SYSTEMATIC REVIEW

A systematic review and meta-analysis on the use of diagnostic ultrasound in guiding corticosteroid injections for shoulder pain (subacromial/ subdeltoid bursa)

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Abstract

Objective: To assess the efficacy of diagnostic ultrasound-guided corticosteroid injections in subacromial/subdeltoid bursa in the management of shoulder pain.

Method: The systematic review and meta-analysis was conducted from November 2023 to February 2024 in line with the Preferred Reporting Items for Systematic Review and Meta-Analysis guidelines, and comprised search on Cochrane Central Register of Controlled Trials, Excerpta Medica dataBASE, Scopus and PubMed databases for randomised controlled and/or clinical trials involving adult patients with shoulder pain/subacromial impingement/bursitis, comparing ultrasound-guided corticosteroid injections versus blind injections, and published in the English language between January 2003 and August 2023. Quality assessment was performed using the Physiotherapy Evidence Database scale, and meta-analysis was performed using MedCalc software.

Results: Of the 72 full-text articles assessed, 11(15.3%) were analysed. There was a definite short-term effectiveness of ultrasound-guided corticosteroid injections in reducing pain, as assessed by visual analogue scale scores ($p < 0.001$ at 6 weeks; $p < 0.05$ at 12 week and 33 week) and improved range of motion in flexion, abduction, internal and external rotation ($p < 0.001$-0.05). While meta-analysis confirms significant pooled effects for pain scores and range of motion outcomes at 6 weeks, long-term efficacy remained inconclusive due to heterogeneity across studies and limited long-term follow-up research on the subject.

Conclusion: Evidence supported short-term efficacy of ultrasound-guided corticosteroid injections for shoulder pain management, but robust trials with extended follow-up periods and larger cohorts are needed to establish their long-term effectiveness.

Keywords: Ultrasonography, Interventional ultrasound, Shoulder pain, Corticosteroids, Shoulder impingement syndromes.

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Introduction

Shoulder pain is one of the most prevailing self-reported musculoskeletal issues in the general population, with a prevalence of 16%[1,2]. The most common cause of shoulder pain and disability has been reported to be subacromial impingement and subacromial bursitis[3]. Subacromial impingement represents about 44-65% of all shoulder pain cases. The clinical presentation of subacromial impingement or subacromial bursitis is reported to be the presence of anterolateral shoulder pain when performing overhead activities, the presence of tenderness on the anterolateral acromion, a positive Neer's sign, Hawkins's sign, and a painful arc within the range of 70-120 degrees[3-6].

The standard treatment procedure for subacromial impingement and bursitis is known to be steroid or corticosteroid injections, which reportedly alleviate pain, have anti-inflammatory effects, and enhance functionality[7,8]. Over the years, the traditional technique of corticosteroid injections has been an anatomic landmark-guided method with either an anterior, posterior or lateral approach. However, anatomical landmarks or blind steroid injections are not known to have accurate precision as they do not visually provide the location of the target sit[3]. In recent years, technology, specifically ultrasonography (USG) scan, has made massive improvements, leading to its use in diagnostics and interventional use. The modern USG scan has better resolution, penetration and probability, and, hence, its use in guiding injections in various musculoskeletal conditions has become more widespread[3,9]. It has been

reported that between 2004 and 2010, the use of USG-guided musculoskeletal injections, such as subacromial injections, increased in different countries, such as the United States and the United Kingdom. Some of the observed benefits of USG-guided injections are the placement of the needle, which results in the accuracy of injection placement on the targetted anatomical site[10].

The accuracy of needle placement is said to make treatment more effective. However, the accuracy of needle placement does not mean that the overall outcome of the treatment will significantly improve as well. Over the years, the literature has shown varying and conflicting results of the efficacy of USG-guided corticosteroid injections against the landmark-guided corticosteroid injections on the subacromial/subdeltoid bursa[8,11].

The current systematic review was planned to assess the effectiveness of diagnostic USG in guiding corticosteroid injections in corticosteroid injections in subacromial/subdeltoid bursa in the management of shoulder pain.

Materials and Methods

The systematic review and meta-analysis was conducted from November 2023 to February 2024 in line with the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) guidelines[12], which was registered with the International Prospective Register of Systematic Reviews (PROSPERO)[13]. Initially, a literature search was conducted on Cochrane Central Register of Controlled Trials (CENTRAL), Excerpta Medica database (EMBASE), Scopus and PubMed databases for randomised controlled and/or clinical trials (RCTs) involving adult patients with shoulder pain/subacromial impingement/bursitis, comparing USG-guided corticosteroid injections versus blind injections, and published in the English language between January 2003 and August 2023. The search strategy combined medical subject headings (MeSH) and free-text search terms. The key words and Boolean Operators used included ultrasound-guided injections AND anatomical landmarks AND corticosteroids AND shoulder pain OR pain in shoulder AND subacromial impingement OR subdeltoid bursa OR subacromial space OR subacromial impingement OR subacromial bursa AND RCT OR randomised control trials OR experimental studies.

The eligibility criteria were formulated based on patient/population, intervention, comparison and outcomes (PICO) format[14]. RCTs with full text availability were included if they comprised patients presenting with shoulder pain/subacromial impingement/bursitis, a painful restriction on active flexion, abduction, internal and external rotation, and had positive Neer's and Hawkins tests. Studies that used USG-guided corticosteroid injections on any other site than subacromial space, such as acromioclavicular or glen humeral injections, or for pathologies or involving other anatomical landmarks than subacromial subdeltoid bursa, such as post-traumatic shoulder pain, previous proximal humeral fractures, cases with glen humeral and acromioclavicular joint arthritis, and patients with capsulitis, calcific tendinitis, and inflammatory joint disease were excluded. Also excluded were studies having patients with a previous history of shoulder surgery.

The initial search results were subjected to Zotero software for the removal of duplicates. The primary outcome assessment from the included studies was pain relief, assessed using the visual analogue scale (VAS), and secondary assessment was the range of motion (ROM), including flexion, extension, and internal and external rotation.

Data comprising author name, publication year, sample size, age and gender, choice of injection, site of injection, follow-up evaluation, and outcome measures was noted. For the quality assessment of the RCTs, the Physiotherapy Evidence Database (PEDro) scale was used, which consists of 11 points with a total score of 10[15].

Meta-analysis was performed using MedCalc version 22.014. The included studies were categorised with respect to the outcome measures. The mean and standard deviation values were extracted from the studies. For statistical analysis, Hedges' g random effect model was used, while the studies were tested for heterogeneity using I-square[I2] statistics. Funnel and forest plots were used as appropriate.

Results

Of the 1,887 studies identified, 72(3.8%) full-text articles were assessed for eligibility, and 11(15.3%) were included (Figure 1)[16-26]. of the 661 total subjects, 390(59%) were females and 271(41%) were males. All the studies had two groups: USG-guided corticosteroid injection group A and blind landmark-guided corticosteroid injection group B. Of the 11 studies, 6(54.5%) had a follow-up evaluation post-injection in the 6th week, 2(18.2%) in the 4th week[16-18], 1(9.1%) in the 3rd month, 1(9.1%) in the 33rd week, and 1(9.1%) in the 12th week post-injection (Table 1).

VAS score significantly improved in the group A compared to group B post-injection at the 6th week

Table-1: Characteristics of the studies analysed (n=11).

Author-Year	Sample size-Groups	Demographics	Follow-up- Injection	Outcomes
Naredo et al, 2004[16]	41; U.S: 20, Blind: 21	Mean age 52.4 years, 27 females and 14 male.	6 week follow up.20 mg triamcinolone	VAS.
Lee et al, 2009[17]	40; U.S: 20 Blind: 20	U.S: mean age 53.1 years and 9 males and 11 females.Blind: mean age 54.1 years and 10 males and 10 females.	6 week follow-up1 week: 0.5-mL triamcinolone (20mg) with 1.5mL of 2% lidocaine and 3mL of normal saline.Other weeks: a 2.5-mL low–molecular-weight sodium hyaluronate (25mg).	VAS, and ROM of the shoulder flexion, abduction, external rotation, and internal rotation.
Ucuncu et al, 2009[18]	60; U.S: 30, Blind: 30.	Mean age 52.55 years.44 females and 16 males.	6 week follow-up.1mL 40mg triamcinolone and 1mL 1% lidocaine.	VAS, and passive and active shoulder ROM.
Zhang et al, 2011[19]	98 - U.S: 53, Blind: 45.	Mean age 47 years.U.S: 34 males and 19 females.Blind:29 males and 16 females.	33 week follow-up.1 mL (10 mg) lidocaine and 1 mL (40 mg) triamcinolone acetonide.	VAS.
Dogu et al, 2012[20]	46; U.S: 23, Blind: 23.	U.S: mean age 55.17 years,15 females and 8 males.Blind: mean age 56.74 years, with 16 females and7 males.	6 week follow-up.1 ml of 5 mg/ml betamethasone dipropionate, 9 ml of 10 mg/ml prilocaine hydrochloride, and 0.02 ml of 0.01 mmol gadolinium diethylenetriaminepentaacetic acid.	VAS (rest, activity, and sleep periods), and ROM.
Saeed et al, 2013[21]	100; U.S: 50, Blind: 50.	Mean age57.7 years, 65 females, and 35 males.	12 week follow-up.40 mg of methylprednisolone acetate.	VAS.
Hsieh et al, 2013[22]	92; U.S: 46, Blind: 46.	U.S: mean age57.59 years, 19 males and 27 females.Blind: mean age 55.87yrs, 17 males and 29 females.	4 week follow-up.a mixture of 0.5 mL dexamethasone suspension and 3 mL lidocaine	VAS and active and passive ROM of the affected shoulder.
Cole et al, 2015[23]	56; U.S: 28, Blind: 28.	Mena age 44 years, 32 females and 24 males.	6 weeks follow-up.1 mL of 40 mg/mL methylprednisolone acetate and 5 mL of 1% lidocaine hydrochloride.	VAS.
Haghighat et al, 2015[24]	40; U.S: 20, Blind: 20.	U.S: mean age 50.4 years, 12 females and 8 males.Blind: mean 52.3yrs, 13 females and 7 males.	6 weeks follow-up.40 mg methylprednisolone with 1cc lidocaine 2%	VAS, and shoulder ROM.
Bhayana et al, 2017[25]	60; U.S: 30, Blind: 30.	U.S: mean age 44.53 years, 17 females and 13 males.Blind: mean age 42.03 years, 10 females and 20 males.	Follow up at day 5, week 3, week 6 and 3rd month.U.S: 2 ml of 40 mg/ml Methylprednisolone Acetate suspension mixed and 2 ml of 1% lignocaine.Blind: 2 ml of 40 mg/ml Methylprednisolone Acetate suspension mixed, 2 ml lignocaine and 2 ml of radio opaque non- ionic contrast media iohexol.	VAS, and active and passive ROM of both the shoulders, flexion, extension, internal and external rotation.
Akbari et al, 2020[26]	28; U.S: 14, Blind: 15.	U.S: mean age 39.5 yrs.Blind: mean age 42.5 yrs.Total 17 females and 11 males.	4 week follow-up.Methylprednisolone acetate 40 mg in 1 mL and procaine 2% 4 mL.	VAS, and active shoulder ROM, flexionand abduction.

US: Ultrasound group, VAS: Visual analogue scale, ROM; Range of motion.

(p<0.001), 12th week (p<0.05), and 33rd week (p<0.05)[16,18]. In some studies, VAS decreased in both groups, but there was no reported statistically significant difference between the groups[17].

There was significant improvement in active and passive shoulder ROM of flexion, abduction, internal rotation, and external rotation in group A compared to group B post-injection at the 6th week (p< 0.001 vs p<0.05)[16,18]. In comparison, 1(9.1%) study reported improvement in ROM of abduction one month (p<0.05) post-injection in group

Table-2: Physiotherapy Evidence Database (PEDro) scale assessment.

PEDro scale	Naredo et al 2004[16]	Lee et al 2009[17]	Ucuncu et al 2009[18]	Zhang et al 2011[19]	Dogu et al 2012[20]	Saeed et al 2013[21]	Hsieh et al 2013[22]	Cole et al 2015[23]	Haghighat et al 2015[24]	Bhayana et al 2017[25]	Akbari et al 2020[26]
Eligibility criteria	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
Random allocation	Yes	No	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Allocation concealment	No	No	No	No	No	No	No	No	No	No	No
Comparable baseline	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
Blinded subjects	No	No	No	No	No	No	No	Yes	No	No	No
Blinded personnel	Yes	No	No	No	No	No	No	No	No	No	No
Blinded outcome assessor	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes
Adequate follow-up	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
Intention-to-treat analysis	Yes	Yes	No	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
Between-group analysis	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Point estimates and variability	No	Yes	No	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Total score	7	6	5	5	7	4	7	7	6	7	7

Table-3: Visual Analogue Scale (VAS) scores at 6th week follow-up.

Study	N1	N2	Total	SMD	SE	95% CI	t	P	Weight (%)	
									Fixed	Random
Naredo et al, 2004[16]	20	21	41	1.70	0.36	0.97 to 2.43			17.33	24.41
Ucuncu et al., 2009[18]	30	30	60	-0.82	0.26	-1.35 to -0.29			31.76	25.42
Cole et al., 2015[23]	28	28	56	-0.98	0.28	-1.54 to -0.42			28.69	25.28
Haghighat et al., 2015[24]	20	20	40	0.62	0.31	-0.02 to 1.26			22.22	24.89
Total (fixed effects)	98	99	197	-0.11	0.15	-0.40 to 0.18	-0.73	0.46	100.00	100.00
Total (random effects)	98	99	197	0.11	0.60	-1.07 to 1.30	0.18	0.85	100.00	100.00
Test for heterogeneity										
Q	47.76									
DF	3									
Significance level	P < 0.00									
I^2 (inconsistency)	93.72%									

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95% CI for I^2	87.10 to 96.94
Publication bias	
Egger's test	
Intercept	29.42
95% CI	8.62 to 50.21
Significance level	P = 0.02

SMD: Standardized mean difference, SE: Standard error, CI: Confidence interval.

Table-4: Range of motion (ROM) (flexion) at 6th week follow-up.

Study	N1	N2	Total	SMD	SE	95% CI	t	P	Weight (%)	
									Fixed	Random
Lee et al, 2009[17]	21	22	43	0.524	0.305	-0.0910 to 1.140			29.80	31.19
Ucuncu et al., 2009[18]	30	30	60	-0.0312	0.255	-0.541 to 0.479			42.61	39.23
Haghighat et al., 2015[24]	20	20	40	0.582	0.317	-0.0591 to 1.223			27.59	29.58
Total (fixed effects)	71	72	143	0.304	0.166	-0.0253 to 0.632	1.825	0.070	100.00	100.00
Total (random effects)	71	72	143	0.323	0.206	-0.0840 to 0.731	1.569	0.119	100.00	100.00
Test for heterogeneity										
Q	3.0235									
DF	2									
Significance level	P = 0.2205									
I^2 (inconsistency)	33.85%									
95% CI for I^2	0.00 to 78.29									
Publication bias										
Egger's test										
Intercept	10.3356									
95% CI	-1.1742 to 21.8453									
Significance level	P = 0.0557									

SMD: Standardized mean difference, SE: Standard error, CI: Confidence interval

Table-5: Range of motion (ROM) (abduction) at 6th week follow-up.

Study	N1	N2	Total	SMD	SE	95% CI	t	P	Weight (%)	
									Fixed	Random
Lee et al, 2009[17]	21	22	43	0.752	0.310	0.125 to 1.378			51.12	51.12
Haghighat et al., 2015[24]	20	20	40	0.606	0.317	-0.0359 to 1.249			48.88	48.88
Total (fixed effects)	41	42	83	0.681	0.222	0.239 to 1.122	3.068	0.003	100.00	100.00
Total (random effects)	41	42	83	0.681	0.222	0.239 to 1.122	3.068	0.003	100.00	100.00
Test for heterogeneity										

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Q	0.1071
DF	1
Significance level	P = 0.7435
I^2 (inconsistency)	0.00%
95% CI for I^2	0.00 to 0.00
Publication bias	
Egger's test	
Intercept	-20.64
Significance level	P < 0.0001

SMD: Standardized mean difference, SE: Standard error, CI: Confidence interval.

Table-6: Range of motion (ROM) (internal rotation) at 6th week follow-up.

Study	N1	N2	Total	SMD	SE	95% CI	t	P	Weight (%)	
									Fixed	Random
Lee et al, 2009[17]	21	22	43	0.67	0.30	0.04 to 1.29			50.31	50.12
Haghighat et al., 2015[24]	20	20	40	-0.03	0.31	-0.66 to 0.59			49.69	49.88
Total (fixed effects)	41	42	83	0.32	0.21	-0.11 to 0.75	1.46	0.14	100.00	100.00
Total (random effects)	41	42	83	0.31	0.35	-0.38 to 1.02	0.90	0.36	100.00	100.00
Test for heterogeneity										
Q	2.60									
DF	1									
Significance level	P = 0.10									
I^2 (inconsistency)	61.63%									
95% CI for I^2	0.00 to 91.12									
Publication bias										
Egger's test										
Intercept	-373.26									
Significance level	P < 0.00									

SMD: Standardized mean difference, SE: Standard error, CI: Confidence interval.

Table-7: Range of motion (ROM) (external rotation) at 6th week follow-up.

Study	N1	N2	Total	SMD	SE	95% CI	t	P	Weight (%)	
									Fixed	Random
Lee et al, 2009[17]	21	22	43	0.345	0.302	-0.264 to 0.955			51.54	50.81
Haghighat et al., 2015[24]	20	20	40	-0.253	0.311	-0.883 to 0.377			48.46	49.19
Total (fixed effects)	41	42	83	0.0554	0.217	-0.376 to 0.486	0.256	0.799	100.00	100.00
Total (random effects)	41	42	83	0.0510	0.299	-0.544 to 0.646	0.171	0.865	100.00	100.00

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Test for heterogeneity	
Q	1.9036
DF	1
Significance level	P = 0.1677
I^2 (inconsistency)	47.47%
95% CI for I^2	0.00 to 0.00
Publication bias	
Egger's test	
Intercept	-63.2200
Significance level	P < 0.0001

SMD: Standardized mean difference, SE: Standard error, CI: Confidence interval.

A compared to group B. Another study reported that initially, 1-week post-injection, both groups improved, but only group A showed improvement in flexion and internal rotation in the 3rd and 4th weeks post-injection, and abduction and external rotation only enhanced in the 2nd week post-injection[17]. Some studies reported that shoulder ROM of flexion, abduction, internal rotation, and external rotation in the group A compared to group B post-injection did not improve significantly.

In terms of quality assessment using the PEDro scale, most of the studies were of high quality (Table 2).

In the meta-analysis phase, 4(%) studies were included in the analysis of pain via VAS[16,18,23,24]) having post-injection evaluation follow-up in the 6th week (Table 3, Figure 2). There were 3(%) studies analysing ROM flexion[17,18] with

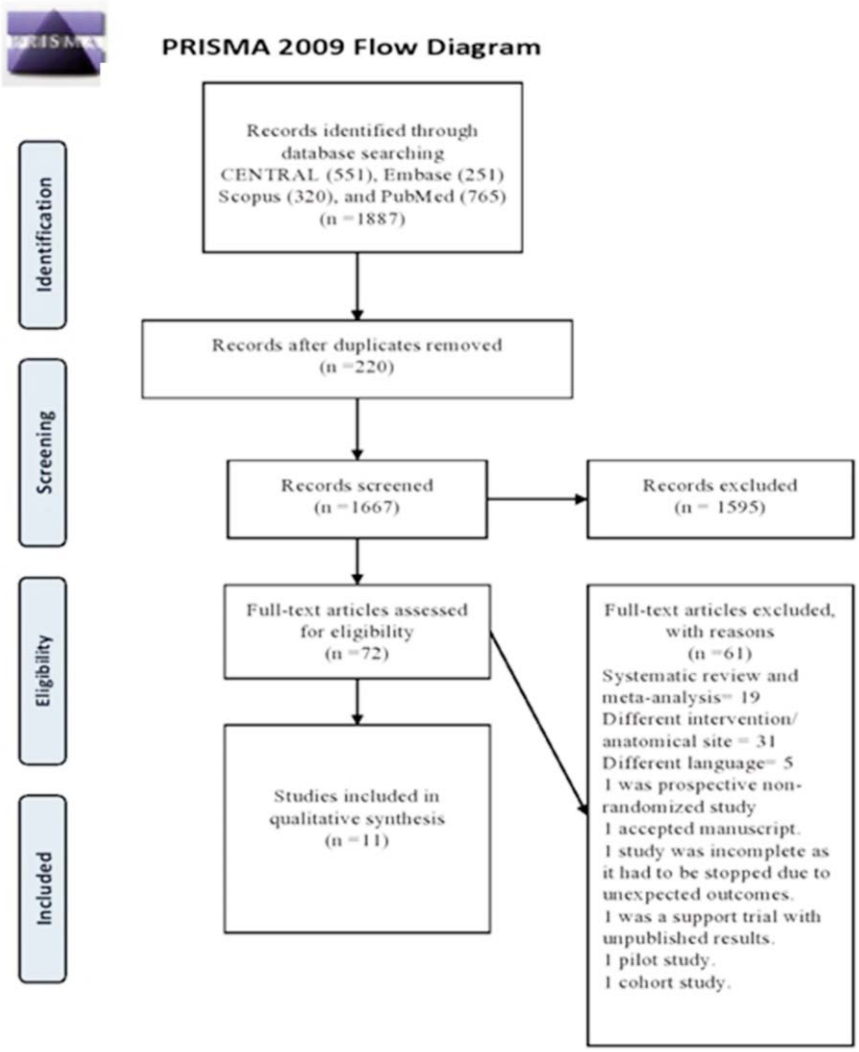

Figure-1: Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) flowchart.

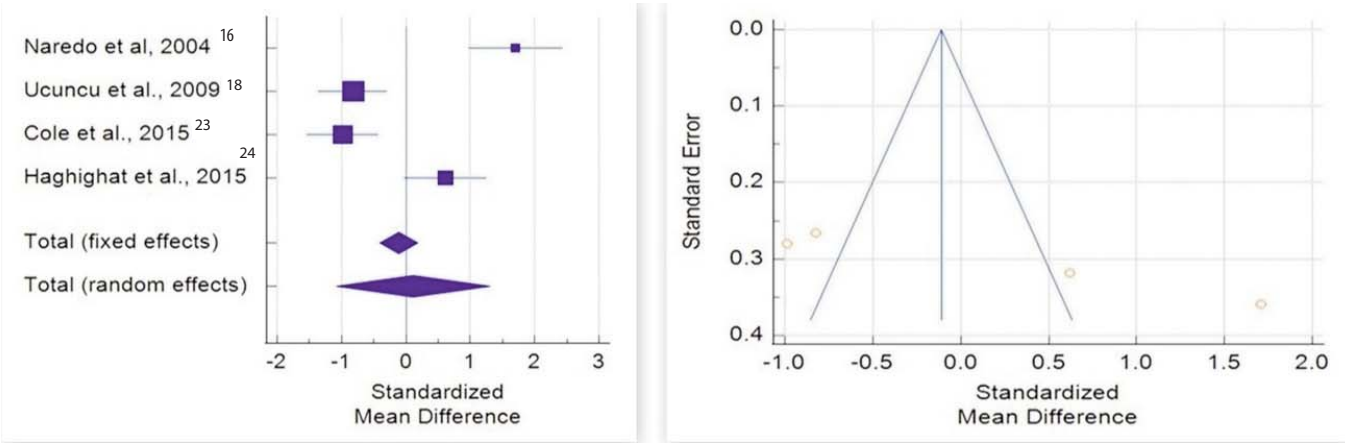

Figure-2: Forest plot and funnel plot for Visual Analogue Scale (VAS).

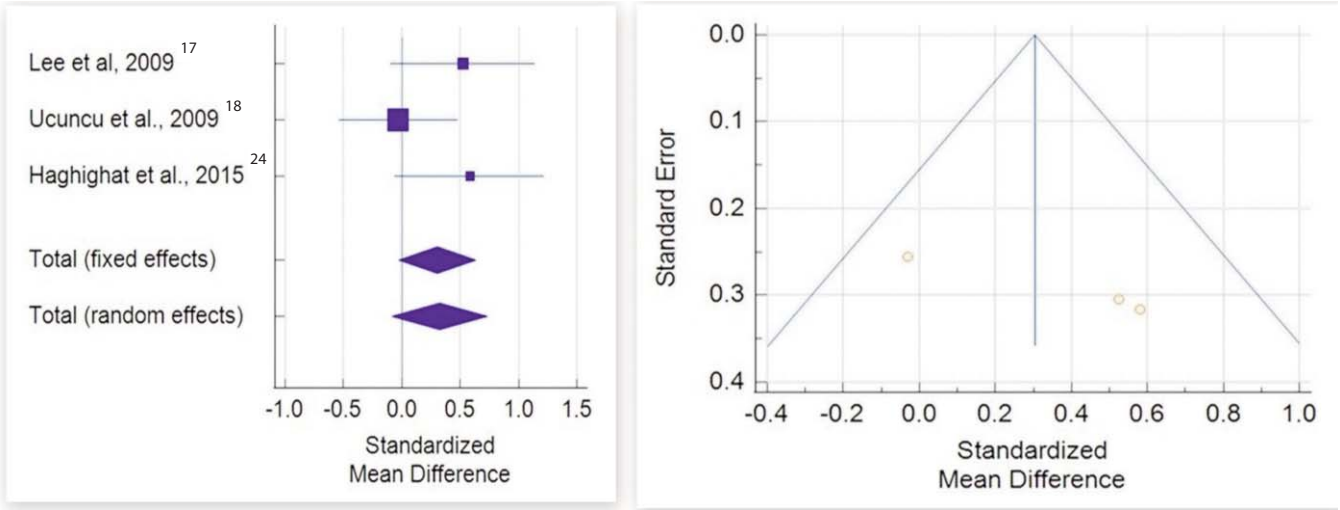

Figure-3:Forest plot and funnel plot for range of motion (ROM) (flexion).

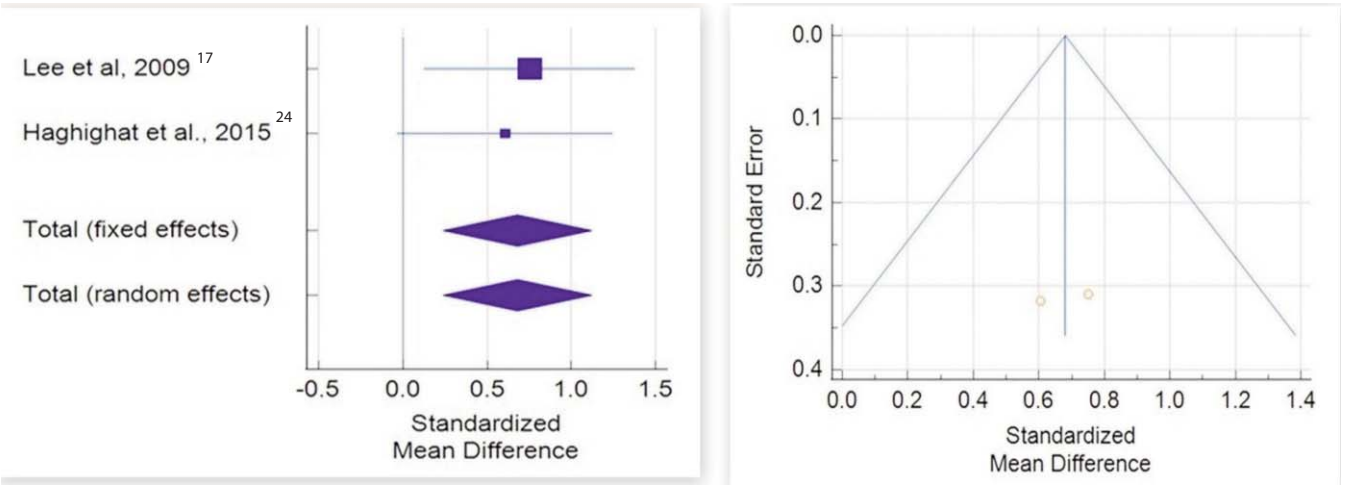

Figure-4:Forest plot and funnel plot for range of motion (ROM) (abduction).

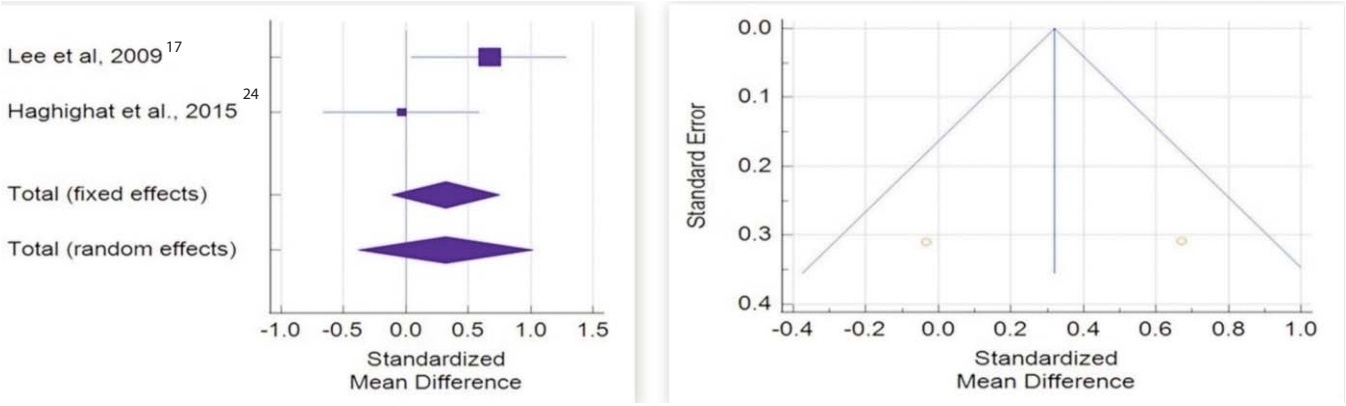

Figure-5:Forest plot and funnel plot for range of motion (ROM) (internal rotation).

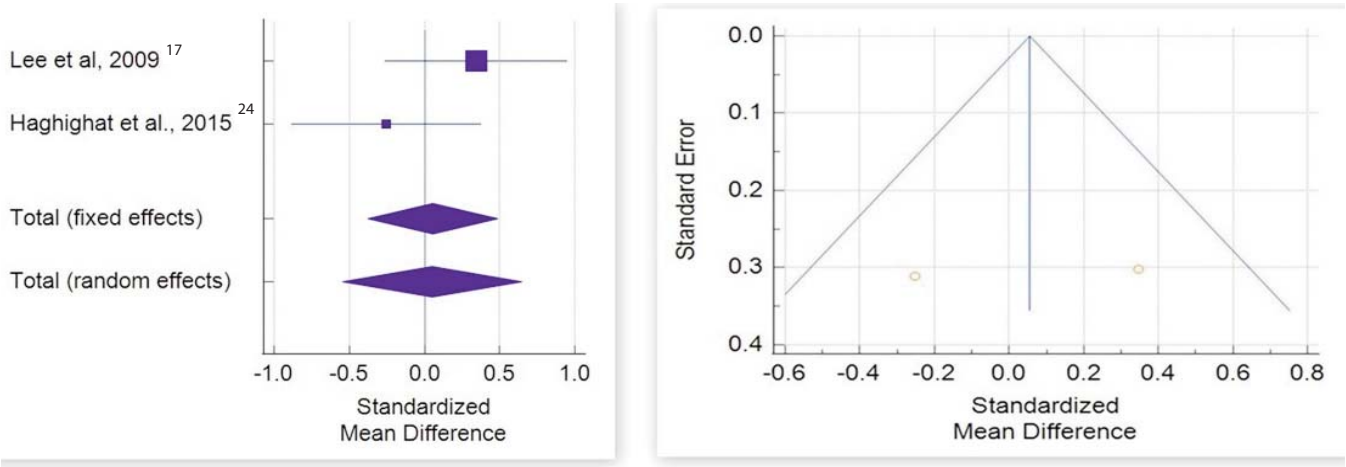

Figure-6:Forest plot and funnel plot for range of motion (ROM) (external rotation).

post-injection evaluation in the 6th week (Table 4, Figure 3). There were 2(%) studies analysing ROM abduction[17] with post-injection evaluation in the 6th week (Table 5, Figure 4). There were 2(%) studies analysing ROM internal rotation[17] and had post-injection evaluation in the 6th week (Table 6, Figure 5). Finally, 2(%) studies analysed ROM external rotation[17] and had post-injection evaluation done in the 6th week (Table 7, Figure 6).

Discussion

Conventionally, corticosteroid injections are administered using anatomical landmarks for guidance[3]. The emergence of musculoskeletal ultrasound has challenged this traditional method, with proponents suggesting that USG-guided injections are far more precise in targeting the bursa, thereby enhancing efficiency[10]. Poor injection technique could result in incomplete responses due to the diffusion of steroids away from the target site. As a reliable and safe method, USG ensures precise needle placement and drug delivery. Real-time visualisation during USG-guided injections allows physicians to monitor the location of corticosteroids, identifiable as echogenic lines or foci[8,27]. However, these claims remain contentious and lack conclusive evidence. It is imperative to consider treatment efficacy rather than just the accuracy of injection placement when justifying the adoption and cost of USG-guided injections. Hence, the current review studied the effectiveness of USG-guided corticosteroid injections compared to blind landmark-guided corticosteroid injections on shoulder pain (subacromial space).

One of the studies suggested superior outcomes for USG-guided corticosteroid injections compared to blind injections, reporting a significant decrease in VAS scores and improved shoulder function in the sonographic-guided group. While the study emphasised the safety and

efficacy of this approach, the limitations, including a small sample size and short follow-up period, highlighted the need for further research to validate the findings[16].

Similarly, another study reported that outcomes initially favoured USG-guided injections for better pain management and functional improvement, but the advantage diminished over time, suggesting a comparable long-term efficacy of both the techniques. These results underscored the need for more comprehensive research, exploring the long-term outcomes and cost-effectiveness of different approaches for managing shoulder pain[17]. Another study also emphasised the importance of patient selection criteria for optimising treatment success.

Moreover, a study highlighted the comparable efficacy of injections in different locations, suggesting the effectiveness of the treatment irrespective of the injection site. The study emphasised the safety and efficacy of the procedure, calling for further investigation into the optimal injection strategies for maximising patient outcomes[20]. Another study indicated the effectiveness of USG-guided and traditional techniques in reducing pain and disability associated with shoulder disorders. While the study demonstrated improvements in various shoulder-related scores, it also suggested additional research to identify factors influencing the efficacy of different intervention techniques.

A study highlighted the short-term benefits of using USG-guided subdeltoid injections, underscoring the necessity for further comprehensive investigations to determine its long-term efficacy and safety. The study emphasised the need for more extensive, more conclusive trials to provide a deeper understanding of the effectiveness of USG guidance for subdeltoid injections. Additionally, some studies provided insights into the comparable efficacy of USG-guided and blind injections in managing shoulder pain. These studies stressed the importance of long-term follow-up, cost-effectiveness, and comprehensive analysis to inform clinical decision-making and optimise patient care.

The current systematic review has its limitations as well, including a small number of relevant studies that had small sample sizes and short follow-up periods, affecting the generalisability and reliability of the findings. More robust and long-term studies are recommended.

Conclusion

While the initial superiority of USG-guided injection in shoulder pain management was evident, the long-term efficacy and cost-effectiveness of the approach compared to the traditional methods remain contentious and need more conclusive evidence.

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