hyaluronic" OR "hyaluronic acid"

#4 #1 AND #2 AND #3 in Trials (Word variations have been searched)

Search strategy for KMBASE

#1 ((Shoulder |total) OR (glenohumeral |total) OR (adhesive capsulitis|total) OR (osteoarthritis |total) OR (frozen|total)) AND ((steroid|total) OR (corticosteroid|total)) AND ((hyaluronic|total) OR (hyaluronic acid|total))

Database	Key words
PubMed	("shoulder"[all fields] OR "glenohumeral"[all fields] OR "adhesive capsulitis"[all fields] OR "osteoarthritis"[all fields] OR "frozen"[all fields]) AND ("steroid"[all fields] OR "corticosteroid"[all fields]) AND ("hyaluronic"[all fields] OR "hyaluronic acid"[all fields]) 299
Embase	("shoulder" OR "glenohumeral" OR "adhesive capsulitis" OR "osteoarthritis" OR "frozen") AND ("steroid" OR "corticosteroid") AND ("hyaluronic" OR "hyaluronic acid") 1,681
Scopus	(ALL ("shoulder" OR "glenohumeral" OR "adhesive capsulitis" OR "osteoarthritis" OR "frozen") AND ALL ("steroid" OR "corticosteroid") AND ALL ("hyaluronic" OR "hyaluronic acid")) 7,033
Cochrane library	(("shoulder" OR "glenohumeral" OR "adhesive capsulitis" OR "osteoarthritis" OR "frozen") AND ("steroid" OR "corticosteroid") AND ("hyaluronic" OR "hyaluronic acid")) in Trials (Word variations have been searched) 300
KMBASE	((shoulder |total) OR (glenohumeral |total) OR (adhesive capsulitis|total) OR (osteoarthritis |total) OR (frozen|total)) AND ((steroid|total) OR (corticosteroid|total)) AND ((hyaluronic|total) OR (hyaluronic acid|total)) 892



Supplementary 2. *Graphic funnel plots showing the differences in (A) VAS scores at 2-4 weeks, (B) SPADI scores at 2-4 weeks, (C) Constant scores at 2-4 weeks, (D) Constant scores at 12 weeks, (E) PROM abduction at 2-4 weeks, (F) PROM external rotation at 2-4 weeks, (G) PROM external rotation at 12 weeks, (H) PROM forward flexion at 2-4 weeks, (I) AROM abduction at 2-4 weeks, and (J) AROM external rotation at 2-4 weeks.*